Teacher Guide—Life Science Module
Activity 3 — Biodiversity in an Estuary

Featured NERRS Estuary:
Rookery Bay National Estuarine Research Reserve, Florida

http://nerrs.noaa.gov/RookeryBay/welcome.html

Activity Summary

In this activity, students investigate the incredible biodiversity that exists in estuarine environments. They begin by exploring the Rookery Bay National Estuarine Research Reserve (NERR) using Google Earth. Students then produce an estuary biodiversity concept map and individual organism profile that becomes part of an estuary wildlife exhibit.

Learning Objectives

Students will be able to:

1. Describe the physical and biological components of habitats that exist as part of an estuary.
2. Explain the relationships between primary producers, consumers, and secondary consumers.
3. Describe some adaptations of living organisms to the changing conditions within an estuary.
4. Explain why biodiversity is important and worth preserving in an estuary.

Grade Levels

9-12

Teaching Time

4 (55 minute) class sessions + homework

Organization of the Activity

This activity consists of 3 parts which help deepen understanding of estuarine systems:

Investigating Habitats in an Estuary

Biodiversity in an Estuary

Portrait of Life in an Estuary

Background

This activity introduces students to the amazing biodiversity of an estuarine environment, focusing on the habitats in the Rookery Bay National Estuarine Research Reserve (RBNERR). The reserve is located at the northern end of the Ten

Thousand Islands on the gulf coast of Florida and represents one of the few remaining undisturbed mangrove estuaries in North America. The total estimated surface area of open waters encompassed within proposed boundaries is 70,000 acres, 64 percent of RBNERR. The remaining 40,000 acres are composed primarily of mangroves, fresh to brackish water marshes, and upland habitats.

Rookery Bay has a surface area of 1,034 acres and a mean depth of about 1 m. Salinities range from 18.5 to 39.4 parts per thousand with lower values occurring during the wet season from May through October. Highest values occur during the dry seasons (winter and spring) and can exceed those of the open Gulf of Mexico (35-36 parts per thousand).

Preparation

- Download Google Earth, if you haven't already done so, and install it on your classroom computer (s) or computer lab machines *http://earth.google.com/* (Refer to *Using Google Earth to Explore Estuaries*, for a brief how-to guide.)

- Arrange for students to access the Internet and/or other resources on organisms. For example, the University of Michigan Museum of Zoology's Animal Diversity Web site: *http://animaldiversity.ummz.umich.edu/site/index.html*

- Obtain the poster paper for the concept maps in Part 2 and the poster board for the students' organism profiles in Part 3.

- Make copies of the *Student Reading* and *Student Worksheet*.

- If feasible, assign the *Student Reading—Introduction to Rookery Bay* and *Student Reading—Biodiversity in an Estuary* before beginning the activity, as preparation for Part 1.

Google Earth

This activity *requires* the use of Google Earth. If students have computer access, the use of Google Earth (http://earth.google.com/) can help them develop spatial skills.

Find Tutorial "*Using Google Earth to Explore Estuaries*" in estuaries.gov, click under Teachers, Classroom Activities and find the tutorial.

Materials

Students

- ❑ Need to work in a computer lab or with a computer and projector
- ❑ Copy of Student Reading Estuary and Watershed
- ❑ Copy of Student Worksheet Estuary and Watershed, Student Data Sheet 1 — Orienting Yourself to the San Francisco Estuary and Watershed
- ❑ Copy of Student Data Sheet 2 — Water Quality Data

Teachers

- large sheets of poster paper (for Part 2)
- large pieces of poster board (for Part 3)

Equipment:
- ❑ Computer lab or
- ❑ Computer and Projector

Procedure

Part 1 — Investigating Habitats in an Estuary

1. Have students read the *Student Reading—Introduction to Rookery Bay* and *Student Reading—Biodiversity in an Estuary*.

2. Show students their starting point (Rookery Bay National Estuarine Research Reserve; 26° 01' 30.55 N, 81° 43' 54.20 W) in Google Earth and have them complete Part 1 of the *Student Worksheet—Biodiversity in an Estuary*.

   If students are using Google Earth for the first time, show them how to use the Search tool, how to zoom in and out to change viewing altitude, and how to use the motion buttons to navigate around the image. (Refer to *Using Google Earth to Explore Estuaries*, available online where you acquired this activity, for a brief how-to guide, or have students go through the "Navigating in Google Earth" tutorial at *earth.google.com/userguide/v4/tutorials/navigating.html*.)

   Discuss why the images seem to change, particularly the color and resolution of some of the images.

3. Review and discuss the Part 1 tasks and questions.

Part 2 — Biodiversity in an Estuary

4. Divide the class into teams, distribute the large paper, and explain that they will produce a large concept map that underscores the biodiversity and the interrelationships of organisms in the dynamic estuarine environment.

5. Have students read the introduction in Part 2 of the *Student Worksheet—Biodiversity in an Estuary*, which describes concept maps. If students are unfamiliar with concept maps, consider drawing a sample concept map on a general topic, such as your school.

6. Have the student teams create their Rookery Bay concept maps, starting with a box that has "Rookery Bay Reserve" and following the instructions in the Concept Map section in Part 2 of the *Student Worksheet—Biodiversity in an Estuary*.

7. When students are done with their concept maps, attach the maps to a board or wall and have a discussion on the similarities and differences between the various maps.

8. Have students answer the question to complete Part 2 of the *Student Worksheet—Biodiversity in an Estuary*.

National Science Education Standards

Content Standard A: Science as Inquiry

A3. Use technology and mathematics to improve investigations and communications.

A4. Formulate and revise scientific explanations using logic and evidence.

A6. Communicate and defend a scientific argument.

Content Standard B: Physical Science

B6. Interactions of energy and matter

Content Standard C: Life Science

C4. The interdependence of organisms

C5. Matter, energy, and organization in living systems

Content Standard F: Science in Personal and Social Perspectives

F3. Natural Resources

F4. Environmental quality

F5. Natural and human-induced hazards

F6. Science and technology in local, national, and global challenges

Part 3 — Portrait of Life in an Estuary: A Wildlife Exhibit

9. Assign or have students select one organism from an estuary to study in detail. You can have students draw the name of an organism out of a bowl (proverbial hat…) or you can have them choose one organism that they would like to focus on.

10. Have students complete Part 3 of the *Student Worksheet—Biodiversity in an Estuary* and produce a poster on their organism.

11. When students finish their posters, create a class exhibit to serve as a viewing area and post students' work.

12. Allow students sufficient time to circulate and read all the class posters.

13. Lead a discussion of the importance of biodiversity, using examples where low biodiversity was problematic, and review the tasks and questions of Part 3.

Check for Understanding

1. Use the concept maps from Part 2 as an assessment of student understanding of the relationships between habitats, characteristics of the habitats, and the species that inhabit the estuary.

   A simple way to do this is to give 1 point for each link on the concept map between two of the three variables. Then, award 2 points for each double link (two lines that reveal a relationship). Add 3 points for complex interrelationships in the concept map (3 or more lines coming from one box). Establish a class scale based on the total points given for each poster.

2. Evaluate the Wildlife Exhibit posters as a summative performance assessment for this activity.

3. Have a discussion with students after the Wildlife Exhibit viewing has ended. Ask students:

- Which animals or plants in Rookery Bay are endangered?
- What conditions in the estuary have caused populations of each of the endangered species to decline?
- Are any actions being taken or projects underway to protect the remaining population and support its recovery?

Optional Extension Inquiries

Ask for permission to take samples of plants native to the estuary region and have student teams compile a pressed sample book. Have students organize their field collection by creating a multi-stage classification and a dichotomous key for the samples they collected.

Teacher Worksheet with Answers
Activity 3: Biodiversity in an Estuary

1a. Describe the estuary features and landforms you saw as you examined the Florida coast.

Answer: Students should mention bays, inlets, wetlands, barrier beaches, and others.

1b. List the types of habitats you identified in the Rookery Bay National Estuarine Research Reserve.

Answer: Upland forests, mangrove forest, salt marsh, and tidal flats habitats are evident.

2. Were there any animal species that were not linked to another with at least one arrow?

Answer: Each species should be have at least one connection to another species and most will have more than one.

3a. Which animals or plants in Rookery Bay are endangered?

Answer: The Florida manatee is endangered. A rare and endangered species list for Rookery Bay can be found at www.dep.state.fl.us/coastal/sites/rookery/species.htm.

3b. Choose one of the endangered animals and find out what conditions have caused its populations to decline. Are any actions being taken or projects underway to protect the remaining population and support its recovery?

Answer: Student answers will vary.

Student Reading—1
Activity 3: Introduction to Rookery Bay NERR

Located at the northern end of the Ten Thousand Islands on the gulf coast of Florida, Rookery Bay National Estuarine Research Reserve (NERR) is a prime example of a nearly pristine subtropical mangrove forested estuary. The Rookery Bay estuarine ecosystem contains bays, interconnected tidal embayments, lagoons and tidal streams. Sources of freshwater drainage include sloughs, strands, a series of tidal creeks and channels, and canals.

A unique upland feature of the Rookery Bay NERR and adjacent region are shell mounds. These are mostly refuse sites used by aboriginal Indians. The mounds form prominent topographical features above the low-lying tidelands of the Reserve.

The region is known for its commercially valuable fishes and shellfish, including mullets, blue crabs and stone crabs. Agriculture, eco-tourism, fishing, and boating are important revenue sources in the region, and the undeveloped areas of the reserve and the Aquatic Preserve are heavily used year-round.

The core of the reserve is currently 12,500 acres of open water, mangrove wetlands, and pine and oak uplands. The state's Rookery Bay Aquatic Preserve and Cape Romano/Ten Thousand Islands Aquatic Preserve are also managed by the reserve, bringing the total of state lands and water managed by the reserve to 112,000 acres.

Figure 1. Rookery Bay seen through an arch of Mangrove trees

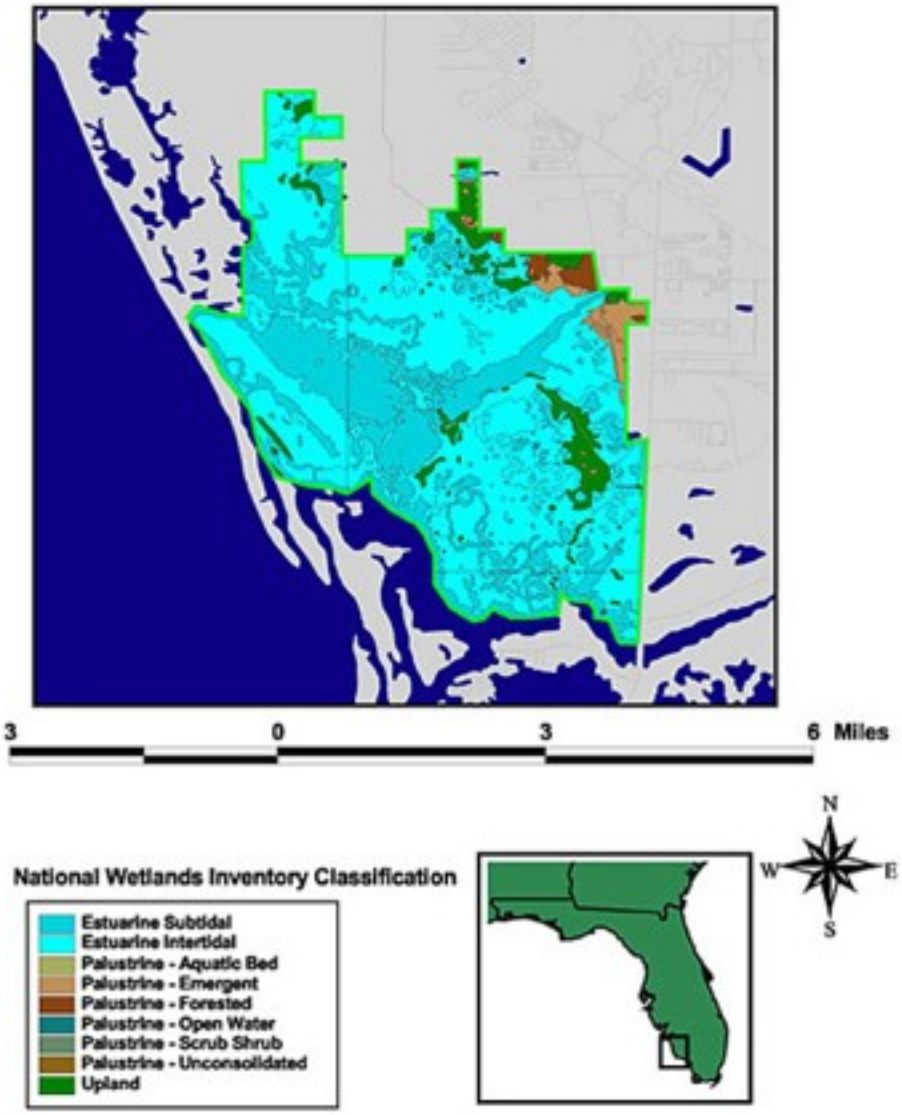


Figure 2. Many diverse habitats occur in the reserve and adjacent lands. Some of these are: 1) Pine/Cabbage Palm/Oak, 2) Pine Flatwoods, 3) Coastal Scrub, 4) Cypress Forest, 5) Freshwater Marsh, 6) Saltwater Marsh, 7) Mangrove Forests, 8) Coastal Strand, and 9) Open Water.

- Adapted from http://nerrs.noaa.gov/RookeryBay/welcome.html and http://www.dep.state.fl.us/coastal/sites/rookery/info.htm

Student Reading—2
Activity 3: Biodiversity in an Estuary

An estuary is a partially enclosed body of water, and its surrounding coastal habitats, where saltwater from the ocean mixes with fresh water from rivers, streams, or groundwater. In fresh water, the concentration of salts, or salinity, is nearly zero. The salinity of water in the ocean averages about 35 parts per thousand (ppt). The mixture of saltwater and freshwater in estuaries is called **brackish** water. An amazing number of plant and animal species have found ways to adapt to the dynamic and ever-changing environmental conditions in the estuary.

A rich array of habitats surrounds estuaries. Habitat type is usually determined by the local geology and climate. Some habitats associated with estuaries include:

- salt marshes
- mudflats
- rocky intertidal shores
- sea grass beds
- mangrove forest
- tidal streams
- barrier beaches

In almost all estuaries, the salinity of the water changes constantly over the tidal cycle. To survive in these conditions, plants and animals living in estuaries must be able to respond quickly to drastic changes in salinity. Plants and animals that can tolerate only slight changes in salinity are called stenohaline. These organisms usually live in either freshwater or saltwater environments. Most stenohaline organisms cannot tolerate the rapid changes in salinity that occurs during each tidal cycle in an estuary.

Plants and animals that can tolerate a wide range of salinities are called euryhaline. These are the plants and animals most often found in the brackish waters of estuaries. There are far fewer euryhaline than stenohaline organisms because it requires a lot of energy and specialized adaptations to tolerate constantly changing salinities. Organisms that can do this are rare and special.

Some organisms have evolved special physical structures to cope with changing salinity. The smooth cordgrass found in salt marshes, for example, has special filters on its roots to remove salts from the water it absorbs. This plant also expels excess salt through its leaves.

Figure 3. Oysters have the ability to adapt to changes in salinity by opening or closing their shells

Oysters and other bivalves, like mussels and clams, can live in the brackish waters of estuaries by adapting their behavior to the changing environment. During low tides when they are exposed to low-salinity water, oysters close up their shells and stop feeding. Isolated in their shells, oysters switch from aerobic respiration (breathing oxygen through their gills) to anaerobic respiration, which does not require oxygen. Hours later, when the high tides return and the salinity levels in the water are considerably higher, the oysters open their shells and return to feeding and breathing oxygen.

Unlike plants, which typically live their whole lives rooted to one spot, many animals that live in estuaries must change their behavior according to the surrounding waters' salinity in order to survive. Blue crabs are good examples of animals that do this.

A Study of One Estuarine Habitat — Mangrove Forest

Mangrove forests grow at tropical and subtropical latitudes near the equator where the sea surface temperatures never fall below 16°C. Mangrove forests line about two-thirds of the coastlines in tropical areas of the world. All mangrove trees are able grow in hypoxic (oxygen poor) soils where slow-moving waters allow fine sediments to accumulate. Mangrove forests can be recognized by their dense tangle of prop roots that make the trees appear to be standing on stilts above the water. This tangle of roots helps to slow the movement of tidal waters, causing even more sediments to settle out of the water and build up the muddy bottom. Mangrove forests stabilize the coastline, reducing erosion from storm surges, currents, waves and tides.

Figure 4. Mangrove forests are common along the southern coast of the United States.

Three dominant species of mangrove tree are found in Florida. The red mangrove colonizes the seaward side of the forest and black mangroves are found further inland. The zone in which black mangrove trees are found is only shallowly flooded during high tides. White mangrove trees face inland and dominate the highest terrain in the estuary. Tidal waters almost never flood the zone where white mangrove trees grow.

—Adapted from
oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar06b_mangrove.html

Biodiversity in a Mangrove Forest

The mangrove forest is a habitat for many species. It provides nursery grounds for young fish, crustaceans and mollusks. Many fish feed in the mangrove forests, including Snook, Mangrove Snapper, Tarpon, Jack, Sheepshead, Red Drum, Juvenile Blue Angelfish, Lined Seahorse, and Great Barracuda as well as shrimp and clams. An estimated 75% of the game fish and 90% of the commercial fish species in south Florida depend on the mangrove system.

The branches of mangroves serve as roosts and rookeries for coastal and wading birds, such as the Roseate Spoonbill, Double-Crested Cormorant, Great Egret, Great Blue Heron, Osprey, Snowy Egret, Green Heron, and Greater Yellowlegs. Other animals that shelter in the mangroves are the American Coot, American Crocodile, Bald Eagle, Peregrine Falcon, Eastern Diamondback Rattlesnake, and the Atlantic Saltmarsh Snake.

Figure 5. Ospreys are secondary consumers. They feed almost entirely on fish they capture from fresh or saltwater.

Above the water mangroves also shelter and support snails, periwinkles, crabs, spiders, Spanish moss, and Reindeer lichen. Below the water's surface, often encrusted on the mangrove roots, are sponges, anemones, corals, oysters, mussels, starfish, crabs, and Florida Spiny lobster.

As you can see, a unique mix of marine and terrestrial species lives in mangrove forests. The still, sheltered waters among the mangrove roots provide protective breeding, feeding, and nursery areas for a host of animal species important to commercial and recreational fisheries. Protecting this habitat is truly a matter of national importance.

Animal species that inhabit any habitat are classified as either **primary producers**, **primary consumers,** or **secondary consumers**. Green plants, algae, and diatoms are examples of primary producers—organisms that produce their own food through the process of photosynthesis. Primary consumers like minnows and other aquatic species eat the algae to provide their energy needs.

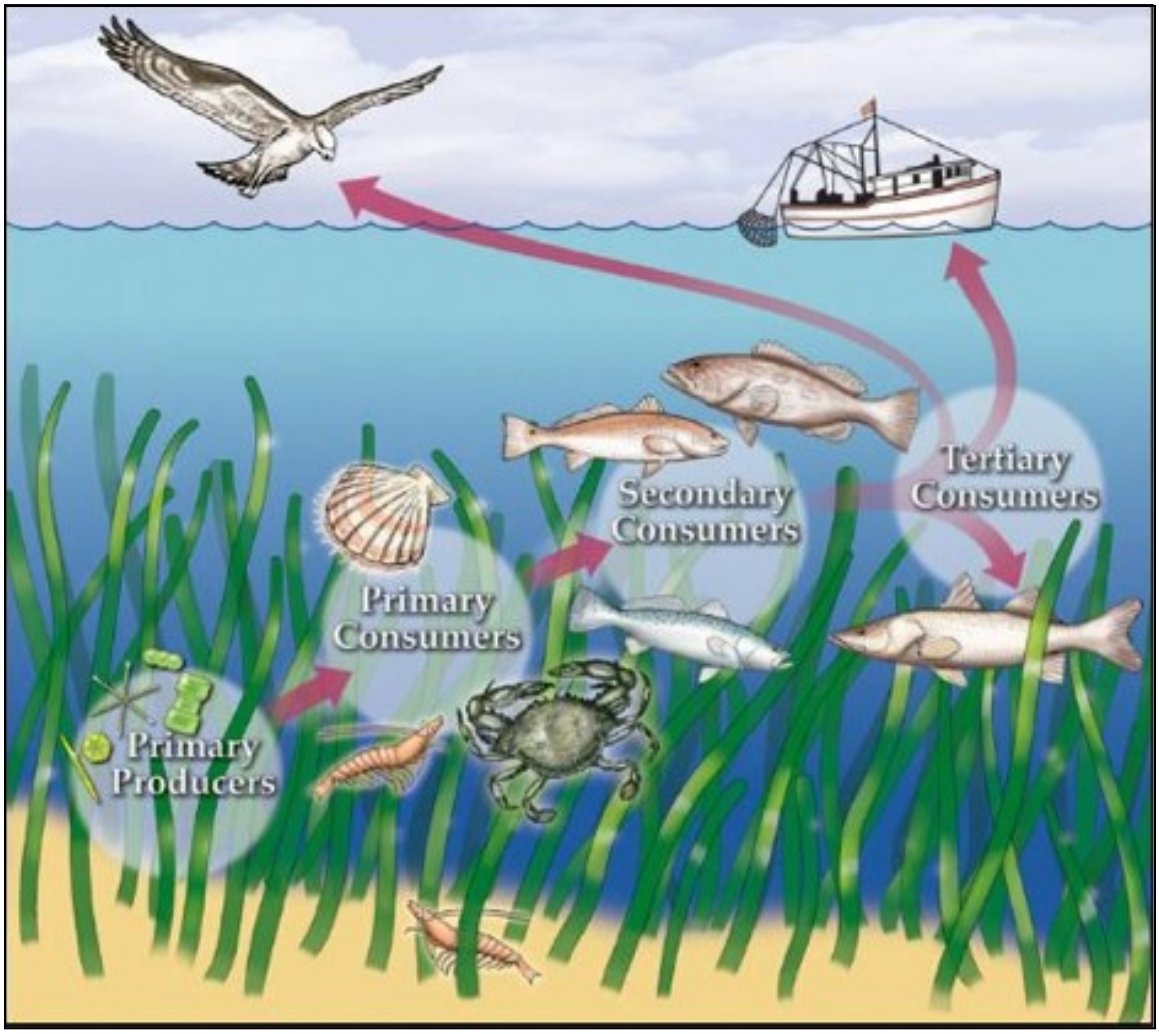


Figure 6. Producers and consumers in an estuarine environment. (Nutrients and Florida's Coastal Waters: The Links Between People, Increased Nutrients and Changes to Coastal Aquatic Systems. http://edis.ifas.ufl.edu/SG061. Published by the Florida Sea Grant College Program with support from the National Oceanic and Atmospheric Administration, Office of Sea Grant, U.S. Department of Commerce. Published for the University of Florida, Institute of Food and Agricultural Sciences [SGEB-55]. October 2001.) Accessed: 2008-07-20.(Archived by WebCite® at http://www.webcitation.org/5ZhWgbRvv)

Organisms such as larger fish that eat primary consumers are called secondary consumers. Birds of prey such as ospreys are secondary or tertiary consumers, as they dive into the water to capture fish in their talons.

Why is Biodiversity Important?

The natural environment is the source of all our resources for life. Environmental processes provide a wealth of services to the living world—air to breathe, water to drink, and food to eat, as well as materials to use in our daily lives and natural beauty to enjoy.

A complex ecosystem like an estuary with a wide variety of plants and animals tends to be more stable. A highly diverse ecosystem is a sign of a healthy system. Since the entire living world relies on the natural environment, especially humans, it is in our best interest and the interest of future generations to conserve biodiversity and our resources.

Some might argue that some species have become extinct with no obvious effect on the environment. But the Earth's systems are so complex that we are still learning about environmental processes and resources and the roles they play. The careless loss of any part of the natural environment means that we may never know what use it was or could have been in terms of future technologies, say, or for medical science, or indeed for the health of the planet itself.

It is important to understand that environments are constantly changing. A healthy, robust environment evolves and adapts to naturally changing conditions. It is fascinating to observe the far-reaching effects that even small changes can make and the importance of genetic diversity for species to adapt, survive and evolve.

Preservation of biodiversity is not necessarily about preserving everything currently in existence. It is more a question of "walking lightly" on the Earth—a balance of respecting the natural changes that occur and of protecting species and environments from wanton extinction and destruction.

Life on Earth would not be the same if our planet's biodiversity were to be radically affected. Estuaries are complex ecosystems that are home for a number of plants and animal species. The loss of a single species has consequences for many others living in the same habitat.

- Adapted from: URL:http://eco-online.qld.edu.au/novascotia/whatsbio/importance.html. Accessed: 2008-07-30. (Archived by WebCite® at http://www.webcitation.org/5Zhq3RSh2)

Student Worksheet
Activity 3: Biodiversity in an Estuary

Student Name:_____

Part 1: Investigating Habitats in an Estuary

In this activity, you will explore the habitats that compose the Rookery Bay Reserve near Naples, Florida.

Open Google Earth and enter the following coordinates in the Search Window: 26° 01' 30.55 N, 81° 43' 54.20 W.

Zoom in to an Eye altitude of 400 m. You should see the main Field Station (buildings in the vicinity of the long dock) of the Rookery Bay Reserve.

Fly south along the coast at a viewing altitude of about 4 km.

1a. Describe the estuary features and landforms you saw as you examined the Florida coast.

Keep going down the coast. You will pass a series of bays: Johnson, East Marco, Goodland, Turtle, and Rookery to name some of the major ones. Stop when you arrive at the region that is bounded by Faka Union Bay and Faka-hatchee Bay.

Zoom into this region and examine the type of habitat that surrounds these bays. Can you locate this region on the map of the Rookery Bay Reserve given below?

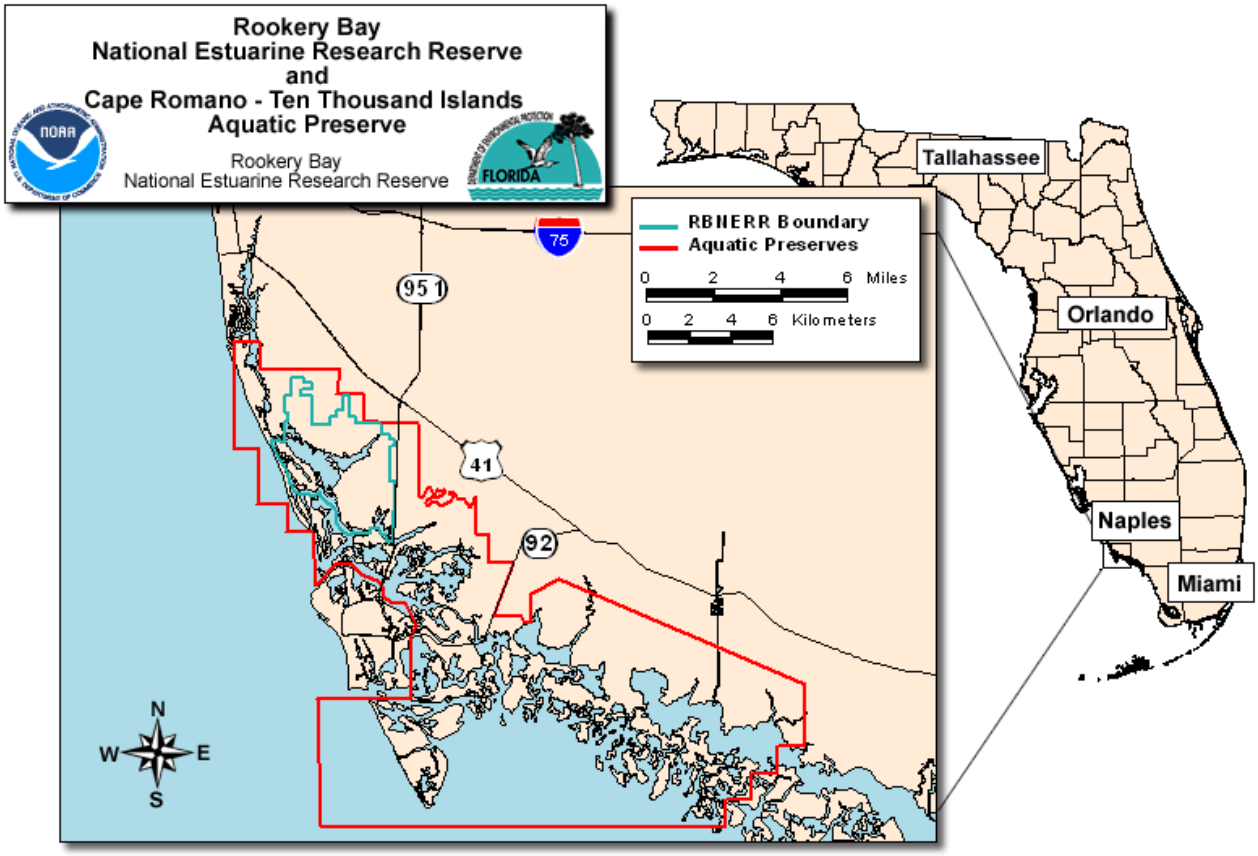


Figure 7. Map of the Rookery Bay NERR

1b. List the types of habitats you identified in the Rookery Bay Reserve. In the first column, list the habitat you identified. In the second column, identify the characteristics of each habitat. In the third column, note whether the habitat is land (terrestrial) or water (aquatic). In the fourth column, note special challenges to living in each habitat to plant and animal species.

Habitat Type

Name of Habitat	Characteristics	Terrestrial or Aquatic	Challenges

Part 2: Biodiversity Concept Map

Every plant and animal that exists in an estuary has a role in the ecosystem. Species depend on each other for food, for shelter, or other life processes. In this part of the activity, you will produce a concept map that shows how the estuarine environment supports the interrelationships of the plants and animals that reside in it.

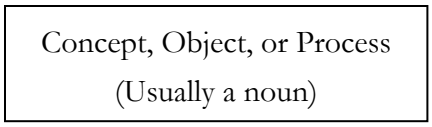
Introduction

Every topic can be broken down into a set of distinct factors. Think about topics such as acid rain, cleaning your room, putting on a dance, the water cycle, or doing homework. You can break each of these down into separate components, which together describe the larger topic. A concept map is a visual way to show how a topic's components or factors are connected or related. In fact, you can think of concept maps as a visual way to outline a topic.

The first step in making a concept map is to identify the individual elements involved in the topic. Just as when you tell a story, you must first identify all the elements before you begin—the characters, the settings, and the plot. A concept map helps people identify which ideas are essential to a topic and which are secondary or only weakly connected. The second step in making a concept map is to show how the parts relate to one another.

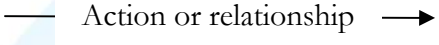
The following guidelines will help you make concept maps that are descriptive and complete.

Concepts, objects, places, or processes appear in boxes. Most often, these words are nouns.

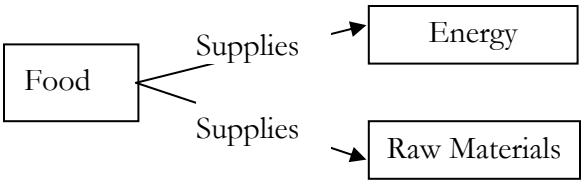


Example:

Arrows connect one box to another. The arrow's direction indicates how the reader should progress through the ideas. Words describing the actions and relationships appear on or just above the arrows connecting different boxes. Most often, these labels are verbs.



Example:



When labeling an arrow, using a noun (or a phrase such as "results in") is a clue that you can probably break the down the flow into more components and refine what is in the boxes.

If a box does not connect to the main topic being described in a concept map, then there is no need to draw a connection. When it is complete, you should be able read a concept map as if it were a paragraph or even a story. Select a box, and read along a sequence of arrows. The boxed words and arrow labels should make sense and explain how the ideas interconnect. In the supernova example, you can trace the sequence describing how stars and planets form by starting at any box.

Concept Map

Create a concept map.

- Begin your map with a single box with Rookery Bay Reserve in it.
- Include the major habitats that exist within the estuary (examples: Mangrove forest, tidal flats, etc.).
- Include characteristics of each habitat (see Habitat Table), salinity and other physical and chemical properties of the water (shallow, deep, fresh water, pH, etc.).
- Include the following plant and animal species: algae, Mangrove trees, clams, oysters, shrimp, periwinkles, horseshoe crabs, blue crabs, sea turtles, Snook, Mangrove Snapper, Tarpon, Juvenile Blue Angelfish, Lined Seahorse, Barracuda, Great Blue Heron, Osprey, Snowy Egret, Green Heron, Greater Yellowlegs, American Coot, American Crocodile, Bald Eagle, Peregrine Falcon, Eastern Diamondback Rattlesnake, and Florida manatee.
- If possible, consult the Rookery Bay field guide for a list of more species to add to your map: http://www.rookerybay.org/Field-Guide.html.
- Indicate which species are primary producers, primary consumers, and secondary consumers.

Question

2. Were there any animal species that were not linked to another species with at least one arrow?

Part 3 — Portrait of Life in an Estuary: A Wildlife Exhibit

In this Part of the activity, you will explore the life of a single animal or plant species and describe how the species adapts to conditions within the estuary. You will either be assigned an organism or allowed to select one that interests you from this estuary system.

Produce a poster about your animal or plant. Include the following:

- A clear title, including the name of your organism;
- The names of the students on your team;
- A series of pictures from the Internet or magazines of your organism;
- Information and, when feasible, pictures on your organism's life cycle, preferred habitat, adaptations to changing conditions in the estuary (such as salinity and temperature), primary and secondary food sources, and whether the species is endangered or not; and
- References for where you got your images and information (e.g. the URLs of the Web sites).

Hang your poster as part of a class exhibit on estuary wildlife.

Walk around the finished class exhibit and read all of the posters.