Fagatele Bay National Marine Sanctuary
Condition Report

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This report provides a summary of resources in the Fagatele Bay National Marine Sanctuary (NMS), pressures on those resources, the current condition and trends, and management responses to the pressures that threaten the integrity of the marine environment. Specifically, this document reports on the status and trends of water quality, habitat, living resources and maritime archaeological resources and the human activities that affect them. It responds to a set of questions posed to all sanctuaries (Appendix A). Resource status is rated on a scale from good to poor, and the timelines used for comparison vary from topic to topic. Trends in the status of resources are also reported, and are generally based on observed changes in status over the past five years, unless otherwise specified. Evaluations of status and trends were made by sanctuary staff, based on interpretation of quantitative and, when necessary, non-quantitative assessments and observations of scientists, managers and users. In many cases, sanctuary staff consulted outside experts familiar with the resources and with knowledge of previous and current scientific investigations. The ratings reflect the collective level of concern among staff and outside experts based on their knowledge and perceptions of local problems, but the final ratings were determined by sanctuary staff. Similar reports summarizing resource status and trends will be prepared for each marine sanctuary once every five years and updated as new information allows. This information is intended to help set the stage for management plan reviews at each site and to help sanctuaries modify monitoring, characterization and research programs to address gaps, day-to-day information needs and new threats.

Abstract

Fagatele Bay is a small, isolated national marine sanctuary contained within a small, flooded volcanic crater on the southern coast of Tutuila, American Samoa. Nevertheless, the sanctuary is uniquely rich in both natural resources and cultural traditions. Although Fagatele Bay and its fringing coral reef have experienced severe disruptions from cyclones, crown-of-thorns starfish outbreaks, and more recently from coral bleaching and diseases (the causes of these are not fully understood), recovery has been remarkably swift, and the bay's isolation from most direct human influences has kept it relatively unspoiled. The most significant threats to the reef from human activities include over-fishing, poaching (especially by blast-fishing and spearfishing at night), and land clearing for agricultural development. There are also concerns about the likelihood of increasing numbers of visitors to the small bay as tourism increases in American Samoa.

By most measures, water quality in Fagatele Bay appears to be relatively good, but observations suggest declining conditions. The frequency of coral bleaching has increased in recent years, owing to higher water temperature. Nutrient levels and sediment loads, while not yet known to be a problem, are likely to increase with land clearing on the steep slopes that surround the small bay. These influences could reduce the resistance of living resources to diseases and bleaching, as well as promote fleshy algal growth on the reef. Habitat quality is fairly good, as indicated by resilient coral populations and high diversity; however, destructive fishing activities, particularly blast fishing, have harmed some areas of the reef. Certain indicators of living resource quality, namely diversity, reef coral recruitment and growth, and the lack of invasive species, suggest good conditions. Other indicators, most notably the lack of large preditory fish, clearly reflect the influence of fishing and selective fishing practices. Of concern to resource managers are the potential effects this may have on non-targeted fish species, benthic invertebrates and algae growth. These have been documented elsewhere when food webs have been disrupted and include algal blooms, species extirpations and invasions, and changes in dominance patterns.

Fagatele Bay NMS and its Territorial partners already work together on management, research, monitoring, education, and outreach. Coordinating with American Samoa's Coral Reef Advisory Group (CRAG), action plans are in place to deal with a number of the threats to Samoan reefs, including fishing, climate change, land-based pollution, and population pressure. FBNMS is working with American Samoa Environmental Protection Agency to improve water quality monitoring in the bay, particularly with respect to bacteria levels and land development. It will work with the U.S. Geologic Survey to assess threats posed by a nearby landfill facility. Mooring buoy installations are expected to reduce threats to habitat from anchoring, but improved enforcement will have to occur to reduce damage caused by illegal fishing. Continuation of the long-term monitoring program in the bay is considered a top priority for FBNMS and will allow management to gauge long-term patterns of change and recovery.

The unique Polynesian culture of the people of American Samoa has tools that can teach environmental stewardship, not only to the local population, but also to the world. Sanctuary staff are looking to the relationships of the Samoan culture to the land and sea to help guide the future of resource protection in Fagatele Bay National Marine Sanctuary.

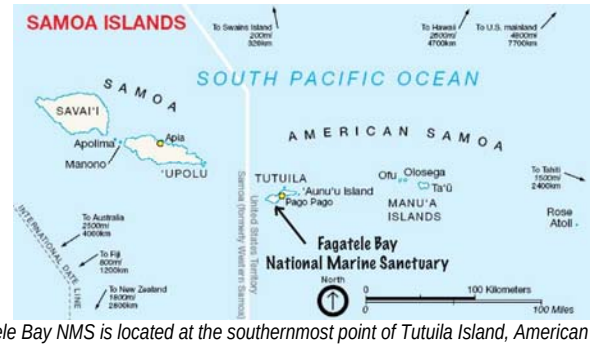
System Wide Monitoring

The National Marine Sanctuary Program (NMSP) manages marine areas in both nearshore and open ocean waters that range in size from less than 1 to almost 140,000 square miles. Each area has its own concerns and requirements for environmental monitoring, however, ecosystem structure and function in all managed areas have similarities and are influenced by analogous factors that interact in comparable ways. Furthermore, the human influences that affect the structure and function of these sites are similar in a number of ways. For these reasons, in 2001 the NMSP began to implement System-Wide Monitoring (SWiM). SWiM facilitates the development of effective, ecosystem-based monitoring programs that address management information needs using a design process that can be applied in a consistent way at multiple spatial scales and to multiple resource types. SWiM identifies four primary components common among marine ecosystems – water, habitats, living resources, and maritime archaeological resources. Assuming that a common marine ecosystem framework can be applied to all places, it follows that there may be a number of questions that can be posed at all sites. The questions found in the table that follows and explained in Appendix A are derived from both a generalized ecosystem framework and from the NMSP mission. The questions are widely applicable across the system of areas managed by the NMSP. The questions will be posed to all sanctuaries and will provide a tool by which the National Marine Sanctuary Program can measure its progress toward maintaining or improving natural and archaeological resource quality throughout the nation.

Fagatele Bay National Marine Sanctuary

- *At the southern tip of the island of Tutuila, American Samoa*
- *0.25 square miles, the smallest of the National Marine Sanctuaries*
- *Flooded crater of an extinct volcano*
- *Congressionally designated in 1986 as a National Marine Sanctuary*
- *Administered jointly by NOAA and the American Samoa Department of Commerce*
- *Extremely diverse and prolific fringing coral reef ecosystem*
- *Threatened by storm damage, coral bleaching, coral and coralline algae diseases, and destructive fishing*
- *Highly resilient ecosystem, which has recovered from numerous natural and human induced disruptions that have occurred over the last three decades*

American Samoa is a group of islands located in the South Pacific Ocean, about half way between Hawai'i and New Zealand.



Fagatele Bay NMS is located at the southernmost point of Tutuila Island, American Samoa.

Fagatele Bay is surrounded by 200-400 foot cliffs and steep slopes covered with dense, lush vegetation.

Status:

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

Fagatele Bay NMS

Condition Summary: The results in the following table are a compilation of findings from the "State of Sanctuary Resources" section of this report. (For further clarification of the questions posed in the table, please see Appendix A.)

Trends:
- ▲ Conditions appear to be improving toward one of the higher categories.
- — Conditions do not appear to be changing.
- ▼ Conditions appear to be declining toward one of the lower categories.
- **?** Undetermined trend.
- **N/A** Question not applicable.

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings
WATER				
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	▼	Increasing number of warm-water events causing coral bleaching	Selected conditions may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources and habitats.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	▼	Good water clarity; lack of fleshy algae; land clearing for agriculture	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
3	Do sanctuary waters pose risks to human health?	?	No known risks	Conditions do not appear to have the potential to negatively affect human health.
4	What are the levels of human activities that may influence water quality and how are they changing?	▼	Land clearing for agriculture, proximity of island landfill	Some potentially harmful activities exist, but they do not appear to have had a negative effect on water quality.
HABITAT				
5	What is the abundance and distribution of major habitat types and how is it changing?	?	Resilient coral populations; destructive fishing activities, diseases present	Selected habitat loss or alteration has taken place, precluding full development of living resources assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
6	What is the condition of biologically structured habitats and how is it changing?	—	Destructive events have not reduced biodiversity	Selected habitat loss or alteration has taken place, precluding full development of living resources, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	—	None identified	Contaminants do not appear to have the potential to negatively affect living resources or water quality.
8	What are the levels of human activities that may influence habitat quality and how are they changing?	—	Low visitation, but fishing impacts occur	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.
LIVING RESOURCES				
9	What is the status of biodiversity and how is it changing?	—	All species present, but some in low numbers	Biodiversity appears to reflect near-pristine conditions and promotes ecosystem integrity (full community development and function).
10	What is the status of environmentally sustainable fishing and how is it changing?	?	Fishing has removed large fish	Extraction has caused severe declines in some, but not all ecosystem components, and reduce ecosystem integrity.
11	What is the status of non-indigenous species and how is it changing?	—	Some non-indigenous algae and invertebrates may be present	Non-indigenous species do not appear to affect ecosystem integrity (full community development and function).
12	What is the status of key species and how is it changing?	—	Reduced numbers and size of certain predatory fish species	Selected keystone species are at substantially reduced levels, and prospects for recovery are uncertain.
13	What is the condition or health of key species and how is it changing?	▼	Coral and coralline algae diseases	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.
14	What are the levels of human activities that may influence living resource quality and how are they changing?	?	Illegal and legal fishing continues to remove large fish	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
MARITIME ARCHAEOLOGICAL RESOURCES				
15	What is the integrity of known maritime archaeological resources and how is it changing?	N/A	No documented underwater archeological sites	
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	N/A	No documented underwater archeological sites	
17	What are the levels of human activities that may influence maritime	N/A	No documented underwater	

	archaeological resource quality and how are they changing?		archeological sites	

Site History and Resources

Overview

Fagatele Bay is the smallest and most remote of the National Marine Sanctuaries (NMS), but its coral reefs may have the highest marine-life diversity in the sanctuary system. The bay's habitats are home to a bewildering variety of tropical fish, invertebrates and algae. Fagatele Bay NMS was designated as a National Marine Sanctuary in 1986 because it serves as an extraordinary example of a pristine tropical marine environment and coral reef ecosystem of exceptional productivity. The Sanctuary is co-administered by the National Oceanic and Atmospheric Administration (NOAA), within the US Department of Commerce, and the American Samoa Department of Commerce.

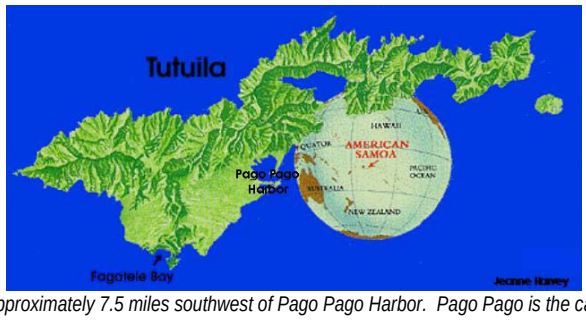
Located in the South Pacific Ocean along the southern coast of American Samoa's main island of Tutuila, Fagatele Bay NMS protects a one-quarter square mile (163 acre) marine area. With water visibility normally around 20 meters (65 ft), the small bay is a partially drowned crater of an extinct volcano and is bordered by a ridge 60 to 120 meters (200 to 300 ft) high with vertical cliffs and steep slopes. These slopes are covered with dense, lush vegetation composing one of America's few tropical rainforests. The steepness of the ridges surrounding Fagatele Bay has helped ensure that most of the watershed has remained free of introduced vegetation, maintaining a relatively unspoiled refuge for American Samoa's native plants and wildlife. (http://fagatelebay.noaa.gov/html/intro.html)

Fagatele Bay NMS's marine environment is typical of the fringing coral reef ecosystems associated with high islands of volcanic origin, many of which lie in the warm waters of the Pacific Ocean. Coral reefs are key coastal marine ecosystems in the tropical Pacific, and provide vital coastal protection and marine resource utilization by the people who live in the region. Therefore, Fagatele Bay NMS was designated as a way to help preserve American Samoa's coastal resources and to contribute to coral reef conservation efforts throughout the Pacific.

As a result of public and government concern to protect the natural resources represented by Fagatele Bay and enhance public awareness of the need to protect marine resources and promote marine ecosystem research, the governor of American Samoa proposed Fagatele Bay to NOAA as a candidate for marine sanctuary designation in 1982. After a lengthy period of public hearings, consultation and review, a management plan was approved, culminating in the designation of the Sanctuary on April 29, 1986 by an Act of Congress. Fagatele Bay NMS is part of American Samoa's conservation strategy, which includes the National Park of American Samoa and a community-based marine protected area program coordinated by the Department of Marine and Wildlife Resources.

Location

Fagatele Bay lies along the southernmost shore of Tutuila, the largest and most populated of the seven islands comprising the U.S. Territory of American Samoa. Located approximately 1,000 miles south of the equator, American Samoa constitutes the eastern portion of the Samoan archipelago. The islands of Savai'i and Upolu to the west form the independent nation of Samoa. American Samoa is the only U.S. Territory south of the equator and comprises five volcanic islands (Tutuila, Aunuu, Ofu, Olosega, and Tau) and two small remote coral atolls (Rose Atoll and Swains Island).



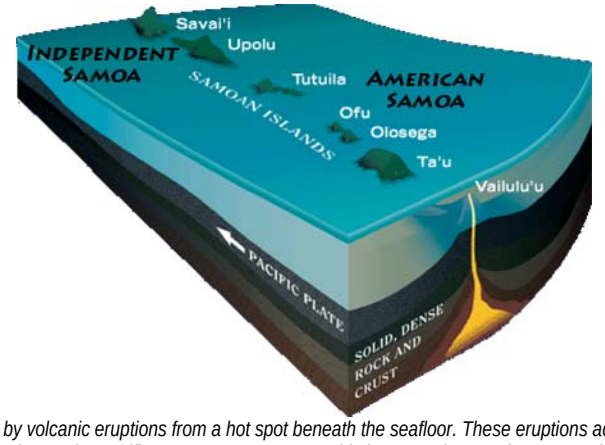
Fagatele Bay is located approximately 7.5 miles southwest of Pago Pago Harbor. Pago Pago is the capital of American Samoa.

Geology – Tutuila Island

Tutuila Island is composed of Pliocene or early Pleistocene volcanics extruded approximately 1.5 million years ago by a series of volcanic eruptions. The island consists primarily of basaltic rocks, with the bulk of the island being made up of lava flows. Because of rapid submergence during the last period of Pleistocene sea level rise, the fringing reefs around Tutuila are

discontinuous and have their foundation on bedded calcareous sand and silt as well as coral reef limestone deposited over the last 10,000 years.

Tutuila lies on the Pacific Plate, which moves in a westward direction at about 7 cm (3 inches) per year. Approximately 160 km (100 miles) south of the island, the Pacific Plate collides with the Australian Plate causing the Pacific Plate to slowly break into two parts. As the northern section of the plate continues to move westward, the southern section slides beneath the Australian plate forming the 10 km (6 mile) deep Tongan Trench. The Samoan archipelago rides on this northern section of the Pacific plate. The islands formed as the plate traveled over a "hot spot" of volcanic activity that is believed to result from geological stresses created in the Pacific plate by its descent into the Tongan Trench. As a consequence, the islands of American Samoa are geologically younger than Savai'i and Upolou, the islands of Independent Samoa to the west. The "hot spot" is presently located 30 miles east of Ta'u Island where ongoing volcanic eruptions on the seafloor are building a new island (Vailulu'u) that has yet to rise above the sea surface.
(http://www.nps.gov/npsa/book/index.htm)



The Samoan archipelago was formed by volcanic eruptions from a hot spot beneath the seafloor. These eruptions accumulated lava on the seafloor until it emerged above sea level and formed islands. As the Pacific crust moves west over this hot spot, the eruptions created the islands that make up the independent nation of Samoa and American Samoa. American Samoa is younger than its western neighbor. The hot spot is actively extruding new lava east of Ta'u that may eventually reach sea level and form a new island. (Diagram: Jayne Doucette, WHOI)

Human Settlement

Archeological evidence suggests the islands of Samoa have been inhabited since at least 1300 BC. While trade and social interactions with Tonga and the other islands of the Pacific occurred over the subsequent 2000 years, a distinctly Samoan society existed in the islands by the time of European arrival. Jacob Roggeveen first documented the islands in 1722, but Louis de Bougainville's 1772 name for the archipelago, "The Navigator Islands," was used until the end of the 19th Century. La Peróuse was the first European to set foot on Tutuila in 1787. The Wilkes Expedition from the US in 1837 provided the first systematic natural history and cultural surveys of Samoa. This expedition and the arrival of Christian missionaries established the Western influence over Samoan society that continues today. Although the shore of Fagatele Bay was the site of a village from prehistoric times to the 1950s, at present no settlement exists in the sanctuary other than a simple structure housing two temporary agricultural workers.

Commerce

In 1878, the U.S. Navy established a lease of land on the shore of the deep harbor at Pago Pago at Tutuila for a coaling station. The subsequent relationship between American Samoa and the United States has brought dramatic changes to the territory's economy. Despite significant social, economic and religious change, Samoan cultural traditions remain strong in American Samoa society, governance and land tenure. Today, tuna processing and the territorial government are the largest employers and the mainstay of the territory's economy. Two large U.S. tuna canneries form the basis of an industry that employs more than 3,000 Samoan and foreign workers. International fishing fleets supply catches to the canneries for export while small-scale artisanal fisheries supply the local market for fish. Tuna canned in South America, which is allowed into the U.S. duty free under the Andean Trade Preferences Act, threatens the future viability of the tuna industry in American Samoa.
(http://www.samoanet.com/amsamoa/)

Retail trade and services dominate the rest of the territory's economy. Agriculture on the islands of American Samoa mainly supplies local markets. The most important crops include taro, coconuts, bananas, oranges, pineapples, papayas, breadfruit, and yams. Tourism is not well developed in American Samoa, but short visits by cruise ships are a periodic addition to the economy. (http://www.mbendi.co.za/land/am/ao/p0005.htm)

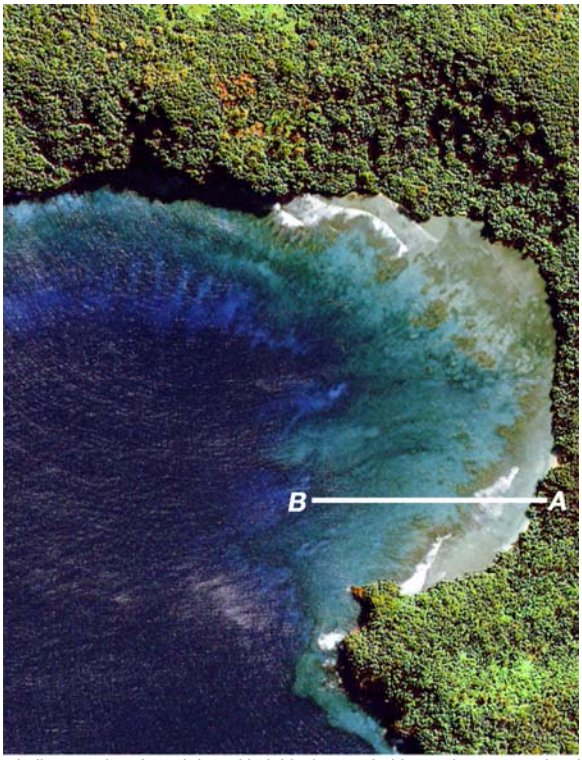
Climate and Water Quality

Yearly air temperatures in American Samoa range from 21 to 32 degrees C (70 to 90 degrees F), with an average humidity of 80 percent. The average yearly rainfall is about 5 meters (200 inches), with the heaviest rains occurring during summer months, from December through March. As summer progresses, the temperature of the ocean's surface waters also increases by about 3 degrees C (6 degrees F). Warmer ocean temperatures, in turn, help provide the energy to start tropical cyclones. Thus the chance of a cyclone is greatest between November and April. The mean annual water temperature of Fagatele Bay fluctuates around 28 degrees C (82 degrees F).

Habitat

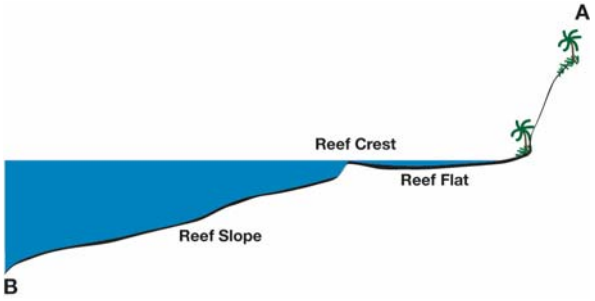
Fagatele Bay formed when the seaward side of the Fagatele volcanic crater was breached by the ocean and flooded sometime in the Pleistocene. The resulting geography is a well-protected marine environment recessed into the adjoining land and surrounded by steep-sided ridges. Seumalo Ridge rises over 120 meters (400 feet) high along the western and northern sides of Fagatele Bay, while the eastern side of the bay is bounded by Manautuloa Ridge over 60 meters (200 feet) high. Although foot trails exist to lead hikers from the mountain ridge to the shore, the steepness of the slope makes access to the bay from land difficult.

The prevailing feature of Fagatele Bay NMS is its extensive coral reef ecosystem. Shallow water coral reefs and reef-building organisms are confined to the upper euphotic zone, with the majority of reef production occurring in less than 10 meters (33 feet) water depth. Maximum water depth in Fagatele Bay NMS is 170 meters (560 feet) with open ocean depths to the southwest dropping-off steeply to more than 1200 meters (4000 feet). Corals thrive in Fagatele Bay NMS to depths of more than 30 meters (90 ft) depth. This testifies to the exceptional water and habitat conditions found in Fagatele Bay. (http://www.wpcouncil.org/documents/FEPs/AmericanSamoaFEP/December12005AmericanSamoaFEP.pdf)

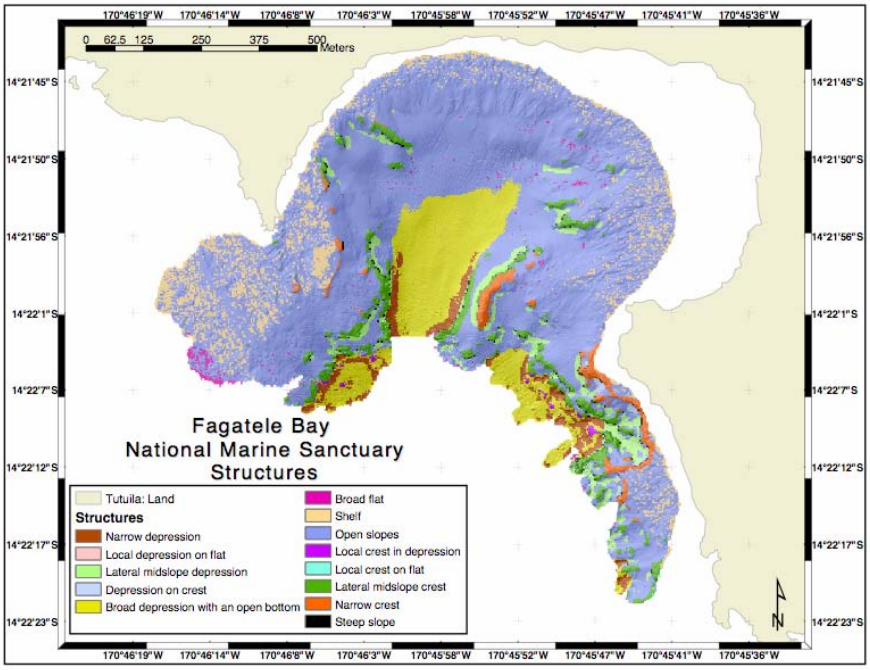


Aerial image of Fagatele Bay showing shallow coral reefs and deep (dark blue) water habitats. Line A-B markes location of cross-section shown below.

Fagatele Bay's coral reef consists of a near-shore inner reef flat that slopes to a deeper water reef (reef slope) farther offshore. The reef crest, between the inner reef flat and outer reef slope, lies in extremely shallow water and is exposed during the lowest tides.



A cross-section of Fagatele Bay's fringing reef at line A-B shown in photo above. The shallow reef flat and crest is often exposed on low tides and the reef slope descends to water depths of 170 meters (560 ft).)



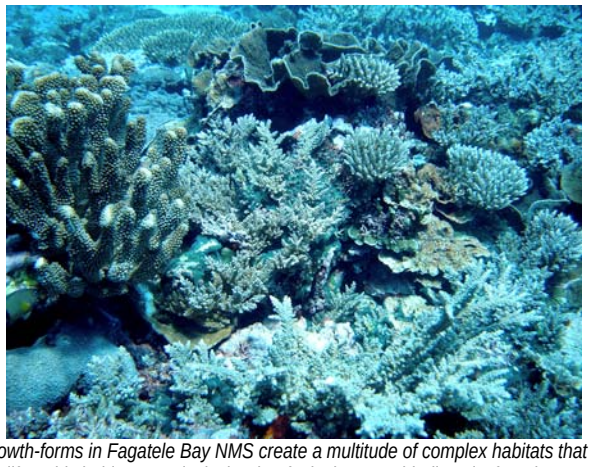
Map of the physical structures on the deep reef slopes within Fagatele Bay National Marine Sanctuary. These features are formed by the coral reefs and the sediments they produce. These structures have been deposited on top of the submerged geological features of the island. (http://dusk2.geo.orst.edu/djl/samoa/)

Waves commonly break on the reef crest. The fringing reefs found in Fagatele Bay, and its geographic orientation relative to prevailing winds, help moderate shoreline erosion by buffering ocean waves.
(http://pubs.usgs.gov/fs/2002/fs025-02/)

Living Resources

The coral reefs of Fagatele Bay NMS provide habitat for numerous reef fishes, with 271 species recorded to date. Abundant groups include adult and juvenile damselfish, surgeonfish, wrasse, butterflyfish, and parrotfish. Surveys have also identified 200 species of coral living on the reefs in the sanctuary. Corals play a particularly important role in coral reef ecosystems because they are shelter and habitat for the abundant varieties of marine life that make coral reefs their home. Many species on coral reefs depend on one another in various ways. For example, some damselfish and corals have a symbiotic relationship. The coral's branches provide the fish protection from predators, and the fish excrete nitrogen in the form of ammonia, which the coral uses for growth. Throughout the reef ecosystem, close, complex relationships like this exist between very different types of organisms creating an extremely diverse and highly productive biological community. Sponge, mollusk, echinoderm, crustacea, annelid, bryozoan, and tunicate fauna are integral components of the overall biodiversity. Taxonomic surveys have identified at

least 1400 species of algae and invertebrates (other than coral) living on Tutuila's coral reefs and likely to be found in Fagatele Bay.



The rich diversity of coral species and growth-forms in Fagatele Bay NMS create a multitude of complex habitats that are colonized by a bewildering variety of fish, algae and invertebrate life. This habitat complexity is what fuels the great biodiversity found on coral reefs. (Photo: Bill Kiene)

In addition to fishes and invertebrate coral reef organisms, several species of dolphin, including the Pacific bottlenose and the spinner dolphin, are found in the vicinity of Fagatele Bay NMS. Hawksbill and green sea turtles are also frequently seen swimming in the bay.

This clownfish and sea anemone live together in a mutually beneficial symbiotic relationship. The clownfish's waste provides the anemone nutrients, and the anemone protects the fish and its offspring from predators with its nematocysts (stinging cells). The fish has a protective coating that mimics the coating of the anemone and avoids its sting. (Photo: Kip Evans)

The migratory paths of humpback whales in the southern hemisphere intersect with American Samoa. Each year, from July through October, humpbacks use the waters around American Samoa for breeding and calving. Occasionally, sperm whales venture into the waters surrounding American Samoa and may be seen seaward of Fagatele Bay NMS.

Whales are seen outside Fagatele Bay NMS from July to October. (Photo: David Mattila)

Birds are the most conspicuous wildlife form in American Samoa. Of the 60 species of birds in American Samoa listed by the U.S. Fish and Wildlife Service, 24 are seabirds and 36 are waterfowl. Only 8 of these species are introduced. Around Fagatele Bay, the abundant bird species use the shore, rocky cliffs, and the surrounding heavily forested ridges for nesting and/or feeding. The area around the bay provides sea and shorebirds with comparatively remote, favorable physical environments for nesting, as well as ready access to rich foraging areas that are necessary during the breeding season. In addition to birds, large colonies of fruit bats, also known as flying foxes, reside in the forest surrounding Fagatele Bay. These bat colonies are infrequently encountered in other locations on Tutuila, and are susceptible to human disturbance. The Fagatele Bay colonies are therefore important because of their relative isolation.

Maritime Archaeological Resources

Imagery and documentation of Fagatele Bay NMS suggests that the sanctuary contains no large submerged archaeological artifacts. However, the site of at least one pre-historic village has been identified and mapped along its shore. This village site is presumed to be a long-occupied fishing village, which exploited the rich resources of the bay. The site consists of foundations of structures and pathways. The site is overgrown by thick forest vegetation and has not been excavated.

Pressures

The coral reefs of Fagatele Bay NMS are resilient. They have been subjected to numerous insults, but their ecological components have been able to recover. This inherent resiliency is an important consideration in the management of the sanctuary and to the understanding how coral reefs respond to disturbances.

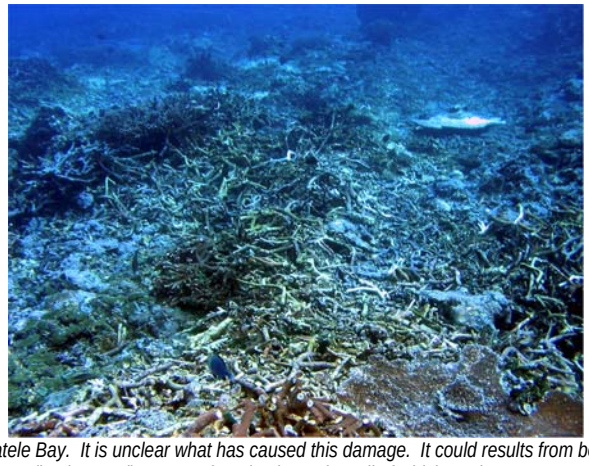
Crown-of-Thorns Starfish Outbreak

The "crown-of-thorns" starfish, *Acanthaster planci* (alamea in the Samoan language), preys on coral. Usually, these starfish are a rare and benign member of the reef community. However, plagues of these starfish occur for reasons that are not completely known. These population outbreaks can rapidly kill large tracts of coral.

In 1978 and 1979, millions of crown-of-thorns starfish devastated coral populations on Tutuila's reefs. The massive infestation resulted in a loss of more than 90 percent of all the living corals in Fagatele Bay. At the time, Fagatele Bay was not a National Marine Sanctuary, but this disaster helped to propel the decision for the site's designation.

When a crown-of-thorns starfish feeds it consumes the soft tissues of coral and leaves the hard coral skeleton. As long as other aspects of the ecosystem are intact, and new disturbances do not occur, new coral recruitment and growth will replace the damage cause by the starfish. The reefs of American Samoa are fortunate because coralline algae rapidly colonizes the dead coral skeletons and cements reef surfaces together to promote the settlement and growth of new coral colonies. Without this rapid colonization by coralline algae, wave action can cause the dead coral skeletons to fragment and turn to rubble before the new coral community can establish.
(http://www.fbnms.nos.noaa.gov/html/docs/birkland_compiled95.pdf)

Healthy coral communities in Fagatele Bay in 2006 (photo: Richard Murphy)



Recently damaged and dead coral in Fagatele Bay. It is unclear what has caused this damage. It could results from bomb-fishing, anchors, storm waves tossing loose dead coral plates (background), or even foraging by turtles, all of which are known to occur (photo: E. Lyman).

A plague of crown-of-thorns starfish ravaged the reefs of Fagatele Bay in the late 1970s (photo: C. Birkeland)

Cycles of coral re-growth and destruction have been documented over the last 26 years. This ability to recover from disturbance attests to the resiliency of the reef ecosystem in Fagatele Bay NMS.
(http://fagatelebay.noaa.gov/html/Research.html)

Tropical Cyclones (Hurricanes)

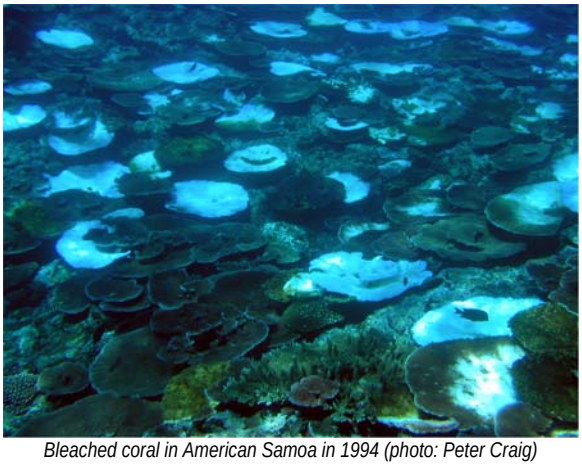
American Samoa is susceptible to tropical cyclones during the southern summer from November to April. In 1990, 1991, 2004 and 2005, cyclones caused decreases in coral coverage and abundance in American Samoa, as well as damaged the reef framework to varying degrees. When severe, damage produced large amounts of coral rubble and redistributed sediments in shallow water. On Feburary 4, 1990, Tropical Cyclone Ofa passed about 140 miles to the southwest of Tutuila Island. Although the wind speed associated with this storm was not exceptionally strong during its passage, storm waves and storm surge generated by the cyclone caused damage to Fagatele Bay reefs. On December 10, 1991, Tropical Cyclone Val proved to be far more serious, causing severe damage to the fringing reef systems and coastal areas of Tutuila. Together, Ofa and Val inflicted considerable damage to the reef communities within the bay. While the impacts of Heta in 2004 and Olaf in 2005 were less severe on Fagatele Bay, they caused significant damage in other parts of the archipelago.

Reef survey after Hurricane Val in 1992. The survey was taken to assess the damage that the hurricane caused to the reef. (Photo: Harold Hudson)

One of the most conspicuous effects of cyclones is the stripping away of many of dead and living corals, thus producing a large amount of new rubble and shingle, which undergoes considerable redistribution. Some structural damage occurs to the reef as well, particularly at the reef margin and reef slope zones, where sections of reef buttresses, pinnacles, and knobs can topple. However, as stated above, the coral populations of American Samoa have proven to be resilient to these damaging events and coral populations currently are in a phase of rapid recovery.
(http://www.fbnms.nos.noaa.gov/html/docs/birkland_compiled95.pdf)

Coral Bleaching

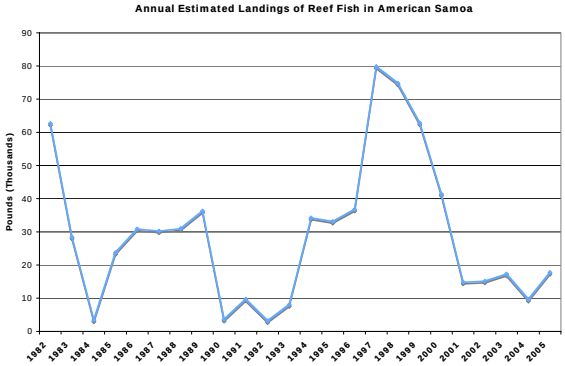
In the summers of 1994, 2002 and 2003, Fagatele Bay NMS experienced one of its most significant natural threats. Unusually warm water surrounded American Samoa for several months and caused corals to "bleach," or to lose their pigment-carrying symbiotic algae partners (zooxanthellae). These algae normally live within the tissues of the coral animal and give the coral its color. A bleached coral appears brilliantly white due to the transparency of coral tissue without its zooxanthellae. Though bleaching is not always lethal, many corals were killed as a result of these bleaching event.
(http://fagatelebay.noaa.gov/html/Research.html)


Bleached coral in American Samoa in 1994 (photo: Peter Craig)

Recent bleaching events have been caused by increases in sea-surface temperatures as a result of regional El Niño events, and possibly the result of global warming. It only takes a slight increase above normal water temperature to bleach coral. Bleaching can be caused by a short-term exposure (1-2 days) to temperature elevations of 3-4 degrees, or by long-term exposure (weeks) to elevations of only 1-2 degrees. Corals can recover from bleaching if temperatures return to normal and the coral regains its symbiotic algae. However, if temperature conditions remain anomalously high for an extended period, or bleaching is particularly severe, bleached coral will die. Bleaching has been observed nearly every summer in recent years. It affects corals mostly in shallow water, but bleaching of coral has been observed as deep as 40 meters (130 ft).
(http://pubs.usgs.gov/fs/2002/fs025-02/) (http://www.nps.gov/npsa/book/index.htm)

Fishing

Although most fishing methods are prohibited in Fagatele Bay NMS, the sanctuary's remote location makes enforcement of regulations difficult. There are several lines of evidence that the bay is, in fact, being fished. Several large species of reef fish that are characteristic of unfished reefs in the Indo-Pacific region are conspicuously absent or are small in size in Fagatele Bay. These include species such as Maori wrasse (humphead wrasse; Napoleon wrasse; *Cheilinus undulates*), sharks and large species of grouper and parrotfish, all of which are known to be particularly vulnerable to fishing pressure. Given that many of these species are more abundant and larger in size elsewhere in the Pacific where fishing is banned, these observations suggest that fishing pressure on the reefs of American Samoa and Fagatele Bay has had a significant impact on fish populations.



Estimated weight of coral reef fish caught in American Samoa.
(Data: Dept of Marine and Wildlife Resources)

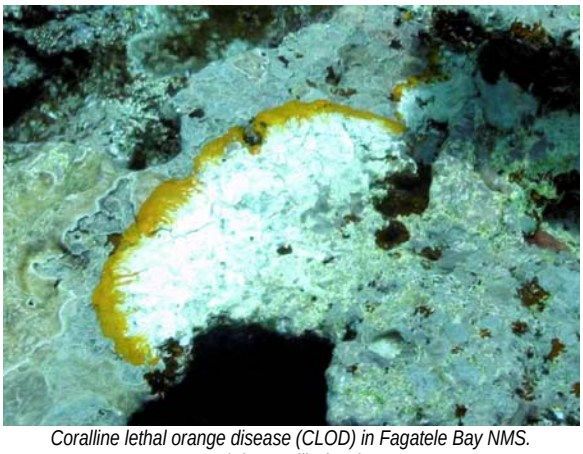
Because no village is present within sight of Fagatele Bay no regular observations of fishing occur, but it is likely that poachers fish in the sanctuary when weather conditions permit. Most recently, in December 2005 law enforcement officials apprehended illegal fishermen in the sanctuary. Fishermen have the potential to very quickly diminish the population of commercial reef fish species in a small area such as Fagatele Bay. One particularly efficient harvesting technique is spearfishing at night using SCUBA equipment. Many targeted species rest on the reef during the night making them easy targets for night fishermen. The Government of American Samoa banned SCUBA spearfishing in 2001 because of concerns by local scientists about declines in fish numbers once this technique became widely used.

Evidence also suggests that fishing with explosives has occurred in the bay. A 2001 survey found a large *Porites* sp. coral colony was severely damaged. The colony had recently been split in two, and one side appeared to have been reduced to rubble. It is likely that explosives caused this damage, because approximately 30 feet of detonation cord was found adjacent to the coral colony. This colony is exceptionally large, and given the slow growth rate of this species, is estimated to be approximately 800 years of age. Although the damage can still be seen, the colony remains healthy away from the fracture. In June of 2005, a new spate of fishing with explosives was documented in Fagatele Bay NMS. A reward for information yielded no suspects, but did bring attention to the problem and a public desire for the apprehension of anyone fishing in this manner.
(http://fagatelebay.noaa.gov/html/docs/birkeland_report2001.pdf)
(http://www.pifsc.noaa.gov/wpacfin/as/Pages/as_data_menu.php)
(http://sanctuaries.noaa.gov/visit/pdfs/dynamitedamage.pdf)

Porites coral head in Fagatele Bay showing a large fracture, alleged to be caused by explosives used to harvest fish. (Photo: C. Birkeland)

Diseases

Disease outbreaks cause not only coral loss, but also cause significant changes in community structure, species diversity and abundance of reef organisms. Of particular concern in Fagatele Bay is the presence of Coralline Lethal Orange Disease (CLOD). CLOD is a bacterial disease that



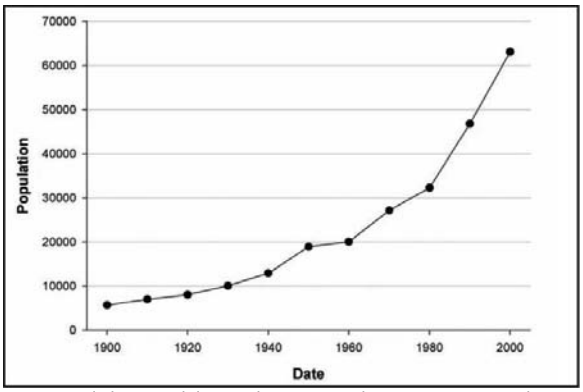
Coralline lethal orange disease (CLOD) in Fagatele Bay NMS.
(Photo: Bill Kiene)

affects encrusting coralline algae, and can be identified by its bright orange color and the white dead areas it produces on affected algae. A 2004 study found that, of seven sites examined around Tutuila, CLOD was most prevalent in Fagatele Bay.

One of the most common coral diseases found around Tutuila is white syndrome. Due to the difficulty of differentiating between the coral diseases that are white in appearance, both white band and white plague diseases are placed in one category: "white syndrome." A symptom of white syndrome disease is a distinct line, or a band of bleached infected coral tissue, between exposed coral skeleton and healthy coral tissue. This disease can be virulent and results in the rapid death of coral tissue. Another coral "disease" often observed around Tutuila involves skeletal growth-anomalies (hyperplasms), which cause distorted, tumor-like growths on the surface of the coral.
(http://www.aims.gov.au/pages/research/coralbleaching/scr2004/pdf/scr2004v1-01.pdf)

Agriculture

Agriculture in American Samoa is still largely a subsistence sector with mostly traditional staple food crops, chickens and pigs raised. The 1999 Agriculture Census of American Samoa reported that about 41 percent of the territorial land area is being farmed, and nearly 6,500 farms were reported with an average farm size of about 3 acres. Of these, about 1,100 were classified as commercial operations. A farm was defined as any place that raised or produced any agricultural products for sale or consumption. Approximately 75 percent of households in American Samoa fit this description.
(http://www.spc.int/prism/country/as/stats/)



Population growth in American Samoa. (Source: U.S. Census)

Tutuila is American Samoa's largest island, the center of all administrative and economic activity, and home to over 90% of American Samoa's population of 65,500. Annual population growth is currently high at around 2% and the population is predicted to exceed 76,000 people by 2020.
(http://doc.asg.as/crag/ASCoralValuation04.pdf)

With an increasing population and a fragile economy, American Samoa is likely to experience an increase in agricultural development. Such development may threaten water quality, habitat integrity and biological health of Fagatele Bay if soil and sediment runoff into the bay is not controlled. With two thirds of American Samoa's 197 square kilometers having slopes greater than 30% and a rainfall of up to 5,000 mm per year, soil erosion is a constant threat. Clearing of land for agriculture within watersheds often decreases the ability of soils to absorb rainfall. Without proper land management, streams carry eroded soils, fertilizers and pesticides into nearshore waters. The developed watersheds around Tutuila generally discharge higher sediment loads than undeveloped areas. The steep topography of Fagatele Bay's watershed is particularly vulnerable to erosion once the land is cleared.
(http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/Threats_Ch3_C.pdf)

Taro, a perennial plant with an edible tuber, is one of the most important staple crops in American Samoa. It is inherently part of the traditions, customs and culture of the Samoans and adherence to traditional cultivation practices can help reduce its environmental impact. In preparation for planting, vegetation is cleared, but most of the trees are left to reduce erosion. To further minimize the risk of erosion, farmers cut weeds to use as mulch and use a planting stick, the oso, rather than tilling the soil. Typically, a legume, *Erythrina variegata*, is grown in these hillside plantations to fix nitrogen and further reduce erosion. Periodic weeding is practiced with weeds left as a mulch for the 6-8 month crop.

Taro is the most important staple crop in American Samoa. If careful cultivation methods are not used on steep slopes, substantial soil erosion will occur. (Photo: Larry S. Hirata, AS Community College)

However, with periodic rainfall of 250 mm in a 24-hour period, substantial soil erosion is still a threat. Additional erosion-reducing practices include contour hedgerows and strip cropping along the contour. (http://www.agroecology.org/cases/notilltaro.htm)

Fagatele Bay NMS has been somewhat protected from the consequences of land development by the steep slopes surrounding the bay. However, within the last year, landowners have cleared adjacent land for taro cultivation.

Land cleared for agriculture on the ridge-slope above Fagatele Bay in 2006 (photo: Bill Kiene).

Once the land is cleared, it will take years for the forest to recover. Without careful stewardship, forest re-growth in cleared areas may be inhibited by the rapid invasion of vines and other plant species. These invasive plants replace the native trees and ground cover with vegetation that cannot efficiently hold soil in place. This choking of the native forest by vines and other invasive species can be seen in other parts of Fagatele Bay's watershed.

Invasive vegetation inhibiting growth of the natural forest in Fagatele Bay's watershed. The reason for this proliferation of invasive vegetation is unclear, but may be exacerbated by land-clearing activities in adjacent areas within the watershed. (Photo: Bill Kiene).

Visitation

There is relatively little tourism in American Samoa and it is likely to be some years before the Territory enters the mainstream of South Pacific tourism. Visiting Fagatele Bay NMS is difficult even in good weather due to its remote location and the nature of the terrain that surrounds the bay. Because the land is privately owned, permission is also needed from the landowners to access the bay by land. Little is known about the number of people who visit the bay on a daily basis, but official patrols and visits by sanctuary staff over the past 18 years indicate those numbers are very low.

There are few locally owned pleasure boats. Yachts come to Pago Pago Harbor to buy provisions and find shelter during the cyclone season. Sportfishing for pelagic tuna, mahi mahi and marlin is popular and occasional fishing tournaments are held, but these activities occur in offshore waters rather than on the coastal reefs. There are no commercial SCUBA-diving operators presently in the Territory, but the potential to attract sport divers to Fagatele Bay's and to the Territory's coral reefs exists.

Despite the low numbers of visitors, impacts to coral reefs surrounding Tutuila Island, including Fagatele Bay NMS, have the potential to be severe. Documented impacts due to visitation of the bay are unregulated fishing, illegal collection of corals and other invertebrates, and damage to the reef from boat anchors and walking on the reef flat. Anchor damage has been observed, and in response, two mooring buoys were recently installed (2006) to allow boaters to visit the bay without dropping anchor. Discarded trash is also a potential problem caused by both land and sea visitors to the bay.

State of Sanctuary Resources

Water

American Samoa has nearly 150 miles of coastline. Fringing coral reefs characterize the coastal embayments and open coastal waters of the Territory. Pollution from poorly constructed human and pig waste disposal systems, as well as increased turbidity and nutrients from soil erosion, pose the greatest threats to near-shore water quality in American Samoa. Solid waste from improper trash disposal adds another significant threat to coastal waters.

With over a century of development, Pago Pago Harbor is the most populated and industrialized embayment in American Samoa. In addition to the non-point source pollution mentioned above, Pago Pago Harbor is potentially affected by pollution from marina and port traffic and a small shipyard. In the outer harbor, effluent from the tuna canneries and sewage treatment plant is discharged. This discharge is permitted under National Pollutant Discharge Elimination System. Due to the segregation and transportation of cannery waste beyond the inner harbor, better treatment of sewage, and more effective monitoring and prosecution of commercial vessels that pollute the harbor, the water quality in the inner harbor has greatly improved in the last decade.

It is unknown to what extent, if any, offshore waters are affected by pollution. High strength wastes (solids, nitrogen, phosphorus) from the tuna canneries are dumped in a designated offshore area approximately five miles south of Tutuila. From data collected by the canneries, the waste is considered to have no more than a localized effect on the marine environment.

Because Fagatele Bay is located approximately 7.5 miles southwest of Pago Pago Harbor and is partially protected by the land surrounding the bay, impacts of pollution from the harbor are unlikely. American Samoa EPA, in collaboration with FBNMS and other ASG agencies, has a comprehensive water-quality monitoring program around Tutuila and makes regular public announcements when contaminant concentrations exceed set standards.

The municipal landfill for Tutuila is less than a mile from Fagatele Bay. Although separated from Fagatele Bay by the high ridge that surrounds the bay, this landfill has the potential to leach contaminants into groundwater. Monitoring of groundwater and springs in the vicinity is needed to be sure this facility is not a threat to water quality.

The following is an assessment by sanctuary staff and American Samoa marine researchers of water quality in Fagatele Bay NMS and how it may be affecting the environment:

- High water clarity and the bay's rich abundance and apparent resilience would suggest that water quality in Fagatele Bay is good. However, the frequency with which high sea temperatures are causing corals to bleach and die is increasing. For this reason water quality based on stressors is considered to be only fair. Temperature impacts on bleaching are expected by many to intensify in the future.
- Nutrient levels in the bay are currently low, as is appropriate for a tropical coral reef, but land clearing and associated human habitation in Fagatele Bay's watershed may increase nutrient levels near streams and beaches used by residents.
- Sanctuary waters do not appear to pose risks to human health. However, an assessment of the potential affects on ground and marine waters by the nearby landfill is needed.
- Extensive land clearing for agriculture on the east side of the bay may impact the integrity of the forest and its ability to prevent soil and sediments from entering Sanctuary waters.

Water Quality Status & Trends

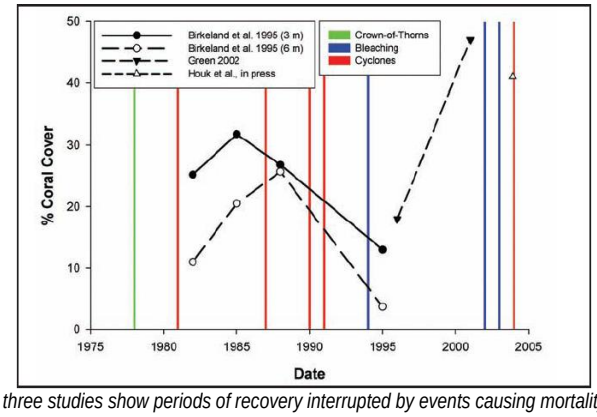
Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend **N/A** = Question not applicable

Status	Trend	Basis for Judgment
Stressors	▼	Warming water: coral bleaching
Eutrophic Condition	▼	Land clearing for agriculture
Human Health	?	No known risks
Human Activities	▼	Land clearing for agriculture

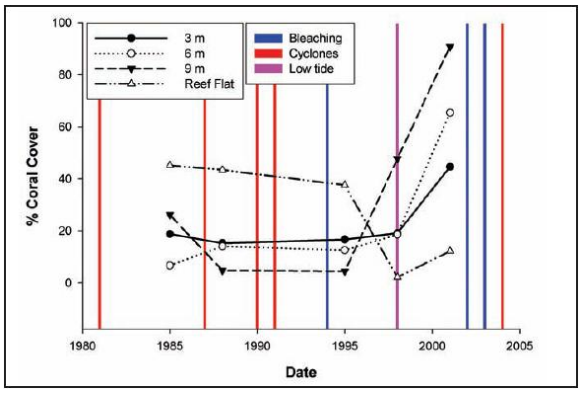
Habitat

A series of reef surveys starting in the early 1980s provides a view of the trends in hard coral cover for Tutuila and Fagatele Bay NMS over the last two decades. In the early to mid-1980s, hard coral cover was increasing. An outbreak of crown-of-thorns starfish in 1978 killed 90% of the corals in the bay and the increases seen in the 1980's demonstrate the recovery from that event. Then, in 1990 and 1991 coral populations were reduced by severe tropical cyclones. A mass-bleaching event in 1994 killed many of the remaining corals. Since that time, survey results show coral populations have bounced back. According to the most recent surveys (2005), coral covers an average of 40% of reef surfaces. Crustose coralline algae dominates the remainder of reef surfaces, which together with high levels of grazing by fishes, encourages new coral recruitment.



Hard coral cover trends for Tutuila from three studies show periods of recovery interrupted by events causing mortality. (Sources: Birkeland et al., 199; Green, 2002; Houk et al., 2005.)

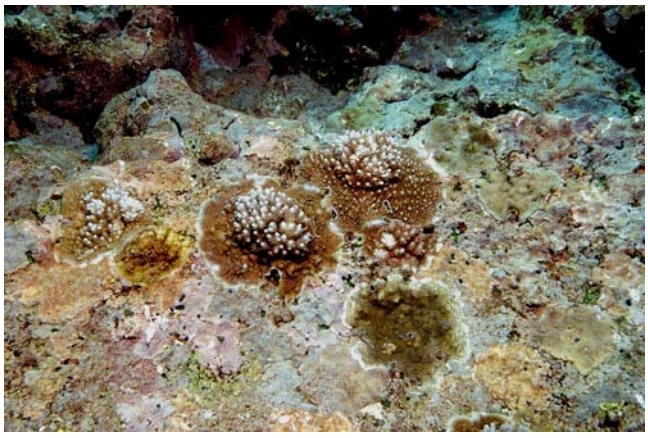
Surveys at different depths show that different habitats have experienced different patterns of coral cover through time. From 1985 through 2001, reef slope surveys found coral cover to be low, increasing to high levels in 2002. Surveys of coral on the reef flat found the opposite pattern, with the highest cover from 1985 to 1995 and dropping to low levels in 1997 and 2002.



Hard coral cover trends for Fagatele Bay (Birkeland et al., 2004). Surveys on the reef slope in 2004 and 2005, while not directly comparable to these data, indicated there has been no decline, and probably an increase, in coral cover (Green et al. 2005, Whaylen and Fenner 2005).

The reef flat and reef slope are very different habitats due to their exposure to wave action, low tide events and extremes in water temperature. Coral cover did not increase from 1985 to 1995 as a result of the three cyclones and the major bleaching event that damaged coral populations during this period. The loss of live hard corals on the reef flat after 1995 was due to a series of extreme low-tide events in 1998. Coral cover had increased in all habitats by 2001 and surveys in 2004 and 2005 indicate this trend continues.
(http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/AmSamoa_Ch11_C.pdf)

Resiliency of the reef: New coral colonies grow on the grey-pink, coralline algae encrusted surface of a large dead table coral (Photo, Richard Murphy).



New life from old: Coralline algae and juvenile coral colonies re-build the reef after the death of a coral.

The following information provides an assessment by sanctuary staff and American Samoa marine researchers of the status and trends pertaining to marine habitat:

- Corals are the primary builder of habitats in Fagatele Bay and their abundance and distribution control, to a large extent, the numbers of other invertebrates and fishes. Coral populations in Fagetele Bay NMS are presently diverse (200 species) and abundant, and they have increased from a series of destructive events in the 1980s and 1990s. However, the trend in coral cover is uncertain due to an apparent increase in potentially destructive fishing activities in the bay and the potential for increasing periods of coral bleaching due to high water temperature.

- As a result of coral recovery from several destructive events, and in spite of some coral diseases, the condition of the biologically structured habitats are in generally good condition and do not appear to be changing.
- Contaminants do not appear to be present in the reef structure or in the sediments.
- Although some human induced damage has occurred, the level of human activity is relatively low and does not appear to be changing.

Habitat Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend **N/A** = Question not applicable

Status	Trend	Basis for Judgment
Abundance/Distribution	?	Resilient coral populations, destructive fishing activities and diseases present.
Structure	—	Destructive events have not reduced biodiversity
Contaminants	—	None identified
Human Impacts	—	Low visitation, but fishing impacts occur

Living Resources

Fish

There is currently debate as to why populations of large carnivorous fishes are low on the coral reefs in American Samoa. The narrow fringing reefs that drop quickly into deep water may limit the extent of critical shallow water habitats as well as the extent of off-reef forage areas for these fishes. However, most of the reef fish species expected to be found in American Samoa are seen and are periodically caught by fishermen. Their small size and numbers may suggest fishing is keeping these fishes from recovering to levels that would be expected on reefs in the region.

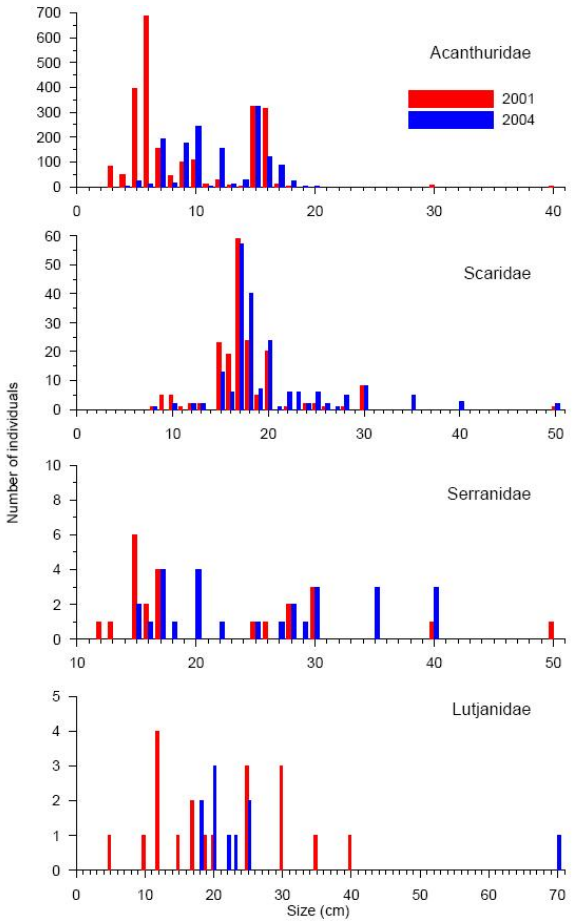
Reef fish are harvested in both subsistence and artisanal fisheries on the five main islands of the Territory. Artisanal fishing includes both nighttime free divers who spear reef fish and small boat fishers who target deepwater bottomfish. There is currently no export of coral reef fish to off-island markets or the aquarium trade.

Two trends are apparent: 1) subsistence fishing has declined steadily over the past two decades as American Samoa shifted from a subsistence to a cash-based economy; and 2) while small surgeonfish and parrotfish have remained abundant, the number and size of other larger coral reef fishes such as grouper and snapper have declined significantly over the same period. It is unclear if the present fishing effort or other factors continue to suppress recovery of these fish populations.
(http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/AmSamoa_Ch11_C.pdf)

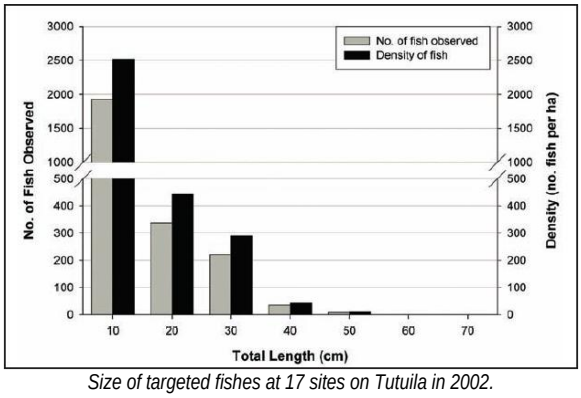
A fisherman on Tutuila with a large Moari wrasse. These fish have become extremely rare on American Samoa's reefs (photo: Samoa News)

There are two types of monitoring programs in the Territory that document characteristics of fish populations. First, underwater visual surveys (fisheries-independent surveys) describe the types of fish observed by divers on the reef. Second, surveys of fish harvests or creel surveys (fisheries-dependent surveys) document the actual species and quantities of fish extracted from the reefs. The Department of Marine and Wildlife Resources has monitored artisanal catches since 1982, but harvests by night-divers and subsistence fisheries have been monitored only intermittently.

Territory-wide visual fish surveys document that large fish are rare on the reefs around the five main islands, a strong indication that populations have been overfished. These include sharks, humphead wrasse (*Cheilinus undulates*), and large species of grouper and parrotfish. The surveys indicate that reefs have had few large fish for at least eight years. Additionally, the surveys show that densities of large fish are higher on American Samoa's remote reefs (Swain Islands and Rose Atoll).



Size structure of populations of important fisheries species in Fagatele Bay. (Source: Green, 2004)

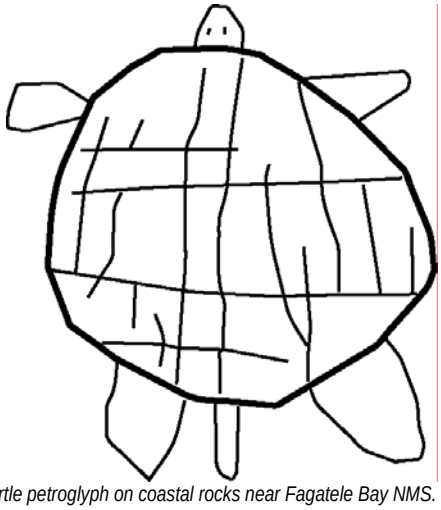


Size of targeted fishes at 17 sites on Tutuila in 2002. (Source: Green, 2002.).

It is of critical importance to understand the direct relationship between fishing pressure and the character of fish populations in American Samoa. This understanding will likely not be gained until functioning no-take areas are established and monitored.

Sea Turtles

Turtles also play an important role in Samoan culture. In one village adjacent to Fagatele Bay, villagers "call" a turtle and shark, which are said to come to shore when the villagers sing a special song. The song recounts a legend of the village sheltering two Western Samoan visitors, who in gratitude vowed to return as a turtle and shark whenever their hosts sang their story to the sea. Turtles are also believed to save fishermen who are lost at sea. For these reasons, the Samoan word for sea turtle is "I'asa," which translates as "sacred fish."



Trace of a turtle petroglyph on coastal rocks near Fagatele Bay NMS. (Craig 2005).

Samoans traditionally harvested sea turtles for food. Turtle shells were made into jewelry, ceremonial decorations and utilitarian items. Federal and Territorial laws now protect turtles and their eggs from harvest in American Samoa's waters and on its beaches. Hawksbill and green turtles are most frequently seen and the hawksbill nests on beaches of Tutuila. There is one report of a turtle nesting on one of the small beaches of Fagatele Bay, and they are often seen in the waters of the bay.

Sea turtle populations have declined, both locally and throughout the South Pacific due to harvest, loss of nesting beach habitats and incidental catches in fishing gear. In American Samoa, a few turtles and their eggs are still illegally harvested, but public education programs have helped to make people aware that turtle populations are seriously threatened, some with extinction, if such harvests continue. In 2003, American Samoa established a sanctuary for sea turtles and marine mammals in its territorial waters (0-3 miles offshore).
(http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/AmSamoa_Ch11_C.pdf)

A hawksbill turtle in American Samoa. The adult hawksbill can reach a meter (3 ft) long and weigh over 90 kg (200 lbs). Caught for food, its beautiful carapace, or shell, has also made this turtle a target for capture. The shell is used to manufacture tortoise shell jewelry and other products (Photo: Gerry Davis)

Marine Mammals

Southern humpback whales migrate from their Antarctic feeding grounds to American Samoa to calve and mate, between July and October. Some individuals documented in American Samoa waters have also been recorded in other parts of the South Pacific, but their migratory patterns within the region are unclear. Other marine mammals, such as sperm whales, rough-toothed and spinner dolphins, and false killer whales occur in American Samoa's waters. NOAA initiated annual marine mammal surveys around Tutuila in 2003. Photographs are taken of flukes and tissue samples that are analyzed for DNA allow comparisons with populations in other regions. Whale populations in American Samoa show low incidences of fishing gear entanglements.
(http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/AmSamoa_Ch11_C.pdf)

A newborn humpback whale calf photographed in American Samoa in 2004 (Photo: David Mattila).

The following information provides an assessment by sanctuary staff and American Samoa marine researchers of the status and trends pertaining to the sanctuary's living resources:

- Biodiversity in Fagatele Bay NMS does not appear to be changing. Fish diversity in Fagatele Bay is higher than most other sites on Tutuila. However, individual numbers of some fish species are lower than expected.
- In spite of restrictions on fishing, illegal fishing in Fagatele Bay occurs and appears to have caused declines in some grouper, wrasse, and snapper species. It is unclear how present levels of fishing are affecting the fish populations, which are now dominated by surgeonfish and parrotfish. Fishing pressure continues because enforcement is difficult. This may be allowing further declines.
- Taxonomic studies of marine species present in American Samoa (including Fagatele Bay) have found non-indigenous and cryptogenic (of uncertain origin) invertebrate and algae species, but these mainly occur in Pago Pago Harbor and are not considered to significantly impact Fagatele Bay NMS. Certain invertebrates, such as zoanthids, have been known to rapidly colonize disturbed reef surfaces, slowing the recovery of coral populations.
- Fishing has reduced the size and number of predatory fish species, particularly grouper and snapper, to the extent that they are rarely seen and their populations do not appear to be changing.
- Disease has impacted the condition of some corals and coralline algae, while abundant herbivorous fishes keep fleshy algae populations low.
- Fishing has removed most large fishes, but awareness of the need for stewardship may influence future harvests.

Living Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend **N/A** = Question not applicable

Status	Trend	Basis for Judgment
Biodiversity	—	All species present, but some in low numbers
Extracted Species	?	Fishing has removed large fish
Invasive Species	—	Some non-indigenous algae and invertebrates may be present
Key Species	—	Reduced numbers and size of certain predatory fish species
Health of Key Resources	▼	Coral and coralline algae diseases
Human Activities	?	Illegal and legal fishing continues to remove large fish

Maritime Archaeological Resources

No marine archaeological artifacts have been found in Fagatele Bay NMS.

Maritime Archaeological Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving ▬ = Not changing ▼ = Getting worse
? = Undetermined trend **N/A** = Question not applicable

Status	Trend	Basis for Judgment
Integrity	N/A	No documented artifacts
Threat to Environment	N/A	No documented artifacts
Human Activities	N/A	No documented artifacts

Response to Pressures

Fagatele Bay NMS works closely with its American Samoa Government partners to promote sound use, conservation and awareness of the sanctuary's marine environment. Sanctuary staff also work throughout the Territory to help American Samoa understand and better utilize its marine resources.

The American Samoa Government coordinates all of its territorial coral reef management activities through the Coral Reef Advisory Group (CRAG). This group comprises both territorial and Federal agencies, including the American Samoa Department of Commerce (which includes the American Samoa Coastal Management Program and Fagatele Bay NMS), the Department of Marine and Wildlife Resources, the American Samoa Environmental Protection Agency, the American Samoa Community College, and the National Park of American Samoa. These agencies collaborate to plan and implement actions related to the management of the Territory's coral reefs.

Each agency within CRAG has specific projects and programs that enhance the quality of marine habitats, regulate activities on coral reefs, promote awareness, and facilitate research into various aspects of coral reef science. CRAG helps to coordinate these efforts as well as build collaborative projects. CRAG members adopted a threat-based approach to identifying key problems on American Samoa's reefs. In tandem with this, CRAG has also created four three-year action strategies to address the issues of overfishing, global climate change, land based sources of pollution, and population pressure (the first three were identified in this report as significant concerns for Fagatele Bay NMS). The U.S. Coral Reef Initiative has been instrumental in supporting the Territory in its coral reef conservation activities. The annual Coral Conservation Grant Program has provided managers and scientists in American Samoa with tools, staff, funds, and equipment with which to accomplish key research and management projects.

Sanctuary staff work with CRAG's Education and Outreach Coordinator to increase public awareness of issues affecting American Samoa's coral reefs. In addition to regular school visits, current projects include education grants to teachers for the materials and supplies necessary to carry out coral reef lessons and projects, the development of marine education brochures and production of a monthly newspaper article, published in both English and Samoan.

CRAG is spearheading an effort to bring a marine laboratory and learning center to American Samoa. This facility is designed to support the territory's marine research needs and build local capacity in the marine sciences. The facility may also house Fagatele Bay NMS offices and a Sanctuary visitor's center. CRAG is seeking partnerships with US and regional institutions to support this endeavor.
(http://doc.asg.as/CRAG/Default.htm)

Water

The American Samoa Environmental Protection Agency (ASEPA) monitors and protects water quality for the Territory of American Samoa. U.S. Federal and American Samoa local environmental legislation and regulations all apply in American Samoa.

ASEPA conducts periodic Territory-wide water quality surveys as well as weekly beach water quality monitoring. The results of the beach monitoring are published in the local newspaper. Fagatele Bay NMS has begun collaborating in this monitoring program by providing water samples from the bay. The analyses measure *Enterococcus* bacterial concentrations in the water samples. American Samoa and Sanctuary water quality standards prohibit any reduction in water quality in Fagatele Bay. This collaboration with ASEPA is important to assessing how development of land around Fagatele Bay may affect its water quality in the future.

With the assistance of USGS scientists, a proposal is being prepared to assess the groundwater beneath the island landfill to determine if contaminants are leaching into the aquifer and being transported to the marine environment. The landfill is on the other side of the ridge, immediately north of the Sanctuary. Geologists believe groundwater beneath the landfill may flow south toward Fagatele Bay and/or Larson's Bay, and discharge in coastal or submarine springs.
(http://www.epa.gov/waterscience/standards/wqslibrary/territories/american_samoa_9_wqs.pdf)

Habitat

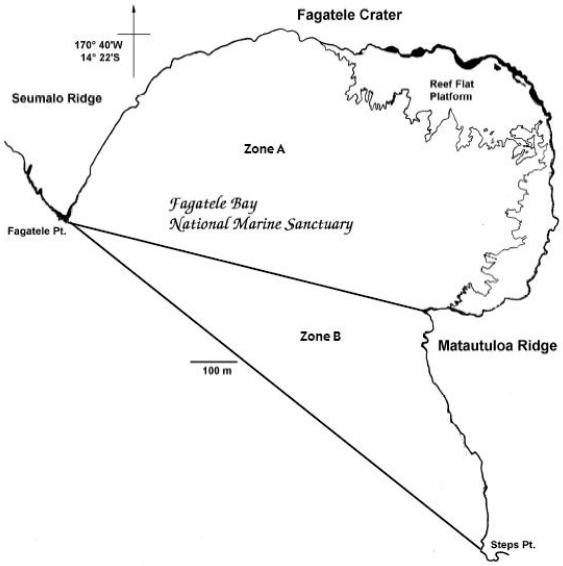
National Marine Sanctuary Program regulations prohibit activities that disturb or damage the natural features of Fagatele Bay NMS. This includes destructive fishing methods and anchoring. With the help of a recent NOAA research cruise to American Samoa, two mooring buoys were installed in the Sanctuary in 2006 to eliminate the need for boats to anchor. Submerged logs were also removed from the reef to stop their movement and damage of corals.

(http://fagatelebay.noaa.gov/html/management.html)

Living Resources

Fagatele Bay NMS is subdivided into two subzones that regulate where certain fishing activities can occur in the Sanctuary. Zone A includes the area from the high water mark of the inner bay to a line between Fagatele Point and Matautuloa Point. Zone B covers the area between the boundary of zone A and a line between Fagatele Point and Steps Point. Present Sanctuary regulations prohibit removing or disturbing any marine invertebrate or plant in both zones. Most fishing gears are excluded from the Sanctuary. The fishing gear that can be used in zone B are fishing poles and hand lines, which are prohibited in Zone A. The use of other fishing gears, including nets and spears, is prohibited in both zones. All sea turtles are protected and ensnaring or trapping them is prohibited in the Sanctuary, as well as anywhere in American Samoa waters.

(http://fagatelebay.noaa.gov/html/management.html)



Map of Fagatele Bay NMS showing zones A and B, which regulate fishing activities. The use of fishing gear is prohibited in zone A and only line fishing is allowed in zone B.

The Sanctuary protects marine mammals and birds from "take," disturbance and harm. These animals are also protected in Territorial and Federal waters under the US Marine Mammal Protection Act, the Endangered Species Act, and the Migratory Bird Treaty Act.
(http://www.nmfs.noaa.gov/pr/laws/mmpa.htm)
(http://www.nmfs.noaa.gov/pr/laws/esa.htm) (http://www.fws.gov/migratorybirds/intrnltr/treatlaw.html)

Sanctuary staff coordinate scientific research and monitoring of the ecological conditions in the bay. The program has built collaborations with local scientists of the Department of Marine and Wildlife Resources as well as US university-based scientists to conduct regular field assessments of coral and fish populations, coral diseases and other indicators of coral reef health in Fagatele Bay NMS. The data collected adds to one of the longest coral reef monitoring datasets in the world, and helps to gauge the long-term patterns of change and recovery from events that have disrupted the ecosystem in the past, and will cause disruptions in the future.
(http://fagatelebay.noaa.gov/html/research.html)

Fagatele Bay NMS also has a substantial geographic information system (GIS) data archive with its partnership with the AS Department of Commerce, NOAA and researchers at Oregon State University and University of South Florida. GIS data are available from shallow-water multi-beam bathymetric surveys, submersible dives, and ecological surveys conducted in 2001-2006. NOAA's Coral Reef Ecosystem Division collected substantial mapping and ecological data on three research cruises to American Samoa and are compiling much of the information for Fagatele Bay into a report and database. Near real-time sea-surface temperature and other oceanographic data are also being collected.
(http://dusk2.geo.orst.edu/djl/samoa/)
(http://doc.asg.as)
(http://www.pifsc.noaa.gov/cred/)

Maritime Archaeological Resources

Although no marine archaeological artifacts have been identified in Fagatele Bay NMS, regulations prohibit the removal, damage, or disturbance of any historical or cultural resource within the boundary of the Sanctuary.
(http://fagatelebay.noaa.gov/html/management.html)

The Future of Fagatele Bay National Marine Sanctuary

Fagatele Bay NMS is at an important period in its history. The Sanctuary will soon begin a process to review its management plan. This opportunity will redefine the Sanctuary's role and renew its place as a vital part of American Samoa's coastal and marine conservation efforts. It will also make Fagatele Bay NMS a key component of the National Marine Sanctuary System's effort to better understand, protect and utilize the Nation's marine environment.

Research and monitoring efforts in partnership with local and international researchers will continue to chart the path of Fagatele Bay's recovery and response to natural and human induced disruptions to its ecosystem. These studies will also help assess and guide future management actions designed to preserve the Sanctuary's resources.

One of the most unique aspect of Fagatele Bay NMS is its location in American Samoa, where the Samoan people have a unique relationship to their land, sea and cultural traditions. Fagatele Bay can become part of this relationship by being a catalyst for revitalizing the bond between the Samoan people and their marine resources. For example, Samoan customs have been resilient to modern social change. This cultural resiliency is exemplified in the tradition of "Sa" which is practiced by villages. It is a time of pause during the day for prayer and quiet reflection on how to improve their life and environment. This practice indicates the level of respect that American Samoa communities have for their traditions. Incorporating such practices into the management of Fagatele Bay could make the Sanctuary a symbol for *"fa'asamoa"* (the Samoan way) for marine stewardship.

An American Samoa community practicing "Sa" a time when activities in the village stop for a period of reflection and prayer. Village men in maroon "lava lavas" stand along the road to signal passing vehicles to drive slowly and pedestrians to sit in respect of this tradition. This practice symbolizes the resiliency of Samoan culture. Fagatele Bay National Marine Sanctuary's place in American Samoa is also a symbol of this resiliency by showing the "Samoan way" of respect and stewardship for their marine environment. (Photo: Bill Kiene)

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National Park Service: National Park of American Samoa
http://www.nps.gov/npsa/

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http://www.wpcouncil.org/

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http://www.whoi.edu/

Appendix A:
Rating Scheme for System-Wide Monitoring Questions

The purpose of this appendix is to clarify the 17 questions and possible responses used in determining the current condition of the sanctuary (see Condition Summary table, and State of Sanctuary Resources section of this document). Individual staff and partners utilized this guidance, as well as their own informed and detailed understanding of their site to proffer judgments about the status and trends of sanctuary resources.

The questions derive from the National Marine Sanctuary Program mission, and a system-wide monitoring framework developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on, and study the ecosystems encompassed by the sanctuaries. They are being used to guide staff and partners at each of the 13 sanctuary sites in the development of this first periodic sanctuary condition report. The questions are meant to set the limits of judgments so that responses can be confined to certain reporting categories that will later be compared among all sites, and combined.

Questions and Possible Responses

Following a brief discussion about each question, statements are presented that were used to judge the status and assign a color code. These statements are customized for each question. However, the following options are available for all questions where: 1) the question does not apply, or 2) status is unknown.

N/A Question not applicable.

Undetermined status

Statements used to assign a trend icon (below) are the same for all questions and simply indicate the likelihood that the status will change toward another category.

Trend:

▲	Conditions appear to be improving toward one of the higher categories.
—	Conditions do not appear to be changing.
▼	Conditions appear to be declining toward one of the lower categories.
?	Undetermined trend.

Question 1 (Water): Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?

This is meant to capture shifts in condition arising from changing natural processes and anthropogenic inputs. Natural processes like increasing average water temperatures, changes in upwelling frequency or intensity and its consequences (e.g. affects on temperature, salinity, and dissolved oxygen), or changes in water clarity arising from coastal sedimentation could all be judged to reduce water quality. Human inputs, generally in the form of contaminants from point or non-point sources – fertilizers, pesticides, hydrocarbons, heavy metals, sewage – are common causes of environmental degradation, often in combination rather than alone. Certain biotoxins, such as domoic acid, may be of particular interest to specific sanctuaries. When present in the water column, any of these contaminants can affect marine life by direct contact or ingestion, or through bioaccumulation via the food chain.

[Note: Over time, accumulation in sediments can sequester and concentrate contaminants. Their effects may manifest only when the sediments are resuspended during storm or other energetic events. In such cases, reports of status should be made under Question 7 – Habitat contaminants.]

Good	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
Good/Fair	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.
Fair	Selected conditions may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources and habitats.
Fair/Poor	Selected conditions have caused or are likely to cause severe declines in some, but not all living resources and habitats.

Poor	Selected conditions have caused or are likely to cause severe declines in most, if not all living resources and habitats.

Question 2 (Water): What is the eutrophic condition of sanctuary waters and how is it changing?

Nutrient enrichment often leads to planktonic and/or benthic algae blooms. Some affect benthic communities directly through space competition. Overgrowth and other competitive interactions (e.g., accumulation of algal-sediment mats) often lead to shifts in dominance in the benthic assemblage. Disease incidence and frequency can also be affected by algae competition and the resulting chemistry along competitive boundaries. Blooms can also affect water column conditions, including light penetration and plankton availability, which can alter pelagic food webs. Harmful algal blooms (HAB) often affect resources, as biotoxins are released into the water and air, and oxygen can be depleted.

Good	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
Good/Fair	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.
Fair	Selected conditions may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources and habitats.
Fair/Poor	Selected conditions have caused or are likely to cause severe declines in some, but not all living resources and habitats.
Poor	Selected conditions have caused or are likely to cause severe declines in most, if not all living resources and habitats.

Question 3 (Water): Do sanctuary waters pose risks to human health?

Human health concerns are generally aroused by evidence of contamination (usually bacterial or chemical) in bathing waters or fish intended for consumption. They also emerge when harmful algal blooms are reported or when cases of respiratory distress or other disorders attributable to HABs increase dramatically. Any of these conditions should be considered in the course of judging the risk to humans posed by waters in a marine sanctuary.

Some sites may have access to specific information on beach and shellfish conditions. In particular, beaches may be closed when criteria for safe water body contact are exceeded, or shellfish harvesting may be prohibited when contaminant loads or infection rates exceed certain levels. These conditions can be evaluated in the context of the descriptions below.

Good	Conditions do not appear to have the potential to negatively affect human health.
Good/Fair	Selected conditions that have the potential to affect human health may exist but human impacts have not been reported.
Fair	Selected conditions have resulted in isolated human impacts, but evidence does not justify widespread or persistent concern.
Fair/Poor	Selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem.
Poor	Selected conditions warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts are likely or have occurred.

Question 4 (Water): What are the levels of human activities that may influence water quality and how are they changing?

Among the human activities in or near sanctuaries that affect water quality are those involving direct discharges (transiting vessels, visiting vessels, onshore and offshore industrial facilities, public wastewater facilities), those that contribute contaminants to stream, river, and water control discharges (agriculture, runoff from impermeable surfaces through storm drains, conversion of land use), and those releasing airborne chemicals that subsequently deposit via particulates at sea (vessels, land-based traffic, power plants, manufacturing facilities, refineries). In addition, dredging and trawling can caused resuspension of contaminants in sediments.

Good	Few or no activities occur that are likely to negatively affect water quality.
Good/Fair	Some potentially harmful activities exist, but they do not appear to have had a negative effect on water quality.
Fair	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized,

not widespread.

Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts have occurred or are likely to occur.

Question 5 (Habitat): What is the abundance and distribution of major habitat types and how is it changing?

Habitat loss is of paramount concern when it comes to protecting marine and terrestrial ecosystems. That which concerns marine sanctuaries most is caused either directly or indirectly by human activities. The loss of shoreline is an issue that most of us immediately recognize as a problem indirectly caused by human activities. Habitats with submerged aquatic vegetation are often altered by changes in water conditions in estuaries, bays, and nearshore waters. Intertidal zones can be affected for long periods by spills or by chronic pollutant exposure. Beaches and haul-out areas can be littered with dangerous marine debris, as can the water column or benthic habitats. Sandy subtidal areas and hardbottoms are frequently disturbed or destroyed by trawling. Even rocky areas several hundred meters deep are increasingly affected by certain types of trawls, bottom longlines, and fish traps. Groundings, anchors, and divers damage submerged reefs. Cables and pipelines disturb corridors across numerous habitat types and can be destructive if they become mobile. Dredging removes, alters, and fragments habitats.

The result of these activities is the gradual reduction of extent and quality of marine habitats. Losses can often be quantified through visual surveys and to some extent using high-resolution mapping. This question asks about the quality of habitats compared to those that would be expected without human impacts. The status depends on comparison to a baseline that existed in the past - one toward which restoration efforts might aim.

Good	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
Good/Fair	Selected habitat loss or alteration has taken place, precluding full development of living resources assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
Fair	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources or water quality.
Fair/Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in some, but not all living resources or water quality.
Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in most, if not all living resources or water quality.

Question 6 (Habitat): What is the condition of biologically-structured habitats and how is it changing?

Many organisms depend on the integrity of habitats that is largely determined by the condition of particular living organisms. Coral reefs may be the best known examples of such biologically-structured habitats. Not only is the substrate itself biogenic, but the diverse assemblages residing within and on the reefs depend on and interact with each other in tightly linked food webs. They also depend on each other for the recycling of wastes, hygiene, and the maintenance of water quality, among other requirements.

Kelp beds may not be biogenic habitats to the extent of coral reefs, but kelp provides essential habitat for assemblages that would not reside or function together without it. There are other communities of organisms that are also similarly co-dependent, such as hard-bottom communities, which may be structured by bivalves, octocorals, coralline algae, or other groups that generate essential habitat for other species. Intertidal assemblages structured by mussels, barnacles, and algae are another example, seagrass beds another. This question is intended to address any of these, or other places where organisms form structures (habitats) on which other organisms depend.

Good	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
Good/Fair	Selected habitat loss or alteration has taken place, precluding full development of living resources, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
Fair	Selected habitat loss or alteration may inhibit the development of living resources, and may cause measurable, but not severe declines in living resources or water quality.
Fair/Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in some, but not all living resources or water quality.
Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in most, if not all living

resources or water quality.

Question 7 (Habitat): What are the contaminant concentrations in sanctuary habitats and how are they changing?

As discussed in Question 1 above, this question addressed the need to understand the risk posed by contaminants within benthic formations, whether they by soft sediments, hard bottoms, or biogenic organisms. In the first two cases, the contaminants themselves can become available when released via disturbance. They can also pass upwards through the food chain after being ingested by bottom dwelling prey species. The contaminants of concern generally include pesticides, hydrocarbons, and heavy metals, but the specific concerns of individual sanctuaries may differ substantially.

Good	Contaminants do not appear to have the potential to negatively affect living resources or water quality.
Good/Fair	Selected contaminants may preclude full development of living resource assemblages, but are not likely to cause substantial or persistent degradation.
Fair	Selected contaminants may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources or water quality.
Fair/Poor	Selected contaminants have caused or are likely to cause severe declines in some, but not all living resources or water quality.
Poor	Selected contaminants have caused or are likely to cause severe declines in most, if not all living resources or water quality.

Question 8 (Habitat): What are the levels of human activities that may influence habitat quality and how are they changing?

Human activities that degrade habitat quality do so by affecting structural (geological), biological, oceanographic, or chemical characteristics. Structural impacts include removal or mechanical alteration. Among other things, they are caused by numerous fishing techniques (trawls, traps, dredges, longlines, and even hook-and-line in some habitats), dredging channels and harbors and dumping spoil, vessel groundings, anchoring, laying pipelines and cables, installing offshore structures, discharging drill cuttings, dragging tow cables, and placing artificial reefs. Removal or alteration of critical biological components of habitats can occur along with several of the above activities, most notably trawling, groundings, and cable drags. Marine debris, particularly in large quantities (e.g., lost fishing gear, like gill nets), can affect both biological and structural habitat components. Changes in water circulation often occur when channels are dredged, fill is added, coastal areas are reinforced, or other construction takes place. These activities affect habitat by changing food delivery, waste removal, water quality (e.g., salinity, clarity and sedimentation), recruitment patterns, and a host of other factors. Chemical alterations most commonly occur following spills and can have both acute and chronic impacts.

Good	Few or no activities occur that are likely to negatively affect habitat quality.
Good/Fair	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.
Fair	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts have occurred or are likely to occur.

Question 9 (Living Resources): What is the status of biodiversity and how is it changing?

This is intended to elicit thought and assessment of the condition of living resources based on expected biodiversity levels and the interactions between species. Intact ecosystems require that all parts not only exist, but that they function together, resulting in natural symbioses, competition, and predator-prey relationships. Community integrity, resistance and resilience all depend on these relationships. Abundance, relative abundance, trophic structure, richness, H' diversity, evenness, and other measures are often used to assess these attributes.

Good	Biodiversity appears to reflect pristine or near-pristine conditions and promotes ecosystem integrity (full community development and function).
Good/Fair	Selected biodiversity loss has taken place, precluding full community development and function, but it is unlikely to cause substantial or persistent degradation of ecosystem integrity.

Fair	Selected biodiversity loss may inhibit full community development and function, and may cause measurable, but not severe degradation of ecosystem integrity.
Fair/Poor	Selected biodiversity loss has caused or is likely to cause severe declines in some, but not all ecosystem components, and reduce ecosystem integrity.
Poor	Selected biodiversity loss has caused or is likely to cause severe declines in ecosystem integrity.

Question 10 (Living Resources): What is the status of environmentally sustainable fishing and how is it changing?

Commercial and recreational harvesting are highly selective activities, in that fishers and collectors target a limited number of species, and often remove high proportions of populations. In addition to removing significant amounts of biomass from the ecosystem, reducing its availability to other consumers, these activities tend to disrupt specific and often critical food web links. When too much extraction occurs (i.e. ecologically unsustainable harvesting), trophic cascades ensue, resulting in changes in the abundance of non-targeted species as well. It also reduces the ability of the targeted species to replenish populations at a rate that supports continued ecosystem integrity.

It is essential to understand whether removals are occurring at ecologically sustainable levels. Knowing extraction levels and determining the impacts of removal are both ways that help gain this understanding. Measures for target species of abundance, catch amounts or rates (e.g., catch per unit effort), trophic structure, and changes in non-target species abundance are all generally used to assess these conditions.

Other issues related to this question include whether fishers are using gear that is compatible with the habitats being fished and whether that gear minimizes by-catch and incidental take of marine mammals. For example, bottom-tending gear often destroys or alters both benthic structure and non-targeted animal and plant communities. "Ghost fishing" occurs when lost traps continue to capture organisms. Lost or active nets, as well as lines used to mark and tend traps and other fishing gear can entangle marine mammals. Any of these could be considered indications of environmentally unsustainable fishing techniques.

Good	Extraction does not appear to affect ecosystem integrity (full community development and function).
Good/Fair	Extraction takes place, precluding full community development and function, but it is unlikely to cause substantial or persistent degradation of ecosystem integrity.
Fair	Extraction may inhibit full community development and function, and may cause measurable, but not severe degradation of ecosystem integrity.
Fair/Poor	Extraction has caused or is likely to cause severe declines in some, but not all ecosystem components, and reduce ecosystem integrity.
Poor	Extraction has caused or is likely to cause severe declines in ecosystem integrity.

Question 11 (Living Resources): What is the status of non-indigenous species and how is it changing?

Non-indigenous species (NIS) are generally considered problematic, and candidates for rapid response if found early following invasion. For those that become established, their impacts can sometimes be assessed by quantifying changes in the affected native species. This question allows sanctuaries to report on the threat posed by non-indigenous species. In some cases, the presence of a species alone constitutes a significant threat (certain invasive algae). In other cases, impacts have been measured, and may or may not significantly affect ecosystem integrity.

Good	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).
Good/Fair	Non-indigenous species exist, precluding full community development and function, but are unlikely to cause substantial or persistent degradation of ecosystem integrity.
Fair	Non-indigenous species may inhibit full community development and function, and may cause measurable, but not severe degradation of ecosystem integrity.
Fair/Poor	Non-indigenous species have caused or are likely to cause severe declines in some, but not all ecosystem components, and reduce ecosystem integrity.
Poor	Non-indigenous species have caused or are likely to cause severe declines in ecosystem integrity.

Question 12 (Living Resources): What is the status of key species and how is it changing?

Certain species can be defined as "key" within a marine sanctuary. Some might be keystone species, that is, species on which the persistence of a large number of other species in the ecosystem depends - the pillar of community stability. Their functional

contribution to ecosystem function is disproportionate to their numerical abundance or biomass and their impact is therefore important at the community or ecosystem level. Their removal initiates changes in ecosystem structure and sometimes the disappearance of or dramatic increase in the abundance of dependent species. Keystone species may include certain habitat modifiers, predators, herbivores, and those involved in critical symbiotic relationships (e.g. cleaning or co-habitating species).

Other key species may include those that are indicators of ecosystem condition or change (e.g., particularly sensitive species), those targeted for special protection efforts, or charismatic species that are identified with certain areas or ecosystems. These may or may not meet the definition of keystone, but do require assessments of status and trends.

Good	Key and keystone species appear to reflect pristine or near-pristine conditions and may promote ecosystem integrity (full community development and function).
Good/Fair	Selected key or keystone species are at reduced levels, perhaps precluding full community development and function, but substantial or persistent declines are not expected.
Fair	The reduced abundance of selected keystone species may inhibit full community development and function, and may cause measurable, but not severe degradation of ecosystem integrity; or, selected key species are at reduced levels, but recovery is possible.
Fair/Poor	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in some, but not all ecosystem components, and reduce ecosystem integrity; or, selected key species are at substantially reduced levels, and prospects for recovery are uncertain.
Poor	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in ecosystem integrity; or, selected key species are a severely reduced levels, and recovery is unlikely.

Question 13 (Living Resources): What is the condition or health of key species and how is it changing?

For those species considered essential to ecosystem integrity, measures of their condition can be important to determining the likelihood that they will persist and continue to provide vital ecosystem functions. Measures of condition may include growth rates, fecundity, recruitment, age-specific survival, tissue contaminant levels, pathologies (disease incidence tumors, deformities), the presence and abundance of critical symbionts, or parasite loads. Similar measures of condition may also be appropriate for other key species (indicator, protected, or charismatic species). In contrast to the question about keystone species (#12 above), the impact of changes in the abundance or condition of key species is more likely to be observed at the population or individual level, and less likely to result in ecosystem or community effects.

Good	The condition of key resources appears to reflect pristine or near-pristine conditions.
Good/Fair	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.
Fair	The diminished condition of selected key resources may cause a measurable, but not severe reduction in ecological function, but recovery is possible.
Fair/Poor	The comparatively poor condition of selected key resources makes prospects for recovery uncertain.
Poor	The poor condition of selected key resources makes recovery unlikely.

Question 14 (Living Resources): What are the levels of human activities that may influence living resource quality and how are they changing?

Human activities that degrade living resource quality do so by causing a loss or reduction of one or more species, by disrupting critical life stages, by impairing various physiological processes, or by promoting the introduction of non-indigenous species or pathogens. (Note: Activities that impact habitat and water quality may also affect living resources. These activities are dealt with in Questions 4 and 8, and many are repeated here as they also have direct effect on living resources).

Fishing and collecting are the primary means of removing resources. Bottom trawling, seine-fishing, and the collection of ornamental species for the aquarium trade are all common examples, some being more selective than others. Chronic mortality can be caused by marine debris derived from commercial or recreational vessel traffic, lost fishing gear, and excess visitation, resulting in the gradual loss of some species.

Critical life stages can be affected in various ways. Mortality to adult stages is often caused by trawling and other fishing techniques, cable drags, dumping spoil or drill cuttings, vessel groundings, or persistent anchoring. Contamination of areas by acute or chronic spills, discharges by vessels, or municipal and industrial facilities can make them unsuitable for recruitment; the same activities can make nursery habitats unsuitable. Coastal armoring and construction can increase the availability of

surfaces suitable for the recruitment and growth of hard bottom species. But in doing so, recruitment patterns for other species may be disrupted (e.g., intertidal soft bottom animals) and habitat may be lost.

Spills, discharges, and contaminants released from sediments (e.g., by dredging and dumping) can all cause physiological impairment and tissue contamination. Such activities can affect all life stages by reducing fecundity, increasing larval, juvenile, and adult mortality, reducing disease resistance, and increasing susceptibility to predation. Bioaccumulation allows some contaminants to move upward through the food chain, disproportionately affecting certain species.

Activities that promote introductions include bilge discharges and ballast water exchange, commercial shipping and vessel transportation. Releases of aquarium fish also frequently lead to species introductions.

Good	Few or no activities occur that are likely to negatively affect living resource quality.
Good/Fair	Some potentially harmful activities exist, but they do not appear to have had a negative effect on living resource quality.
Fair	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts have occurred or are likely to occur.

Question 15 (Maritime Archaeological Resources): What is the integrity of known maritime archaeological resources and how is it changing?

The condition of archaeological resources in a marine sanctuary significantly affects their value for science and education, as well as the likelihood that sites can become eligible for listing in the National Register of Historic Places. Assessments of archaeological sites include evaluation of the apparent levels of site integrity, which are based on levels of previous human disturbance and the level of natural deterioration. The historical, scientific and educational value of sites is also evaluated, and are substantially determined and affected by site condition.

Good	Known archaeological resources appear to reflect little or no unexpected disturbance.
Good/Fair	Selected archaeological resources exhibit indications of disturbance, but there appears to have been little or no reduction in historical, scientific, or educational value.
Fair	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, scientific, or educational value, and may affect the eligibility of some sites for listing in the National Register of Historic Places.
Fair/Poor	The diminished condition of selected archaeological resources has substantially reduced their historical, scientific, or educational value, and is likely to affect their eligibility for listing in the National Register of Historic Places.
Poor	The degraded condition of known archaeological resources in general makes them ineffective in terms of historical, scientific, or educational value, and precludes their listing in the National Register of Historic Places.

Question 16 (Maritime Archaeological Resources): Do known maritime archaeological resources pose an environmental hazard and is this threat changing?

Ship sinking events potentially introduce hazardous materials into the marine environment. This is true for historic shipwrecks as well. This issue is complicated by the fact that shipwrecks older than 50 years are also considered archaeological resources and must, by federal mandate, be protected. Many historic shipwrecks, particularly early to mid-20th century, still have the potential to retain oil and fuel in tanks and bunkers. As shipwrecks age and deteriorate, the potential for release of these materials into the environment increases.

Good	Known maritime archaeological resources pose few or no environmental threats.
Good/Fair	Selected maritime archaeological resources may pose isolated or limited environmental threats, but substantial or persistent impacts are not expected.
Fair	Selected maritime archaeological resources may cause measurable, but not severe impacts to certain sanctuary resources or areas, but recovery is possible.

Fair/Poor	Selected maritime archaeological resources pose substantial threats to certain sanctuary resources or areas, and prospects for recovery are uncertain.
Poor	Selected maritime archaeological resources pose serious threats to sanctuary resources, and recovery is unlikely.

Question 17 (Maritime Archaeological Resources): What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?

Some human maritime activities threaten the physical integrity of submerged archaeological resources. Archaeological site integrity is compromised when elements are moved, removed, or otherwise damaged. Threats come from looting by divers, inadvertent damage by scuba diving visitors, improperly conducted archaeology that does not fully document site disturbance, anchoring, groundings, and commercial and recreational fishing activities, among others.

Good	Few or no activities occur that are likely to negatively affect maritime archaeological resource integrity.
Good/Fair	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.
Fair	Selected activities have resulted in measurable impacts to maritime archaeological resources, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts have occurred or are likely to occur.