STATION 6: SATITOA, SAMOA

Background Information

Watch the *video on Satitoa, Samoa*.

Exiting Neumayer Station III, you are transported from the deep freeze of Antarctica to the tropical breeze of Satitoa, Samoa, located at 171º 22′ W, 14º 1′ S. Don't worry, although the longitude has changed to 171º W, you are still on a path to Bremerhaven. Samoa is a Polynesian island nation.

The centerpiece of the exhibit room is a traditional open thatched-roof structure called a fale. The fale design is an engineering solution for comfort in a sunny, warm, wet, and breezy tropical climate. It was difficult to find construction tradespeople in Europe who had the knowledge and skills needed to build a fale. Two of the local residents of Satitoa, whom Axel Werner befriended, traveled to Bremerhaven to construct the fale.

The fale overlooks a lagoon. Standing in the fale, you gaze over a white sand beach to blue waters that sparkle in the tropical sun. Off the coast, a tropical reef is teeming with life. Tropical reefs are often referred to as the rainforests of the ocean because of their biodiversity. The coral reef habitat sustains a variety of animals, some of which are important food sources for the Samoan islanders.

The original village visited by Werner and Goldberg no longer exists. After a tsunami destroyed the village in 2009, the inhabitants resettled further inland. There are other events taking place that are related to changes in climate that also made the move inland a necessity.

As an island in the Pacific, Samoa is particularly vulnerable to changes in sea surface temperatures in the Pacific Ocean. Precipitation patterns change with the naturally occurring changes in ocean currents known as El Niño Southern Oscillation.

Warmer ocean water evaporates more quickly from the surface, thus raising the water vapor concentration in the air above the water. More water in the atmosphere can lead to cloud formation. More water in the air has the potential to increase the chance of rain. Although evaporation of surface water leads to increased salinity, the return of freshwater as rain reduces salinity. Unlike Antarctica, the problem is not changing ocean salinity; rather, it is increased cycling of water between the ocean and atmosphere driven by heating. Sunlight drives water evaporation from sea surfaces. Because of the Earth's axial tilt, incoming solar radiation is most direct and intense in tropical regions.

Warmer ocean water has other impacts as well. As seawater warms, the kinetic energy of water molecules increases. As the kinetic energy increases, water molecules spread out, causing the volume to expand. Seawater expansion contributes to global sea-level rise. Rising sea levels may cause flooding and beach erosion. Silt in the water from beach erosion affects coral reefs by blocking sunlight needed by photosynthetic zooxanthellae that live on corals and produce nutrients and energy for corals.

Warmer water temperatures also impact the symbiotic relationship between zooxanthellae and corals. When temperatures are 1º to 2º C higher than normal for 5 to 10 days, zooxanthellae abandon the coral. If conditions remain too warm, even if the water is clear and shallow, the zooxanthellae do not return. When corals become deprived of nutrients, they begin to turn white and die, which is called coral bleaching. Warmer ocean surface temperatures are one cause of coral bleaching.

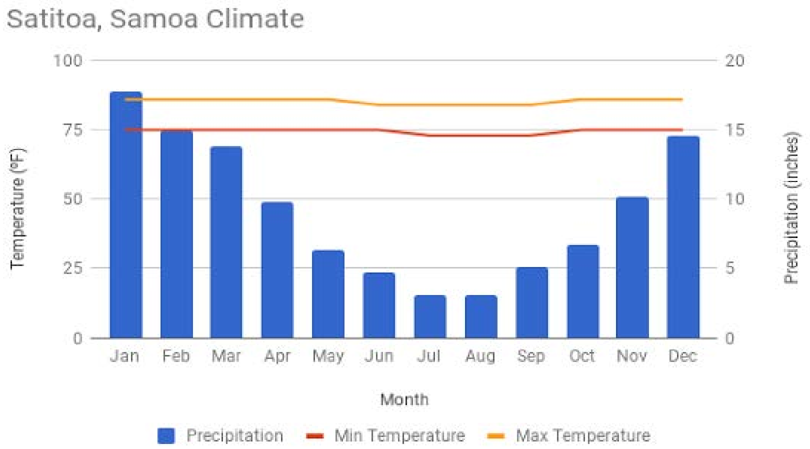
Another factor affecting ocean life is ocean acidification. The acidity of a substance is measured using a pH (potential of hydrogen) scale from 0 to 14. Substances with a pH less than 7 are called acids, substances with a pH of 7 are neutral, and substances with a pH greater than 7 are bases. Acidity refers to an acid; alkalinity refers to a base. Acidification describes processes that result in lower pH measurements, even if the altered pH is still equal to or greater than 7.

Prior to the Industrial Revolution, the average pH of ocean water was 8.2. The alkalinity of ocean water depends on chemical reactions taking place in the water. Oceans serve as a sink for atmospheric carbon dioxide. When carbon dioxide mixes with ocean water, it forms carbonic acid. Rising concentrations of carbon dioxide in the atmosphere correlate to lower pH levels in ocean waters. The current average pH of ocean water is 8.1. That may not seem like a big difference, but the pH scale is based on powers of 10. A 0.1 decrease in pH is a 25 percent reduction in alkalinity and increase in acidity. Lower pH levels affect the survival of corals and animals with calcium carbonate shells.

The signs of climate change in Samoa are alarming. A downed electrical line pole indicates the power of recent storms. Flood waters lapping at the steps of the church are a sign of sea-level rise. Ocean reef productivity has declined as a result of warmer ocean temperatures and acidification. Could our own actions be connected to sea-level rise, ocean acidification, increased storm intensity, and coral bleaching in Samoa?

Explore Satitoa

1. Use Google Earth to develop a sense of place.
2. Use the data and information on the climograph to observe patterns in rainfall and temperature.



3. Find out more about coral bleaching by watching *What Is Coral Bleaching?* (Time, 2016).
4. Read *Everything You Need to Know about Coral Bleaching and How We Can Stop It* (Hancock, n.d.).
5. Find out more about sea-level rise by reading *Sea Level Rise* on the Smithsonian: Ocean Find Your Blue website.
6. Identify factors that influence climate.
7. Identify sources of carbon dioxide and other greenhouse gas emissions.

Explore sea-level rise at *NASA Global Climate Change: Vital Signs of the Planet*.

Predicted Climate Change	Climate Change Threat	Climate Change Impact
Warmer ocean temperatures	Sea-level rise	Flooding
	Increased storm intensity	High wind damage
	Ocean acidification	Loss of coral reef biodiversity

Text by Lori Chen

Activity 1: Model Seawater Expansion: Design a System

Phenomenon

"Ocean water expands as it warms, filling larger volumes. The ocean absorbs more than 90 percent of the heat that greenhouse gases trap in Earth's atmosphere, making thermal expansion a significant contributor to global sea-level rise—about one-third of the total observed." (NASA, n.d.)

Engineering Challenge

Design and construct a physical model that demonstrates thermal expansion of saltwater. Your model must demonstrate thermal expansion within a class period time frame. The expansion must be the result of warming only. Expansion must be measurable.

- Identify the criteria and constraints.
- Consider the types of materials that could be used to create a working model.
- Propose two or three possible design solutions.
- Draw the final design solution, indicating the materials to be used and how the system works.

Activity 2: Model Ocean Acidification

Phenomenon

"The rising acidity of the oceans threatens coral reefs by making it harder for corals to build their skeletons" (Woods Hole Oceanographic Institution, 2018).

Materials Needed

- 500-ml Erlenmeyer flask
- Rubber stopper with glass tube and flexible tubing
- Test tube or small beaker
- Salt
- Water
- Baking soda
- Vinegar
- Bromothymol blue

Instructions

1. Make a saltwater solution of 35 grams of salt in 1,000 ml of distilled water.
2. Pour saltwater into the test tube or beaker to about three-fourths of the volume.
3. Add a few drops of bromothymol blue to observe the pH.
4. Place the flexible tubing into the saltwater.
5. Add a tablespoon of baking soda to the Erlenmeyer flask. Pour in 125 ml of vinegar and quickly place the stopper into the neck of the flask. You may need to hold the stopper in place.

6. If all went well, carbon dioxide gas should be bubbling into the salt water.
7. Observe the color of the saltwater.
8. Use your model to explain how rising atmospheric levels of carbon dioxide contribute to ocean acidification.

Text by Lori Chen