North Carolina State Standard Course of Study

Earth/Environmental Science Grades 9-12

COMPETENCY GOAL 5: The learner will build an understanding of the dynamics and composition of the atmosphere and its local and global processes influencing climate and air quality.

Objectives

5.01 Analyze air masses and the life cycle of weather systems:
- Planetary wind belts.
- Air masses.
- Frontal systems.
- Cyclonic systems.

5.02 Evaluate meteorological observing, analysis, and prediction:
- Worldwide observing systems.
- Meteorological data depiction.

5.03 Analyze global atmospheric changes including changes in **CO^2**, **CH^4**, and stratospheric **O^3** and the consequences of these changes:
- Climate change.
- Changes in weather patterns.
- Increasing ultraviolet radiation.
- Sea level changes.

American Association for the Advancement of Science

Benchmarks for Science Literacy

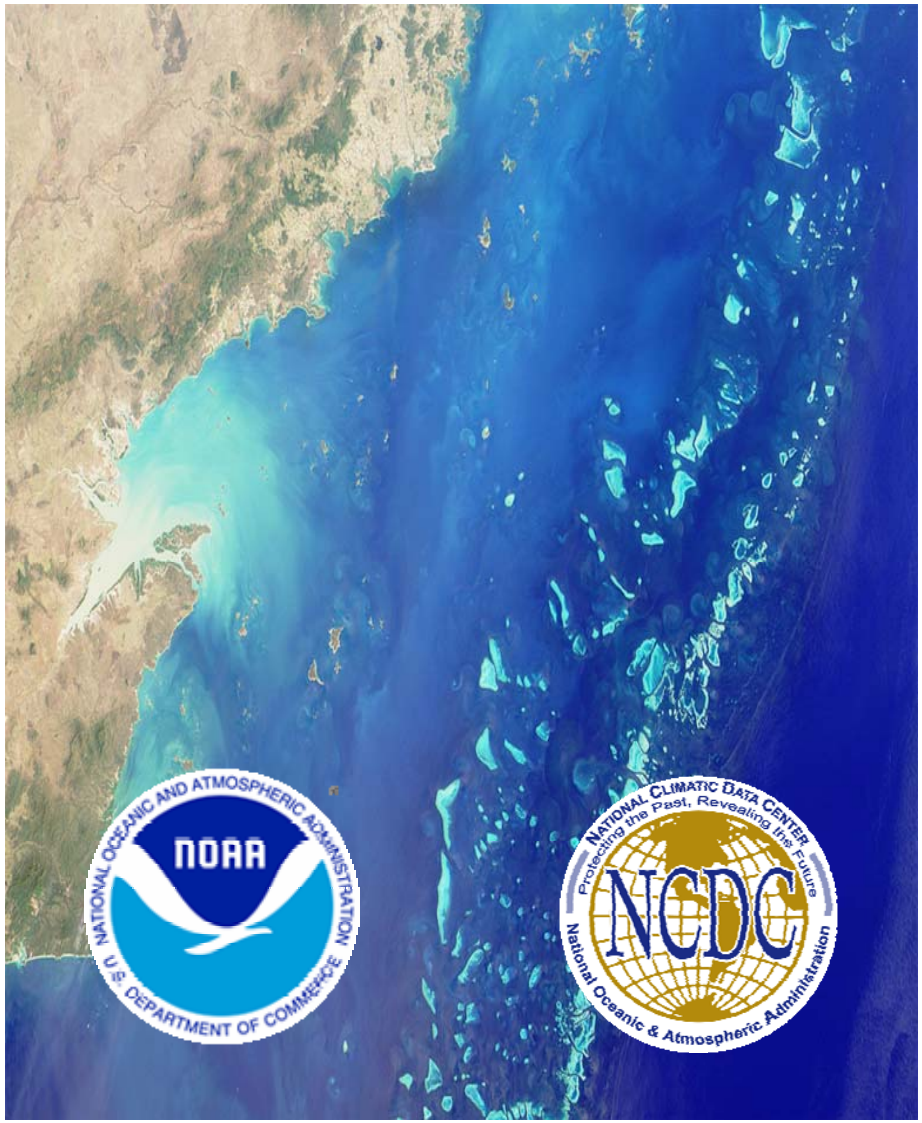
Benchmark 4B The Earth

Grades 9-12
Weather (in the short run) and climate (in the long run) involve the transfer of energy in and out of the atmosphere. Solar radiation heats the land masses, oceans, and air. Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the oceans results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different densities causes them to rise or fall- and such circulation influenced by the rotation of the earth, produces winds and ocean currents.

NOAA Paleoclimatology Program

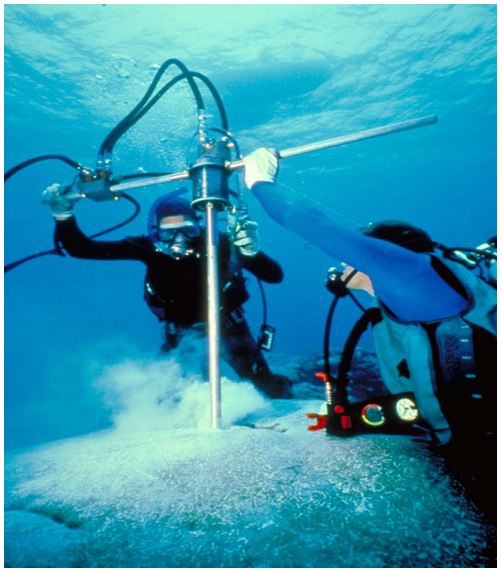
CORAL REEFS

Vulnerable Treasures of Climate Clues & Biodiversity



NOAA Paleoclimatology Program

Collecting Climate Data



Cores taken from coral reefs provide insights into ocean temperatures going back hundreds of years, allowing scientists to reconstruct past climate patterns and variability.

When a coral grows, the chemistry of the skeleton looks in an indelible record of the conditions under which it was created. Some colonies live as long as 800 years! It is this long record that paleoclimatologists are trying to unlock by drilling long cores into the coral skeleton.

In the photo to the left, divers use a portable drill to sample a coral. Scientists drill cores that follow the coral's axis of maximum growth. Like trees, many corals deposit a new ring each year. To sample across these years, a core is taken from the top to the bottom of the coral. While drilling does kill the tissue living on the core surface, it does little damage to the colony as a whole. In fact, corals often grow over the drilling holes within a few years.

Reefs at Risk

Coral reefs, one of the most diverse habitats in the world, appear solid, permanent and immune to external attack, but nothing could be further from the truth. They are extremely sensitive ecosystems that can be easily destroyed.

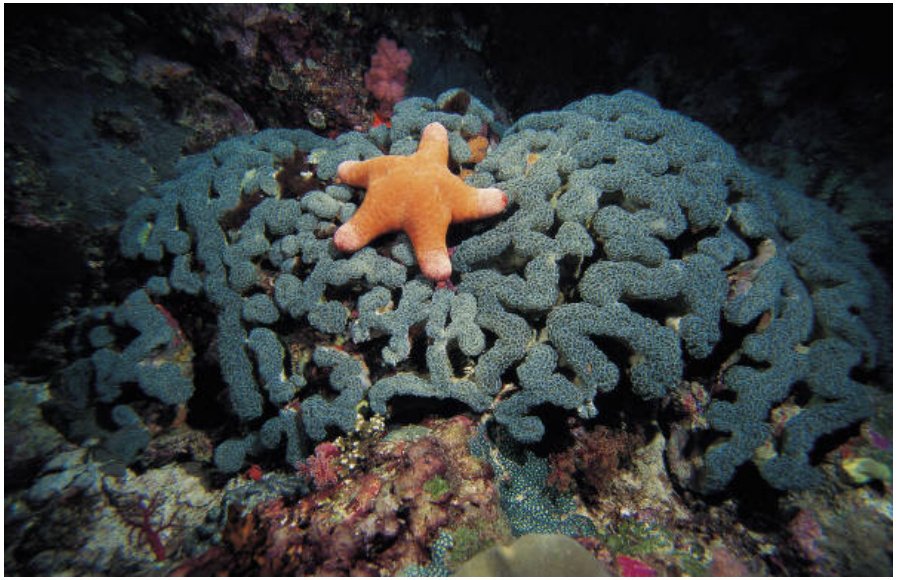
In many areas of the world, corals are being killed by poor land use, pollution, over-fishing, sewage, boat damage and destructive fishing. The 1982-83 El Niño killed many corals in the eastern Pacific, and corals bleached around the globe during the 1997-98 El Niño. Some scientists predict that as much as 20% of the reefs around the world will

Paleoclimate

NOAA serves the nation by observing changes in climate and the environment, and by providing estimates of future change. Coral reefs are one of the sources of information on the large climatic changes (temperature, drought, and the hydrologic cycle) that have occurred over decades to thousands of years. The information obtained from these natural recorders of earth history play an essential role in helping societies understand and live with our changing environment.

Photo Credits:

All images from NOAA Coral Kingdom Photo Library or NOAA Paleoclimatology Program except the mass spectrometer, courtesy of DOE and the background image of the Great Barrier Reef, courtesy of NASA



Web Resources

NOAA

Coral Reef Information System (CORIS)

http://www.noaa.coris.gov

NOAA's Paleoclimatology Program at the National Geophysical Data Center

Paleoclimatology: What can corals tell us about climate?

http://www.ngdc.noaa.gov/paleo/outreach/coral/coralintro.html

Corals and Sclerosponges Data

http://www.ngdc.noaa.gov/paleo/corals.html

National Oceanographic Data Center

Coral Reefs and Associated Ecosystems

http://www.nodc.noaa.gov/col/projects/coral/Coralhome.html

NOAA Research: Coral Health & Monitoring Program

http://www.coral.aoml.noaa.gov/

Other Coral Resources

Reef Base: A Global Information System On Coral Reefs

http://www.reefbase.org/

Reef Relief:

http://www.reefrelief.org/main.html

Reef Check:
http://www.reefcheck.org/

Global Coral Reef Monitoring Network:

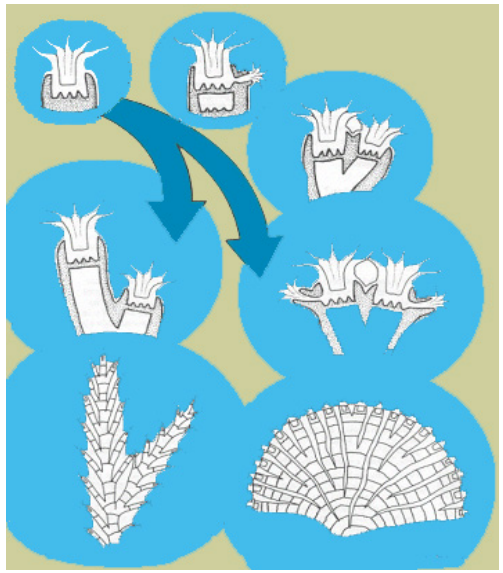
http://www.coral.noaa.gov/gcrmn/

collapse within 10-20 years. The reefs at greatest risk are those in Southeast Asia, East Africa, and the Caribbean.

Coral Colonies

From a distance, corals appear to be one organism. When we take a closer look however, we see that corals are colonies of tiny organisms called polyps. The polyps make up the coral colonies, and many corals make up structures called reefs.

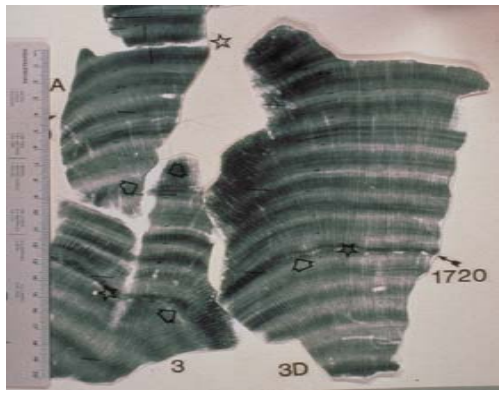
The polyp lives in a pit inside the coral skeleton that it builds. This skeleton is composed of calcium carbonate ($CaCO_3$) crystals that are secreted by the lower half of the polyp. The live tissue lies entirely along the surface of the skeleton. As long as the colony is alive, calcium carbonate is deposited beneath its living tissues. The live tissue lies entirely at the upper edge of the skeleton, covering it with a network of interconnected polyps.



As a polyp grows outward it leaves behind a skeleton made of calcium carbonate. This process forms the skeleton of corals, which forms the structure of the reef.

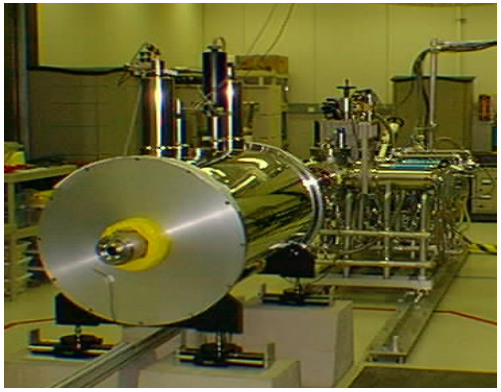
Reef-building corals contain algae called zooxanthellae, that live within the tissues of the coral polyps, supplying food and oxygen through photosynthesis. These algae give living corals their vibrant color.

Analyzing Coral Data



The core is taken to the laboratory where scientists analyze them, band by band. Some scientists study the growth rates like tree ring (see x-radiograph to the right showing banding) while others study chemical composition using machines such as the mass spectrometer pictured to next page. Scientists studying coral cores pay particu-

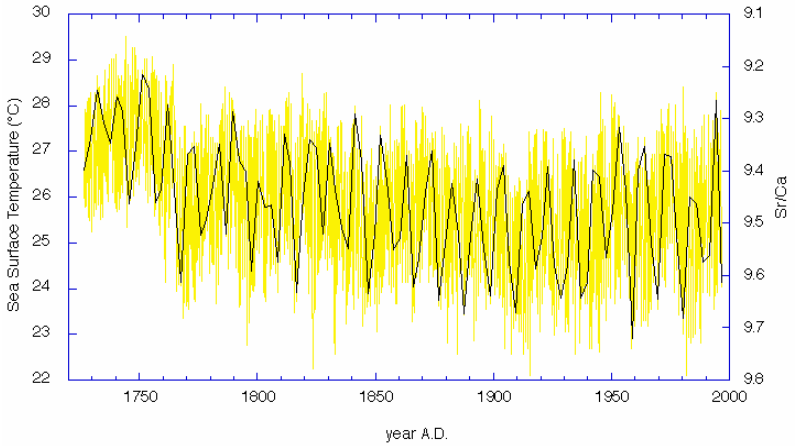
lar attention to the ratio between two stable isotopes of oxygen, ^{16}o and ^{18}o, found in the calcium carbonate ($CaCO_3$) skeletons, and the ratio of strontium (Sr) to calcium (Ca). These chemicals in coral skeletons reveal past changes in temperature. Changes in evaporation and precipitation over the ocean are also preserved in the ratio of oxygen isotopes.



Windows into Past Centuries

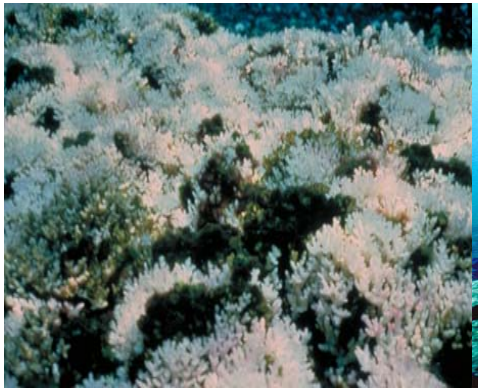
The instrumental record that spans the last century is too short to evaluate the ocean's role in climate variability, so corals and other "proxy" data (such as tree rings, ice cores and pollen) help provide a longer term perspective to the study of dynamic fluctuations in climate.

Below is a reconstruction of sea surface temperature (SST) between 1726 and 1997 A.D. by Bruce Linsley and colleagues using St/Ca isotopes of coral cores from Rarotonga in the eastern Pacific.



Coral Bleaching

A dramatic sign that a coral is living under stressful conditions is coral bleaching. The algae are expelled (kicked out) and the coral loses its color causing the polyps to look clear and the colony to turn white--hence the term "bleaching". Corals might bleach when they face water that is too hot or cold, live above water for too long or when they encounter waters that are clouded with silt or pollution.



Coral Reef Biology

Thousands of corals species exist worldwide. Stony (hermatypic) corals are the best recognized because of their elaborate and colorful formations. One trait of stony corals is their ability to build reef structures that range from tens, to thousands of meters across. As they grow, reefs provide structural habitats for hundreds to thousands of different vertebrate and invertebrate species.

Although corals are found throughout the world, reef-building corals are confined to ocean water exhibit certain characteristics. The water must be warm and clear, and are almost always low in nutrients. Physiologically and behaviorally, corals have evolved to thrive in this unique environment.

Corals and El Niño

El Niño is a climatic event that significantly transforms the weather ever the Pacific Ocean and elsewhere. The average occurrence is every 3-7 years and it lasts for an average 1-2 years. During El Niño parts of the Pacific Ocean are much warmer than in other years, causing dramatically different regional climate patterns around much of the world.

The stress due to warmer than normal ocean temperatures can cause some of the coral polyps to bleach. Although bleaching after El Niño is normal, the amount of coral bleaching occurring seems to be on the rise, and El Niño events appear now to be effecting areas that have not been affected in the recent past.

Scientists can detect the past occurrence of El Niño by looking at the past sea-surface changes in corals. El Niño affects the growth and chemistry of the coral bands, and analysis of the annual bands reveals information about the frequency and duration of past El Niño.