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Islands in the Stream 2002: Exploring Underwater Oases

Reef Fish Real Estate in the South Atlantic Bight

Focus
Reef fishes

Grade Level
7 – 8 (Can be easily adapted for High School Biology)

Focus Questions
What are the habitat requirements of juvenile and adult reef fishes? How do the actions of humans on land impact the fishes living on reefs found offshore?

Learning Objectives
Students will research a species of reef fish to determine its habitat requirements as both a juvenile and an adult. Students will use this information to create a pamphlet in the style of a real estate brochure that will:

- Describe the habitat and food requirements of a particular reef fish species as adults and as juveniles.
- Describe how the water quality of local watersheds and other stresses can affect that particular reef fish.

Additional Information for Teachers of Deaf Students
In addition to the words listed as Key Words, the following words should be part of the vocabulary list.

Habitats	Organisms
Contaminate	Migratory
Larvae	Estuaries
Nutrients	

There are no formal signs in American Sign Language for any of the words listed as key words and many are difficult to lipread. Having the vocabulary list on the board as a reference during the lesson will be extremely helpful.

The Background Information for the teacher can easily be copied and given to the students as a starting place for information. To reduce the time required for this activity, students can work in pairs. The teacher may select several species from the list and have the students pick from a smaller select group. Each class may choose different species so that in the end, a more complete representation is available. Each class should make their pamphlets available to the other classes.

Materials
- ❒ Reference materials
- ❒ Drawing paper and pencils
- ❒ Example of a real estate brochure (to see a sample please access the following website)

Front page
http://206.74.146.33/scaquarium/scaweb/curriculum/iexplore/sixth_eighth/units/reefs/gag_front.htm
Back page
http://206.74.146.33/scaquarium/scaweb/curriculum/iexplore/sixth_eighth/units/reefs/gag_back.htm

Audio/Visual Equipement
Internet connection for student use

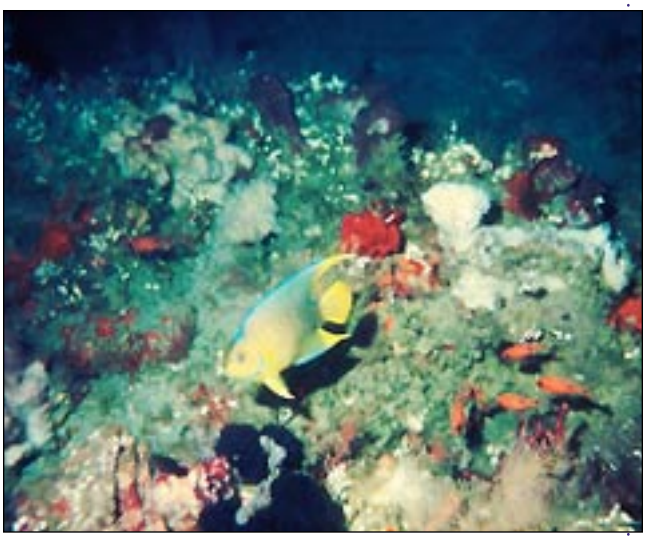
Teaching Time
1 class period to introduce the activity
One week for student research and brochure pro-

duction

Seating Arrangement
Individually

Maximum Number of Students
35 students

Key Words
Estuary
Hard bottom reef
Detritus
Live bottom reef
Phytoplankton
Relief
Sessile
Zooplankton



Background Information
Key Points

- Hard bottom reefs are environments found off the coast where rocks and ancient coral reefs jut out of the ocean floor and become habitats for a variety of fishes and invertebrates.
- Hard bottom reefs are well-populated habitats because the hiding places and hard structure of the reef provide shelter for many smaller animals. The abundance of smaller animals at the reef provides food for many larger animals.
- Fishes in hard bottom reefs are affected by watersheds in several ways. The nutrients carried by watersheds support the microscopic plants in the ocean that are the basis of all the food webs in the ocean, including the ones reef fish are dependent on.
- Pollutants in watersheds can also affect reef fishes, because they will eventually flow into and contaminate the ocean, and can be detrimental to the fishes' health.
- Many reef fishes are particularly affected by contamination in watersheds, because their larvae are carried inshore by currents to estuaries and salt marshes. These estuaries and salt marshes act as nurseries for these young fishes. Because these habitats do not have as much water in them as the ocean, and they are also having water flow through them from watersheds, any pollutants in the watershed will be in these habitats in high concentrations. These high concentrations of contaminants can have devastating effects on the vulnerable larval fish populations. This will eventually decrease the adult populations in the hard bottom reef habitats.

When thinking of ocean reefs, one tends to think of the coral reefs of places such as the Caribbean, not places such as the offshore waters of North Carolina, South Carolina and Georgia, yet many reef habitats can be found there. The reef habitats of the South Atlantic, known as hard bottom reefs, are distinct from coral reef habitats and are home to a variety of sea life species. This activity will introduce students to the hard bottom reef habitats and show how they, too, are dependent on watersheds.

Hard bottom reefs are areas of rock and ancient coral outcrops; places where the underlying rock sticks up through the sand. This rock can stick up above the surface only a few inches or as high as several feet. The hard surfaces provide structure to which sessile organisms, such as sponges and sea whips, attach themselves. Sessile organisms are animals that attach to a surface and remain there their entire lives. These sessile organisms cover

hard bottom areas. Because of this luxuriant animal growth, these reefs are also known as live bottom reefs. In South Carolina, approximately 20% of the bottom area is made up of hard bottom reefs, the rest being a sandy bottom.

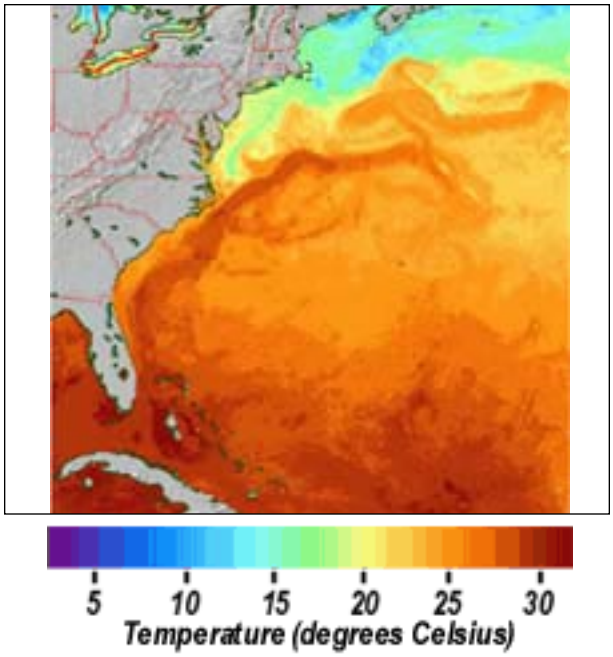
Natural live bottoms can be classified into three zones according to their location on the continental shelf. The zone closest to the shore is known locally as the "Blackfish Banks". They are found in depths of 49 to 98 feet of water. Generally the outcrop in this area affords less than three to four feet of relief from the surrounding sea floor. Relief is the geologic term for difference in elevation, so the top of these live bottom reefs is only three or four feet higher than the surrounding sand. As the name implies, the blackfish or black sea bass (*Centropristis striata)* is the most abundant fish species found in this zone of live bottom habitat. In addition to black sea bass, this area is also home to sharks, sheepshead (*Archosargus porbatocephalus*), tripletail (*Lobotes surinamensis*), greater amberjack (*Seriola dumerili*), Atlantic spadefish (*Chaetodipterus faber*), great barracuda (*Sphyraena barracuda*), and king mackerel (*Scomberomorus cavalla*). The invertebrates found attached in this area include worm tubes, sponges, barnacles, and soft corals.

Because they are in relatively shallow water, the Blackfish Banks are more susceptible to sudden change than the other live bottom zones. When these areas are heated in the summer and cooled in the winter, the water is more likely to undergo temperature changes. Deeper water, because of its proximity to the warm waters of the Gulf Stream, can maintain a consistent temperature throughout the year. Blackfish Banks are also vulnerable to storms and hurricanes. Powerful storms stir up the bottom in these areas and can bury these live bottom reefs in sand, as well as all the animals attached to them. For this reason, it unusual to see large sessile invertebrates in these reefs. The Blackfish Banks have been fished commercially since the 19th century and have been seriously depleted by overfishing in recent years.

The second live bottom zone, the "Snapper Banks," occurs in depths of 82 to 180 feet of water. The outcrops of this zone have relief up to eight feet above the ocean floor. This live bottom habitat features sessile invertebrates such as soft corals, seafans, sponges, barnacles, and seawhips. Here, too, one fish species, the red porgy (*Pagrus sedecim*), not a true snapper, dominates over all others. Red porgies constitute more than 70 percent of the fishes on this area, but other bottom species such as Nassau grouper (*Epinephelus striatus*), gag grouper (*Mycteroperca microlepis*), speckled hind grouper (*Epinephelus drummondhayi*), red snapper (*Lutjanus campechanus*), and vermilion snapper (*Rhomboplites aurorubens*) begin to appear. In warm months, highly migratory species such as greater amberjack, jack crevalle (*Caranx hippos*), sharks, king mackerel, and Spanish mackerel (*Scomberomorus maculatus*) move into this habitat from Florida and Caribbean waters.

The deepest live bottom area lies at the edge of the continental shelf in 180 to 656 feet of water. Sometimes called the "Shelf Edge Reef," this area features 30 to 40 feet of relief above the sea floor. The Shelf Edge Reef originated in a relic Pleistocene reef that was laid down in less than 150 feet of water over a half million years ago. At the time of the last great glacial activity, called the Wisconsin Period, sea level was much lower than today. As the glaciers melted and sea level rose again, the old reef died and was gradually colonized by more modern sea life.

This zone is covered by the Gulf Stream. Since the warm water of the Gulf Stream remains constant, without the dramatic seasonal changes of inshore waters, Caribbean organisms, such as those common in Florida, now exist farther north than expected. Such exotic species as yellow edge grouper (*Epinephelus flavolimbatus*), snowy groupers (*Epinephelus niveatus*), hogfish (*Lachnolaimus maximus*), and the longfin scorpionfish (*Scorpaena agassizi*) inhabit this deep live bottom.



Sea surface temperature along the east coast produced by John's Hopkins University's Applied Physics Lab. The Gulf Stream is the dark red stream of water flowing up from Florida and located just off the coasts of Georgia, South Carolina, and North Carolina. This image was accessed from NMEAís BRIDGE website.

Fish species populations that utilize live bottoms are not always permanent, and will change seasonally as water temperatures vary. This is particularly true of the shallow water live bottoms where the low water temperatures that occur in winter can stress fishes. The turbulence of winter storms can also strip a live bottom of much of its invertebrate life, leaving less food for fish. Increased water depth decreases storm stress, and reduces the variability in water temperature. Near the Gulf Stream, the water temperature remains almost constant throughout the year, resulting in increased diversity and less change in species composition.

The movement of highly migratory fish species, particularly the higher predators, also seasonally affects live bottoms near shore. As the days become longer and the water warms, sharks move closer inshore and fish such as jack crevalle, cobia (*Rachycentron canadum*), Spanish and king mackerel, amberjack, and barracuda concentrate around live bottoms where prey abounds.

When the water starts to cool in the late fall, the migratory fish move south, and fish formally living in nearshore waters then move farther offshore to occupy the live bottom. Bluefish (*Pomatomus saltatrix*), sheepshead, black drum (*Pogonias cromis*), red drum (*Sciaenops ocellata*), flounder (*Paralichthys spp.*), and spotted seatrout (*Cynoscion nebulosus*) find cover and food in water warmer than the beach and estuarine areas they inhabit during the rest of the year.

Some reef fish are dependant on the health of the estuaries for their survival. When these fishes spawn, the current and flood tides carry the larval fishes inshore to the estuaries and coastal wetlands. Approximately 80% of recreationally and commercially important marine organisms found in coastal waters along the South Atlantic are dependent on estuarine waters during at least a part of their life cycles. This occurs because estuaries are prime nurseries that offer larval and juvenile fish food, shelter, and protection from predators.

Estuaries are integrally tied to inland watersheds, as they are often the last stop for these watersheds before they discharge into the ocean. For this reason some estuaries in South Carolina are receiving water literally drained from across the State. This means they also can receive pollutants from across the State as well. For example, a chemical spill in Spartanburg, South Carolina, can have a negative effect on the salt marshes around the Santee Delta as the pollutants may be carried downstream through the watershed to this area. This in turn will have a negative effect on the juvenile fishes and other populations found in the estuaries. Impacting the juvenile populations will eventually impact the adult populations, as not as many of the young fishes will reach adulthood to reproduce.

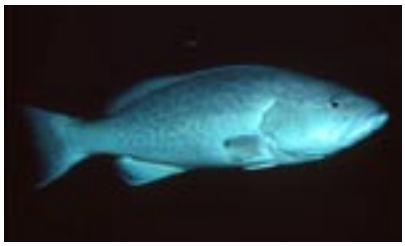
A good indicator of water quality contamination in saltwater estuaries is the health of mollusks, such as

the oyster. Oysters are animals found in estuaries throughout South Carolina. Oysters are filter feeders that pump water through their bodies to strain food from them. In the process of doing this, any contaminants in the water will also be collected in the oysterís body. Scientists can examine the oyster to determine if the contaminants collected in the oyster's bodies have reached a dangerous level. This in turn is an indicator of the water quality in the surrounding estuary. Currently in the United States, over 33% of oyster beds have been closed because of dangerous contamination levels.

Another way that reef habitats are tied to watersheds is the nutrients the watersheds carry into the ocean. As the streams and rivers flow across the land, they pick up minerals and decaying organic material, known as detritus, and carry them to the ocean. This is why the coastal waters of South Carolina are so murky, because they are so abundant in nutrients. Contrary to what tourists think, this murkiness is very beneficial to the ocean ecosystem, because it can support a variety and abundance of life not found in the Caribbean. The nutrients in the water support a large phytoplankton (microscopic or small plants) population, which in turn supports a large zooplankton, (microscopic or small animals) population, which in turn supports all the rest of the animal populations in the South Carolina ocean waters. Without the nutrients being constantly brought into the ocean by watersheds, there would not be enough food to support the same size populations that can currently be found on hard bottom reef habitats.

During the South Atlantic Bight Expedition, Dr. Steve Ross will be exploring the unique outer shelf and slope habitats off the Carolinas. One of Dr. Ross' goals is to determine the extent to which adjacent habitats serve as nurseries for juvenile reef fishes. Dr. George Sedberry from South Carolina's Department of Natural Resources and a team of scientists will also be study reef fish habitat during the expedition. Dr. Sedberry wants to know more about the spawning grounds of reef fishes and how ocean currents (like the Gulf Stream) impact the fish larvae.

Spotlight Species — Gag Grouper (*Mycteroperca microlepis*)



One of a dozen grouper species inhabiting tropical and subtropical American waters, the gag, ranges from North Carolina to the Yucatan. Gag live more than 30 miles offshore in warm waters. The gag averages two to four pounds, although it can reach 50 pounds. Favored habitat includes rocky live bottoms, generally in water from 122 to 300 feet deep. The gag feeds mainly on small fishes, particularly grunts, and reef dwelling crustaceans, such as crabs, shrimp, and squid.
Female gag groupers mature sexually at five to six years of age and spawn in water over 200 feet deep. The eggs and planktonic larvae that hatch are carried inshore to the estuaries by eddies spinning off the Gulf Stream. Juvenile gag move inshore into oyster reefs to feed, primarily on grass shrimp, and mature. Within a few months they will reach lengths of up to 12 inches and will begin to swim offshore to the hard bottom reefs.

As with most groupers, gags change sex with age. All gags start off as females. Since it requires more energy to produces eggs than sperm, it is necessary to have a larger number of females in the population than males. A handful of male gags can produce enough sperm to fertilize the eggs of a large number of female gags. For this reason, only 5 to 20% of a gag population are males. When a female reaches a size where they are among the largest fish in the population, they will change their sex and become males. In a gag, this change occurs between 10 and 11 years of age.

Typical of the grouper family, this fish has a long life expectancy and tends to remain in its preferred habitat, perhaps behaving territorially. This trait makes it vulnerable to heavy fishing pressure. Gag are also vulnerable to over-fishing because they concentrate together when they spawn. When ready to spawn, many gags will migrate to southern Florida in a narrow area of ocean water. They do this consistently every year to spawn during the full moons of February and April. As fishermen are aware of this yearly event, they often take advantage of the fishing opportunities it offers. As large numbers of gag can be taken during a short period of time, this can have a negative effect on the gag populations all over the Southeast.

The survival of the gag grouper is in serious danger because of overfishing. Population size and genetic diversity have been in decline. Gag caught today are smaller in size and mature much sooner than gags caught 20 years ago. To ensure the gag's survival, new management practices, such as marine reserves where no fishes may be caught, may need to be instated. Unfortunately, because of the dependence of fishermen on fishing for their livelihood and because of the long-held belief that the fishes in the ocean are an unlimited resource, it is hard to gain acceptance for such new practices.

Learning Procedure

1. The teacher will give the students a mini-lesson on hard bottom reefs off the South Carolina coast. The teacher will give them brief information on where the reefs are located, what type of organisms live in them and what the habitat is like. The teacher will tell the students they will do research to determine how inland watersheds impact these animals.

2. Each student will be assigned a reef fish species. Students will research the species to determine their habitat and food requirements, where larvae and juveniles of the species live, and what watersheds may impact both the adults and juveniles.

Species:

Gag grouper	Tomtate
Warsaw grouper	Yellowtail snapper
Jewfish	Vermillon snapper
Speckled hind	Gray triggerfish
Nassau grouper	White grunt
Red snapper	Red porgy
Wreckfish	King mackerel
Black sea bass	Atlantic spadefish
Snowy grouper	Great barracuda
Scamp	Hogfish
Blueline tilefish	Greater amberjack
Tripletail	Sheepshead

3. From this information, students will create a real estate pamphlet that is geared towards their particular species of fish. The pamphlet will describe a home (the type of habitat the fish is most likely to live in and thus, most likely to appeal to it), local restaurants and the food they serve (food that fish would eat), and nurseries that would be used by the young of the species (the places where the young of the species go to mature and why these places are beneficial to them). The location in the coastal waters of these habitats will be described.
4. The last page of the pamphlet will be used to describe potential problems with the habitats they are describing. For adult fish habitats, students should describe things such as fishing pressures the fishes may have to deal with. As many juveniles use salt marshes as nursery grounds, the students will describe the water quality of the salt marsh they have chosen as a nursery, the watershed that flows into it, and potential sources of pollution that may be flowing in with the watershed.

Follow-up Questions

- What happens to pollution that flows into the ocean?
- If a chemical spill occurred in a river located inland, how might it affect the salt marsh areas along the coast?

The BRIDGE Connection

Go to http://www.vims.edu/bridge/ and click on "Virtual Vacationland". Click on the Ocean Temperature link to access images of sea surface temperatures along the Southeast coast.

The "ME" Connection

Ask each student to write down four things they can do at home to protect the habitats of reef fishes and to explain to family members why it is so important to do these four things.

Connections to Other Subjects

Art Extension

Along with reef fish, have students look at other animals in the Southeast region that are threatened or endangered. Have them research life histories of the animal and the threats and stresses to the survival of their population, such as loss of habitat, overfishing, boating, or pollution. Have students create a visual display of their findings and then hang them up in the room to create a gallery walk. Give students the opportunity to examine each other's displays and then as a class, discuss the results.

Social Studies Extension

Using the reef fishes they have created a pamphlet for, have the students contact biologists and agencies in the Southeast who are responsible for researching and managing that species. Students will find out the causes to any declines in their species populations and the conservation steps currently being planned or implemented. Students will determine what part they can play in the recovery of their species. Students will write up their findings in a report.

Social Studies Extension

Students will contact local restaurants and grocery stores to see what types of fishes they sell. Students will research these fishes to see if any of them are in decline because of overfishing. Students will consider the results they come up with and then write a letter to the grocery store or restaurant expressing their opinions about the fishes they market.

Social Studies Extension

Have the students research actual aquatic ecosystem accidents in South Carolina. For example, in 1999 loons and other aquatic birds covered in oil began to wash ashore on the Atlantic coast. Have the students research and plot the location of the accident on a map. Students should determine the species affected by the accident. Students should determine the cleanup procedures for the species and the ecosystem and the punitive actions involved.

Evaluation

In their pamphlets students will:

- Describe a hard bottom habitat
- Describe the habitat and food requirements of their target species
- Describe stressors for the survival of their fish
- Explain how inland watersheds can affect reef fishes

Scoring Rubric (Out of 5 points):

In their pamphlets: (Each question is 1 point)

- Describe a hard bottom habitat as a habitat off the South Carolina coast that is composed of rocky outcrops and is a home to a variety of animals: 1 point
- Describe at least two of the habitat requirements of their chosen species: 1 point
- Describe at least two of the food requirements of their chosen species: 1 point
- Describe at least one stressor that may affect the survival of their chosen species: 1 point
- Describe at least one way that inland watersheds affect their target species: 1 point
- Total: 5 points

Extensions

Have students submit questions for the researchers participating in the South Atlantic Bight Expedition to answer.

Resources

Teacher Reference Books:

Moyle, Peter B. Fish: *An Enthusiast's Guide*, University

of California Press, Berkley, 1993. Basic biology and information is provided on fishes.

Moyle, Peter B. and Joseph J. Cech, Jr. *Fishes: An Introduction to Ichthyology,* Prentice Hall, New Jersey, 2000. Though admittedly college textbooks are often a little too dry and in-depth, with their text, photographs and illustrations they are often the best resources for finding information on a particular subject. This college textbook is an excellent resource for anyone wanting to know more about fish.

The Audubon Society Field Guide to North American Fishes, Whales and Dolphins, Alfred A. Knopf, New York, 1993. This field guide contains colorful photographs and information on fish North America

Reference Web sites

EPA'S Environmental Education Center
www.epa.gov/teacher – Provides information on water and watersheds and links to other sites.

EPA Office of Water: Office of Wetlands, Oceans and Watersheds
www.epa.gov/owow/ – Provides information on watersheds, wetlands, water quality plus much more.

Fish Identification
www.indian-river.fl.us/fishing/fish/index.html – This site provides information on specific species of fishes found along the South Carolina coastline and in the southeastern Atlantic Ocean.

NOAA Fisheries: National Marine Fisheries Service
www.nmfs.noaa.gov/ – The latest research information is provided at the informative site.

South Carolina Department of Natural Resources: Fishing
www.dnr.state.sc.us/ – Offers information on all Divisions of the DNR. The fishing page is full of information.

Surf Your Watershed: A Service to Help You Locate, Use, and Share Environmental Information About Your Place
www.epa.gov/surf – This site allows you to learn specific information related to the watershed your town is located in.

U.S. Geological Survey
www.usgs.gov/
This site offers valuable earth science information on a variety of topics.

Water Science for Schools
http://ga.water.usgs.gov/edu/ – Background information on water and watersheds is provided on this site.

Additional websites for student research:
http://www.divediscover.whoi.edu
http://www.nationalgeographic.com
http://www.marine.whoi.edu/ships/alvin/alvin.htm
http://www.ocean.udel.edu/deepsea
http://www.pbs.org/wgbh/nova/abyss/life/extremes.html
http://www.whoi.edu/WHOI/VideoGallery/vent.html

Student Reference Books:

National Audubon Society First Field Guide: Fishes, Scholastic Inc., New York, 2000. This field guide is a great resource for students. It provides colorful photographs and information on a variety of fish.

Student Fiction Books:

Cherry, Lynne. *A River Ran Wild*, Gulliver Books/ HBJ, San Diego, California,1992. Follow the environmental history of the Nashua River, from its discovery to present day. Learn how it was polluted during the Industrial Revolution but has since been cleaned.

Curricula:

Aquatic Project WILD
Aquatic Project WILD is an interdisciplinary curriculum for K-12 teachers on aquatic wildlife and ecosystems. The activities cover a broad range of

environmental and conservation topics. For more information click on:
www.dnr.state.sc.us/cec/educate/edu1.html#teacher

JASON Project
The JASON Project is an interdisciplinary curriculum for K-12 teachers focusing on the geology, climate, biology and biodiversity of specific regions in the world. The activities cover a broad range of topics.

Project WET
Project WET is an interdisciplinary curriculum for K-12 teachers on water. The activities cover a wide range of water-related topics. For more information visit the website at: www.montana.edu/wwwwet

SC MAPS
SC MAPS is a standards-based interdisciplinary curriculum for middle school teachers that focuses on the geology of the five regions of South Carolina using aerial photographs, images and topographic maps. For more information visit the website at: www.ces.clemson.edu/scmaps

National Science Education Standards

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science
- Structure and function in living systems
- Populations and ecosystems

Content Standard D: Earth and Space Science
- Structure of the Earth system

For More Information

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