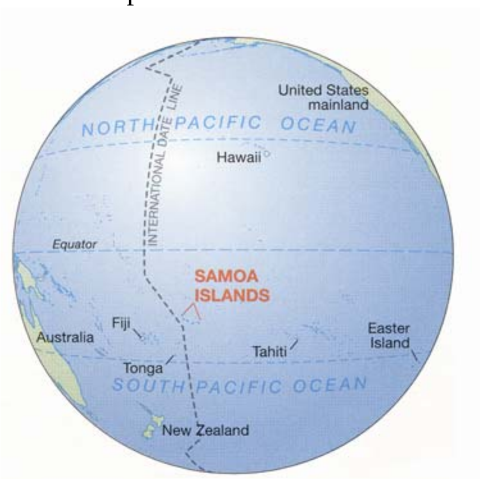
3. Biodiversity in our rainforests and coral reefs

There's a certain mystique about the word 'biodiversity' that seems to be associated with images of steamy jungles or wondrous new medicines, but the word more specifically refers to the number of species or 'species richness' of an area. One reason why tropical areas are so fascinating is that they contain the highest numbers of plant and animal species found anywhere on earth.

American Samoa sits squarely in the tropics, so we should have a high biological diversity here, but we do and we don't. There is a sharp contrast between the number of plant and animal species that live on land here (few) versus those that live in our coastal waters (many). Most small islands in the South Pacific share this characteristic.

To start at the beginning, when our islands emerged as fiery volcanoes from the depths of the sea, they were devoid of plants or animals. As time passed and the terrain became more hospitable, life for organisms became possible, but the plants and animals still had to cross vast ocean distances to get here from someplace else.



A quick look at a map will show one reason why few land species got here. We are really quite isolated in the Pacific Ocean, far from potential sources of plants and animals. To reach our shores, organisms would either have to blow in on the wind, drift for hundreds or thousands of miles on some piece of floating debris, or be carried in by another organism like plant seeds in a bird's stomach. The species that were successful probably got here by 'island hopping' across the Pacific, spreading from island to island over the course of many thousands or millions of years.

The difficulty in getting here is best illustrated by the sparse representation of native mammal species. Over the past 1.3 million years that Tutuila Island has existed, only 3 mammal species (all bats) got here and established viable populations. Our native species list also includes about 478 flowering plants and ferns, 25 resident land and water birds, 20 resident seabirds, 7 skinks, 4 geckos, 2 sea turtles, 1 snake, and occasional other visitors (this list does not include all the introduced non-native species like rats, dogs, pigs, toads, myna birds, and many weeds).

There's a second reason for our low diversity on land -- the small size of our islands. In general, the smaller the island, the fewer the species on it. For example, tiny Rose Atoll (0.4 sq mi) supports only 5 native plant species, 21 birds (virtually all seabirds), 2 geckos, and 2 sea turtles.

So, although American Samoa technically has 'tropical rainforests' due to our high level of rainfall (200-300 inches per year in some mountainous areas), we lack the high species richness found in the jungle rainforests of Indonesia, Africa or South America that are filled with hooting monkeys, poison dart frogs, pythons and flesh-eating piranhas.

On the other hand, because of our isolation, some terrestrial species in Samoa have evolved over many thousands of years to such an extent that they have become distinctly different species found nowhere else but here. For example, 1% of our plant species occur only in American Samoa; 30% of our plant species and the Samoan starling (*fuia*) occur only in the Samoan archipelago (which includes western

Samoa); and the Samoan fruit bat occurs only in the Samoan and Fijian islands. So, our rainforest may lack diversity, but it contains some species found nowhere else on earth.

Turning to our marine environment, we find the opposite situation. There is an incredibly diverse ecosystem just beneath the waves. Coral reefs are among the most species-rich ecosystems in the world. We have, for example, 890 nearshore fish species which is an amazingly high number compared to many other coastal areas. To get a sense of this species-rich environment, if you were to dive on our reefs once a week, you could in theory see a new fish species on every dive for 17 years.

Although coral reefs are limited to shallow waters, usually around the fringes of islands, most coral reef species have eggs and larvae that can survive for weeks or months in the open ocean and get dispersed by ocean currents to new locations. As a result of this genetic exchange of marine organisms between islands, there are probably few marine species that are unique to the Samoan islands.

Finally, superimposed over the South Pacific region is a larger-scale pattern of species distributions. Most of our marine and land species can be traced back to the same or related species inhabiting mainland and insular southeast Asia. From that center of remarkably high diversity, rainforest and coral reef species radiated out, spreading eastward across the South Pacific islands. But like ripples in a pond, the farther away one gets from that 'center', the fewer the species (see map below). This same pattern applies to corals, fishes, sea turtles, seagrasses, mangroves, land birds and plants. Very few species reached here from the opposite direction (South America) probably due to the much greater distance and fewer islands in that direction to facilitate 'island hopping'.

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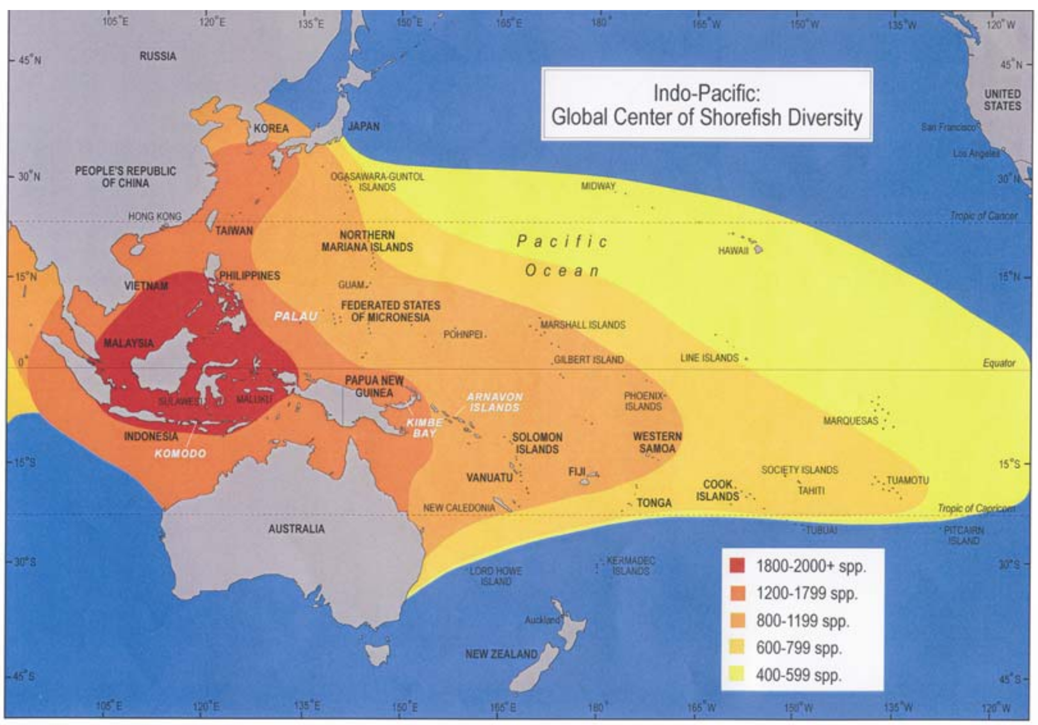


Contours represent the number of tropical fish species (reef, inshore and epipelagic species).

4. This volcano we live on

The geology of the Samoan islands is surprisingly interesting. First, we are living on a volcano, which is resting quietly at the moment. Second, our volcano is on the move -- it's traveling towards China with us on it. And, finally and most unfortunately, our volcano is doomed and it will eventually sink back into the dark ocean depths.

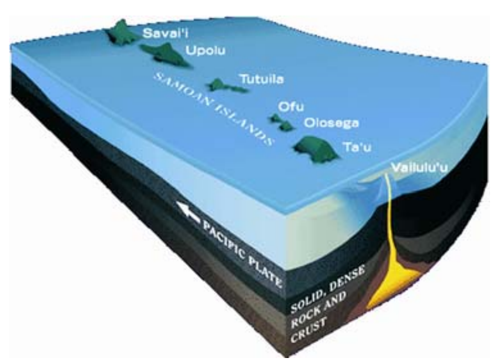
About 1.3 million years ago, our volcano spewed forth enough lava to rise up out of the ocean and become “Tutuila Island”. Actually, just the tip of the volcano is visible to us -- most of the mountain is underwater. While the tallest mountain peak on Tutuila is about one half mile high, the mountain extends another 2 miles below the sea surface.

It is not really an exaggeration to call the Samoan islands 'active volcanoes'. These islands were indeed formed by volcanism, and the volcanoes are still active, in a geologic timeframe of course, and due to some unusual circumstances as described below.

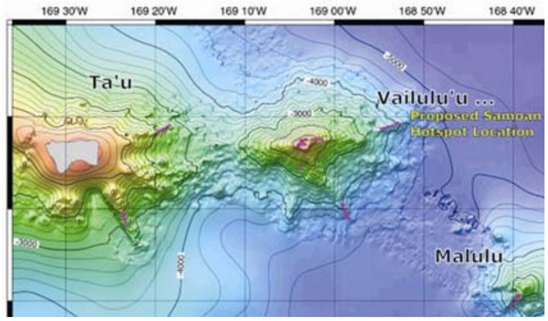
The most recent volcanic eruptions were a lot more recent than many people realize. In western Samoa, major eruptions occurred in 1905 when lava flows destroyed a village. In the Manu'a islands, subsurface volcanic eruptions and earthquakes occurred in 1866, causing dense clouds of smoke and pumice to erupt from the ocean surface for several months. One hundred years ago is just a blink of the eye to a volcano, which measures time in the millions of years. We humans tend to forget how briefly people have lived upon these shores. Human habitation on Tutuila, even considering the whole 3000-year period that Samoans have dwelt here, represents a mere 0.2% of the time since the sun first shone on this new land.

To explain our volcano's slow-motion march towards China, we first need to review the nature of the earth's surface or crust. The earth's outer layer, the one we live on, is several miles thick, but that is a thin skin compared to the total size of the earth. This outer layer is made up of many separate sections that seemingly float on top of the earth's molten core and move about in very slow motion. Geologists call these outer sections “plates”. You may recall, for example, that the continents of Africa and South America were once joined together when the earth first formed, but the two continents slowly drifted apart to where they are today. The same process applies to the plates under the Pacific Ocean. The plate we're on is called the Pacific Plate and it is moving westward (towards China) at a leisurely speed of about 3 inches per year. At this rate, in one million years we will be 50 miles closer to China.

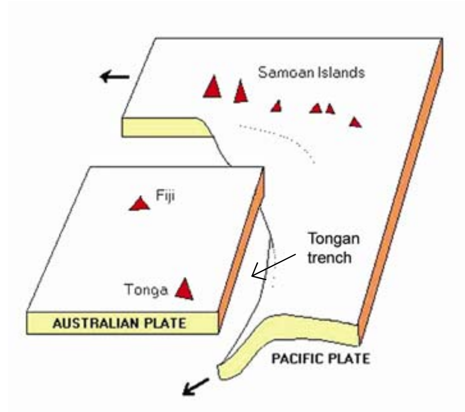
It is not accidental that the islands of American Samoa and western Samoa lie roughly in a straight line. Directly underneath us is what geologists call a “hot spot” of thermal activity in the earth's core. It's a volcano just waiting to happen. When the pressure builds up at the hot spot, molten magma bursts up through the Pacific Plate and forms a volcanic island. Then the hot spot calms down for awhile, perhaps a million years or so. During this peaceful interval, the Pacific Plate keeps marching onward, so when the hot spot acts up again, it forms a new volcanic island rather than build upon the previous one. In other words, the hot spot stays in one place but the plate above it keeps moving.



The islands formed generally lie in a straight line that is oriented in the direction the plate is moving. The new islands form on the eastern end of the chain, so the islands become progressively older as you

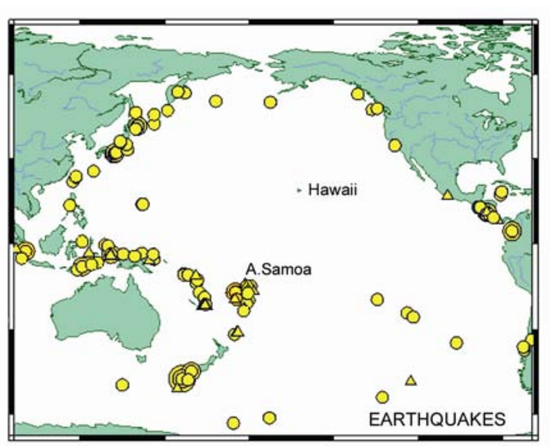


move from east to west. For that reason, the islands in western Samoa are about 1 million years older than the islands in American Samoa. (Early geologists got this direction of movement backwards.) The newest volcanic eruption in our island chain is forming about 30 miles east of Ta'u Island, but it will probably be another few hundred years before this sub-surface volcano, named Vailulu'u, breaks the sea surface (in 2005 it was 1800 feet below the surface but growing rapidly).



But something else really exciting also happens in our area. As Tutuila Island glides westward, a part of our plate collides with another plate to the west of us (the Australian Plate), and our plate actually rips in two at this point (see diagram). One piece of our plate continues moving towards China, but the other piece slides down into the 6-mile deep Tongan Trench and under the Australian Plate, never to be seen again.

The collision of these two colossal pieces of the earth's surface causes the seafloor to bend and rip, which in turn causes some earthquakes. This is shown on the map at right which pinpoints all earthquakes (magnitude 6.0 or greater) in the Pacific region in 2004. Samoa and the Tongan Trench are a geologically active area and this is presumably the cause of renewed volcanic activity in our archipelago. Recent surveys suggest how this might be happening. Long cracks in the seafloor have been discovered between the Samoan islands and the Tongan Trench. The cracks are oriented in an east-west direction and seem to be formed as the seafloor bends southward down into the top of the Tongan Trench. These cracks may make it easier for the hot magma beneath the crust to spew upward and emerge as young lava on top of our old islands.



And all this is happening a mere 100 miles south of Tutuila Island. We live in a very unique area.

Finally, most oceanic volcanoes eventually disappear. As time passes, two things happen. Volcanoes erode continuously as ocean waves attack its shorelines and rivers gouge into its terrain. In addition, the weight of a newly formed volcano is so heavy that it causes the volcano to sink slowly back down into the sea. Rose Atoll and Swains Island are good examples of sunken volcanoes. In the distant past, Rose and Swains may have been magnificent mountainous islands with beautiful rainforests and coral reefs. But that's ancient history now, because those islands, over a period of several million years, eventually sank out of sight. All that remains are tiny amounts of coral that grew up from the peaks of the mountains as they slipped below the sea surface.

Not to worry. Tutuila Island should be around for a few more million years.

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5. Status of species in American Samoa

Taxonomic Group	Native species	Archipelago endemics (in AS)[1]	Rare, threatened or endangered species[2]	Incidental species	Locally extinct[3]	Introduced & invasive* species	Ref. next page
Terrestrial fauna & flora							
Mammals	3 bats	Samoan fruit bat[4]	Sheath-tailed bat (C1)		Sheath-tailed bat?	rats*, feral pigs*, dogs, cats, house mouse	1
Birds	18 land/water birds, 7 regular migrants, 20 seabirds	Samoan starling	Spotless crake (C1), Friendly ground dove (C1), Many-colored fruit dove (C1)	White-faced heron, 9 seabirds	Mao, Megapode	Mynas*, Bulbul*, Rock dove, Red junglefowl	1,2
Reptiles: land	4 geckos, 7 skinks, 1 snake		Pacific boa snake (R)			marine toad*, house gecko, potted soil snake	1
Fish: freshwater	8-12 fishes[5]	Stiphodon hydoreibatus				Mexican molly, mosquitofish, tilapia	3
Crustaceans	9 stream shrimps, several land crabs		coconut crabs are rare in some areas				4
Insects	2,523+ insects[6]					probably many	5
Snails	47 land snails, 17 freshwater snails	16 land snails	8 land snails (C1, SC), several others rare or declining		Diastole matafaoi	African snail*, rosy wolf snail*, 3 slugs, 22 others	6
Plants	343 flowering plants, 135 ferns	30%	109 species (R)			over 250 alien species, many invasive	7
Marina fauna & flora							
Marine mammals	11 whales,[7] 7 dolphins[7]		Humpback whale (E), Sperm whale (E)				1,8
Reptiles: marine	2 sea turtles (hawksbill & green)		Hawksbill turtle (E), Green turtle (T)	Leatherback turtle, Olive ridley turtle, Banded sea snake			1
Fish/sharks	890 coral reef species, 101 deep or pelagic	see note in Reference 9	many species overfished	whale shark			9
Invertebrates	200 corals (approx.)		giant clams are rare in some areas		giant clam (*Hippopus hippopus*)[8]	2 giant clams (*Tridacna derasa, T. gigas*) & 30 misc. species	10
Marine plants	239+ algae species, 2-3 seagrasses, 2 mangrove species					4 algae species	11

Footnotes: [1]Additional endemic species occur in (western) Samoa. [2]Abbreviations: E (endangered), T (threatened), C1 (candidate listing), SC (species of concern), R (rare). [3]Recent extinctions. [4]Distribution includes Fiji. [5]Excludes several brackish water species near stream mouths. [6]Includes (western) Samoa. [7]Includes species probably common in region but have not yet been documented in American Samoa. [8]Re-introduced in 1997. *Invasive non-native species that significantly impact the ecosystem.

Note: blank spaces mean "no available data".

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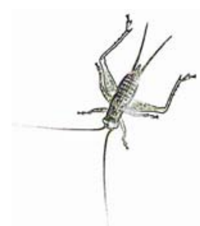
Selected references for "Status of species" table (previous page)

1. ***General***: (1) See checklists in this Guide. (2) Amerson et al. 1982. Wildlife and wildlife habitat of A. Samoa. Vol. 1. Environment and ecology. US Fish & Wildlife Service (Wash. DC). 119p. **Sheath-tailed bat**: Grant et. al. 1994. Decline of sheath-tailed bat on A. Samoa. Micronesica 27:133-137. ***Misc. introduced organisms***: Tauili'ili, P. & A. Vargo. 1993. History of biological controls in A. Samoa. Micronesica Suppl. 4:57-60.

2. ***Megapode***: Steadman, D. 1993. Bird bones from the To'aga site: prehistoric loss of seabirds and megapodes. Chapt. 14. In: P. Kirch and T. Hunt (eds.). The To'aga site: three millennia of Polynesian occupation in the Manu'a islands, American Samoa. Contributions Univ. California (Berkeley), No. 51. 248p.

3. ***Stream fish***: (1) D. Vargo & K. van Houte-Howes, A. Samoa Community College (pers. com.). (2) US Army Corps of Engineers. 1981. American Samoa stream inventory, island of Tutuila. Rept. by USACE for A. Samoa Water Resources Study. 121p. (3) Burger, I. & J. Maciolek. 1981. Map inventory of non-marine aquatic resources of A. Samoa. US Fish & Wildlife Service (Seattle). 182p. (4) FishBase 2004 <www.fishbase.org>. ***Introduced fish***: Eldredge, L. 1994. Perspectives in aquatic exotic species management in the Pacific islands. Vol. 1. Introductions of commercially significant aquatic organisms to the Pacific islands. South Pacific Comm., Inshore Fisheries Project Tech. Document No. 7 and SPREP Reports and Studies Series No. 78. 127p.

4. ***Freshwater shrimp***: (1) D. Vargo & K. van Houte-Howes, American Samoa Community College (pers. com.). (2) Cook, R. 2004. Macrofauna of Laufuti Stream, Ta'u, American Samoa, and the role of physiography in its zonation. Pacific Science 58:7-21.



5. ***Insects and related arthropods***: Kami, K. & S. Miller. 1998. Samoan insects and related arthropods: checklist and bibliography. Bishop Museum (Honolulu), Tech. Rept. 13. 121p.

6. ***Land snails***: (1) Cowie, R. 2001. Decline and homogenization of Pacific faunas: the land snails of American Samoa. Biological Conservation 99:207-222. (2) Cowie, R. 1998. Catalog of the non-marine snails and slugs of the Samoan islands. Bishop Museum Bulletin of Zoology 3, Bishop Museum Press, Honolulu, 122p. ***Freshwater snails***: (1) Haynes, A. 1990. The number of freshwater gastropods on Pacific islands and the theory of island biogeography. Malacologia 31:237-248. (2) Bardi, E., S. Fanolua. K. vanHoute-Howes & D. Vargo. 2004. Freshwater snails of Tutuila Island. American Samoa Community College. 6p.

7. ***Plants***: Whistler, A. 2003. Plants of concern in American Samoa. US Fish and Wildlife Service (Honolulu). 56p. ***Introduced plant species***: Space, J. & T. Flynn. 2000. Observations on invasive plant species in American Samoa. Rept. by USDA Forest Service (Honolulu).

8. ***Marine mammals***: Reeves et al. 1999. Marine mammals in the area served by the South Pacific Regional Environment Programme (SPREP). SPREP (Samoa). 48p.

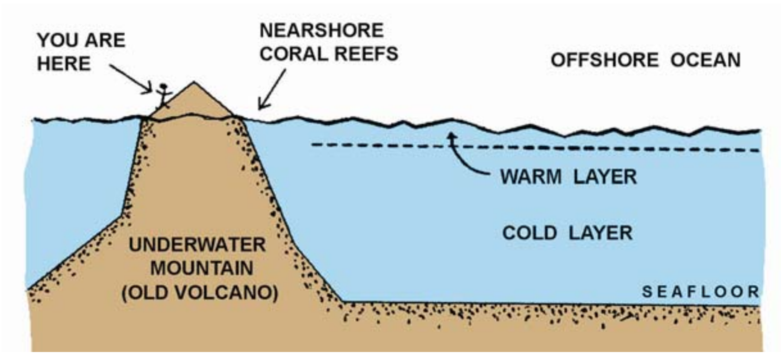
9. ***Marine fish***: Wass, R. 1984. An annotated checklist of the fishes of Samoa. NOAA Tech. Report SSRF-781. 43p. Wass notes that 40 mostly undescribed fish species are known only from the Samoan Archipelago but that the majority of these will likely be found elsewhere in the region as more extensive collections are made.

10. ***Corals***: (1) Birkeland, C., 2004. Draft species list for American Samoa. (2) Fisk, D. & C. Birkeland. 2002. Status of coral communities on the volcanic islands of A. Samoa. Rept. to Dept. Marine & Wildlife Resources (A. Samoa). 135p. ***Introduced marine invertebrates***: (1) Eldredge, L. 1994 (cited above in #3). (2) Cole, S., et al. 2003. A survey of introduced marine species in Pago Pago Harbor, Fagatele Bay, and the National Park of A. Samoa. Rept. by Bishop Museum (Hawaii).

11. ***Algae***: (1) Skelton, P. 2003. Seaweeds of Am. Samoa. Report to DMWR by Int'l. Ocean Inst. & Oceania Research and Development Assoc. (Australia). 103p. (2) Skelton, P. & R. South. 2004. New records and notes on marine benthic algae of A. Samoa – Chlorophyta & Phaeophyta. Cryptogamie Algol. 25:291-312.

6. Our deep blue ocean

American Samoa is much larger than you might think it is. The whole Territory covers 117,500 square miles, which is about the size of New Zealand or the state of Oregon. The Territory is big because we claim jurisdiction of the ocean that surrounds American Samoa, from the shoreline out to 200 miles offshore. That is standard procedure throughout the world (each country with marine coasts wants to protect its coastline and marine resources from others). To be more precise, American Samoa has jurisdiction over territorial waters out to 3 miles, while the US federal government maintains control of the zone from 3 to 200 miles from shore.



Most of the Territory is open ocean, of course. Only a minuscule 0.1% of the area consists of dry land (all 7 islands total only 76.1 square miles). The other 99.9% marine portion consists of two main habitats -- the shallow coastal waters adjacent to the islands (*a'au, aloalo*) and the deep waters offshore (*vasa*). Shallow coastal habitats, with their coral reefs and colorful fish, are quite limited in total area because our islands slope steeply down into deeper water and depths of 2000 feet are reached within 0.5-2 miles from shore. So, most of our coral reefs are restricted to a narrow ring around each island. There is also some coral on the tops of several offshore seamounts in the Territory.

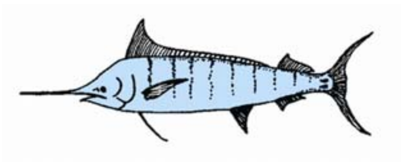
The rest of our marine environment consists of deep blue ocean with a fairly flat seafloor 2-3 miles below the sea surface. The reason for the blue color of the ocean is an interesting one and it is a key factor to understanding our ocean ecosystem, so we need to get technical for a moment. Water by itself is highly transparent with a bluish tinge. What adds other colors to the ocean are, in large part, small marine plant-like cells called phytoplankton. The more phytoplankton in the water, the greener the water becomes. Phytoplankton require two main ingredients to grow well: sunlight and nutrients (fertilizers). If they have both, they grow in abundance. This, in turn, supports a productive food web: phytoplankton provide food for the microscopic shrimp-like animals (zooplankton), and the zooplankton provide food for the fish to eat.

Tropical oceans are not green because conditions are generally not good for phytoplankton growth. Although phytoplankton have all the sunlight they could ever want in the surface layer, nutrient levels there are too low to support much plant growth. This occurs because the deep tropical ocean is typically stratified into two layers with very different temperatures. The sun heats up the surface layer, which is about 300 feet deep, to a pleasant 84^0 F, but the deeper layer remains a chilly 42^0 F. Because warm water is lighter than cold water, the warm ocean water generally stays on top, the cold water stays on the bottom. The two layers do not mix.

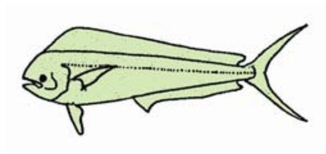
That's the rub. The bottom layer is where the nutrients are, but because of the 2-layer stratification, the nutrients can't get up to the surface layer where they are needed to combine with sunlight for plant growth. So, conditions for phytoplankton are not very good in the tropical ocean. The surface layer has lots of light but few nutrients, while the bottom layer has lots of nutrients but no light. It's pitch black down there. This arrangement doesn't support a very productive foodweb, so there are generally fewer fish in tropical oceans than in non-tropical oceans.

You might wonder, how is it that non-tropical oceans are much more productive? The answer is, again, temperature. Away from the tropics, seasonal changes in water temperature cause the water to mix. Winter temperatures cool the upper layer causing it to sink and mix with the bottom layer, and when this occurs, some nutrients are brought up to the surface. The nutrients in shallow sunlit waters stimulate phytoplankton growth, thus fueling a more productive foodweb.

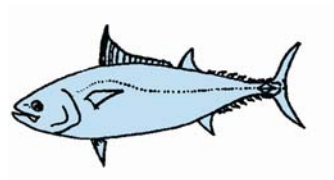
In the tropics, the 2-layer stratification of the ocean persists year-round because hot sun keeps the surface layer warm. The tropical ocean has been called a 'biological desert' for this reason. That's an exaggeration, of course, because all the tuna out there are finding something to eat. And, many other species live out there as well, from an occasional whale, dolphin, sea turtle or seabird, to numerous species of fish and invertebrates such as jellyfish and shrimp-like crustaceans.



Marlin (*sa'ula*)



Mahimahi (*masimasi)*



Tuna (*atu*)

What are some of the marine resources in our offshore waters? Three ocean resources of potential interest to American Samoa are fish, minerals and the water itself. Several kinds of food and sport fish are present in modest numbers: tuna, *masimasi*, marlin, wahoo, sharks, and flying fish. Surveys indicate, however, that the abundance of oceanic fishes within our 200-mile limit is probably not high enough to warrant significant commercial development of offshore fisheries. That's the main reason why the big tuna boats that deliver to American Samoa's canneries travel far beyond our 200-mile zone to other locations where the tuna are more abundant (the canneries are located here only to gain duty-free access to US markets).

Another resource mentioned from time to time are mineral deposits, such as manganese nodules, that lie on the seafloor. However, these nodules, even if present in our waters, are too deep for economic extraction by current technologies.

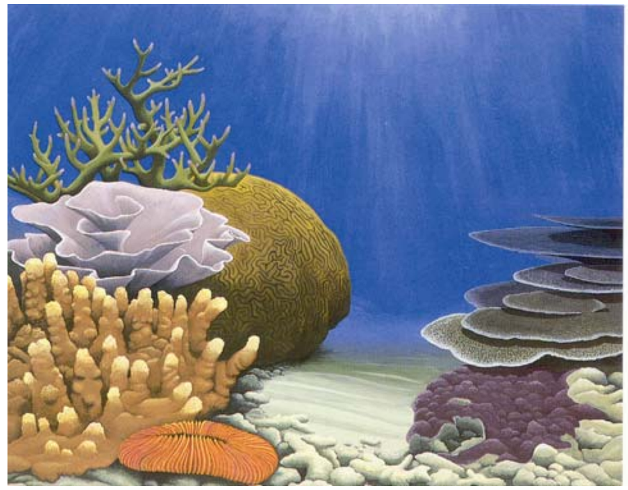
Perhaps a more exploitable resource in the future involves the temperature of the ocean's cold bottom layer. Scientists are working on a technology that extracts energy (to produce electricity) through a heat-exchange mechanism that is made possible by the large temperature difference between the tropical ocean's warm surface and cold bottom layers. A demonstration facility for this technology has been operating in Hawaii since the 1970's, but it has been an uneconomical venture so far. The two requirements for this technology -- a large temperature differential in the ocean, and easy access to this temperature difference by land-based facilities -- are met in American Samoa. Will our future electricity needs be powered by our own blue ocean?

P.Craig, NPS

7. What is coral?

The islands of American Samoa are blessed with an abundance of coral (about 200 species), so this article presents an introduction to these unusual organisms.

Corals are animals like ourselves, although that may not be readily apparent because many look like whitish rocks, especially those washed up on the beach. In a sense, corals are indeed partly rock, because only the outer thin layer of the coral is inhabited by the coral animal itself. In that way, corals are like large trees – the inner part is hard and provides structural support, the outer part is the living, growing organism. And, like trees, most coral animals are permanently attached to one spot on the reef.



Seven general kinds of coral growth forms.

The coral rubble that Samoans traditionally spread outside their houses, and the coral rocks along our beaches, are old, dead pieces that broke off the reef during a storm, got tumbled around and tossed up on the beach.

Living corals grow primarily on the outer reef flat and in deeper water. Although they take varied shapes, the coral animals inhabiting their surfaces are similar. They look somewhat like miniature sea anemones (*matamalu*, *ulumane*) or upside-down jellyfish (*alualu*) with short tentacles that give the coral a slightly fuzzy appearance when the tentacles are extended. Each single coral animal is called a polyp, but the coral branch or block we see on the reef is actually not a single animal but a colony of hundreds or thousands of tiny polyps living side by side, giving the appearance of being a single "coral". The coral's short tentacles can be pulled back into the hard part of the coral when the animal is disturbed or when the coral is exposed at low tide, so even a live coral can look like a rock at such times.

In the coral shown at left, a single polyp lives in each hole, but all the polyps have withdrawn into their skeleton (the polyps of many coral species emerge only at night). In the coral at right, many fuzzy-looking polyps have emerged to feed.

It seems inconceivable that these tiny coral polyps can build the hard coral 'rocks' that we see on the reef. They do this by secreting layers of a hard substance (calcium carbonate) beneath their living cells.

A coral polyp with tentacles extended

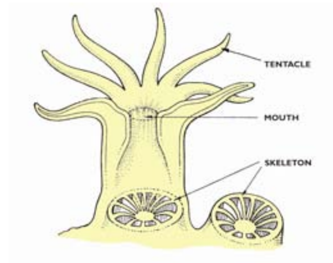
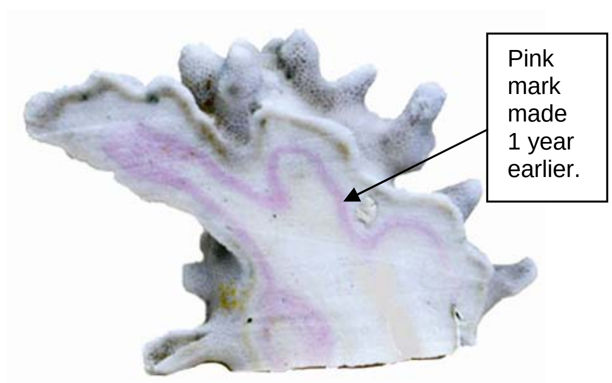


Diagram of a coral polyp

It's as if each tiny polyp built a rock-solid house for itself but then, as it grows bigger, it decides to close-off the bottom rooms in its house. Then it grows some more and closes-off another layer of bottom rooms, and so on. In this way, the coral polyp always lives in the outer, top layer which has been built upon layers and layers of rooms below. Each polyp also cements its house to those of its adjacent neighbors which strengthens the whole structure, resembling a solidly built high-rise apartment complex.

Adding on these new rooms is a slow process. Growth varies from about 0.5-3 inches per year depending on the species. The photo on the right shows this nicely (it was part of a science project). When this particular coral was living on the reef, it was stained with a harmless red die that was absorbed only by the outside layer of living tissue. Then, as the coral grew, it added the red stain to the new skeleton it was making, thus marking the size of the coral at the time it was stained. After the stain was used up, the newly laid skeleton was again white. After a one-year period, the coral was sawed in half and we can clearly see the pink band inside the coral. The distance from the pink band to the new outer edge of the coral is the amount that this coral grew in one year (about 0.3 inches in this case, as measured on the actual sample).

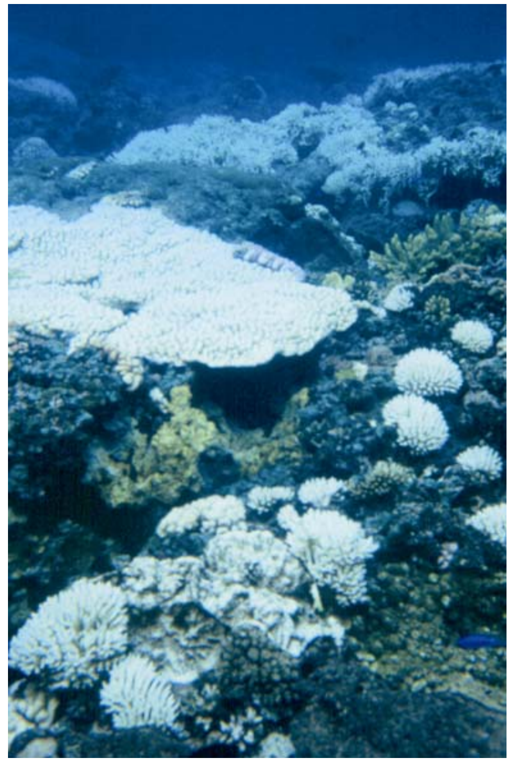


Over very long time periods, these corals grow into massively strong reef structures that can bear the brunt of powerful waves that crash upon them day after day. The very largest corals on our reefs may be hundreds of years old. Corals are one of the few organisms on earth that continually build on top of their old 'houses', forming such large solid structures. This is not like a bird that might build its nest on top of another nest, because both of these nests decay and disappear in a short time. In fact, most organisms on earth leave little trace after they die as their bones or shells disintegrate (dust to dust). Not corals. They build structures much larger and longer-lasting than the Egyptian pyramids. What other organism can do this (except modern man with his steel and cement)?

Consider Swains Island or Rose Atoll, for example. Both are the remnants of old volcanoes that, after millions of years, finally sank back down beneath the ocean's surface and disappeared altogether as volcanic islands usually do (see Chapter 4). But as they slowly sank, the coral continued to grow on top of the submerged mountain tops, layer by layer, keeping pace with the sinking rate of the mountain. The thickness of the coral there now is probably hundreds or thousands of feet thick on top of the old mountain peak and it's all that's left poking above the ocean surface. Were it not for this thick coral formation on top of these old mountains, Swains Island and Rose Atoll would not exist today.

8. When corals turn white and die

Coral reefs in American Samoa have turned pure white on several occasions in recent years. They look freshly bleached, quite pretty, but that's a clear sign that they are in trouble.



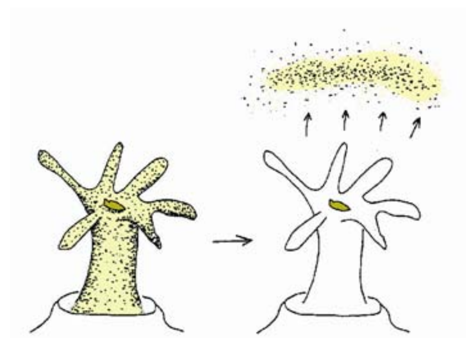
Underwater photo showing several kinds of corals that turned white, or “bleached”, due to heat stress in 1994.

Two very different kinds of stress cause corals to turn white: (1) clorox bleach, and (2) warm water temperatures. Clorox bleaching happens from time to time when a foolish fisherman dumps clorox onto the reef to kill fish. This is very short-sighted because it also kills everything else in the vicinity -- young fish, crabs, snails and corals -- and that harms the reef itself and reduces everyone else's catch.

Unusually warm water temperatures, due either to weather events or global warming, can also cause the coral to bleach. It only takes a slight increase above normal water temperature to bleach the coral. Bleaching can be caused by a short-term exposure (1-2 days) at temperature elevations of 3-4 degrees, or by long-term exposure (weeks) at elevations of only 1-2 degrees. To a diver, this may look like a pretty snowfall on the reef, but it indicates that the reef is seriously stressed.

Because most corals live only in warm tropical waters, it seems odd that corals will die when the water gets slightly warmer. They live close to the hottest temperature that they can tolerate, so it doesn't take much to push them over the limit. To explain what is happening, recall that corals are animals with colorful plant-like cells (zooxanthellae) living in their tissues. These cells use the sun's light to produce food which is also used by the coral animal. Many coral animals receive much of their food this way, so this relationship is quite important to the coral animal. The animal, in turn, provides the zooxanthellae with nutrients and a secure place to live. Both the coral and the zooxanthellae benefit from this arrangement.

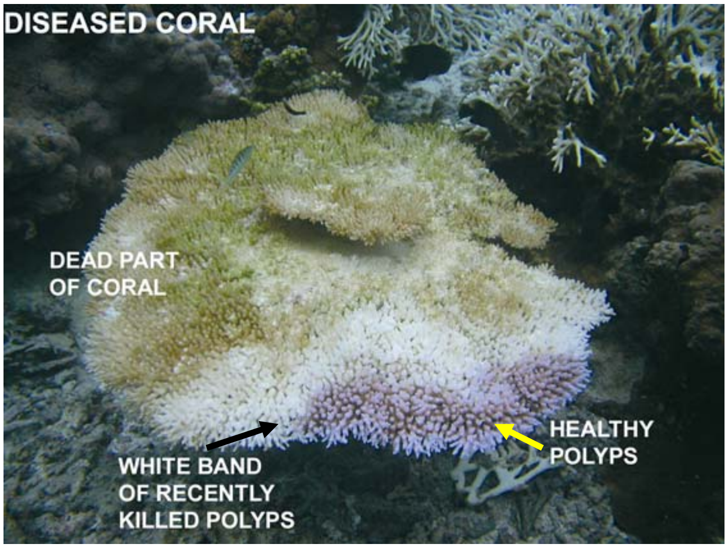
When the coral is stressed by warmer than usual temperatures, the zooxanthellae are released from the coral, for reasons known only to them. What's left is a rather colorless coral animal overlying a bright white coral skeleton (see drawing). The animal portion of the coral may eventually recover its zooxanthellae and continue living, or it may die, depending on how stressed it gets. It's easy to tell when portions of the coral die because they become covered with fuzzy green algae.



Normal coral polyp with plant-like cells inside the coral's tissues.

Heat-stress causes the coral polyp to release its plant-like cells and turn white like the photo above.

A little bleaching now occurs here during most summers, but it was particularly bad in 1994, 2002 and 2003. Not all coral species were affected then, but those in shallow waters were hardest hit, although some bleaching down to the 130-foot depth was observed. Bleaching also occurred in 1998 when we experienced very low tides due to a strong El Nino event. The exposed corals turned white and died.



As if that weren't enough, we are also seeing more coral diseases on our reefs (who would have thought that corals can catch diseases?). Presumably the heat-stressed condition of the corals makes them more vulnerable to diseases that had formerly been rare. In the photo at right, a white band of death is sweeping across the coral, from left to right. Behind the white band (to the left), the coral polyps were killed about a week or two ago, giving time for greenish algae to start growing on the dead coral skeleton. The white band itself is a zone of freshly killed polyps and exposed white coral skeleton. In front of the white band (to the right) is the last remaining bit of live coral (purplish in color). The cause of this disease is not known yet. Although coral diseases have probably always been around, they spread rapidly on our reefs beginning in 2002.

To round-out this rather negative view of the problems coral face in our modern world, an even greater threat to them is a projected change in water chemistry in the ocean due to global warming. Just as carbon dioxide (the main greenhouse gas causing global warming) is increasing in the air, it also increases in seawater in its dissolved form. That will lower the pH of seawater which, in turn, may slow the rate at which corals build their calcium carbonate skeletons. The result is that coral growth would be slowed and there might even be an increased erosion of the reef itself.

Scientists predict that episodes of warm water temperatures will become more frequent due to a general warming of the earth. That's bad news for us. While it's unlikely that all of our corals will die off as the environment gets warmer, the number and/or abundance of corals may well decline here. That might impact American Samoa in two general ways. First, coral growth might not keep up with rising sea levels or the reef itself may begin to erode, thereby allowing more storm waves to reach our shorelines and cause damage to roads and houses. Second, a reduction in coral growth and number of species could reduce the diversity of habitats required by fish, so a downturn in reef catches could eventually occur. Both of these changes would probably occur at a slow but steady pace over the next 30 years.

What to do? Not too much, unfortunately, because American Samoa has little impact on the world's changing climate. On the other hand, it makes sense not to worsen the situation by further stressing our coral reefs with rubbish, sewage from piggeries, or dirt (sediment) from land-use activities that flows into streams and out onto the reefs. The brown water we see entering the ocean from streams after a heavy rainfall is harmful to the corals. Additionally, we should locate and protect any areas where corals appear to be naturally resilient to bleaching events. These hardy survivors could then help re-seed other areas where the corals had died.

P.Craig, NPS t