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
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.

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 to 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.

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 mangoes serve as roosts and rookries 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.

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

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

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.
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.

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 Maps and enter the following coordinates in the Search Window: 26° 01' 30.55 N, 81° 43' 54.20 W or type in Rookery Bay Reserve.

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. Using the Biodiversity in an Estuary reference, 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 Fakahatchee 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?
1b. List the types of habitats you identified in the Rookery Bay Reserve. Using the chart (Habitat Type) 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.

<table>
<thead>
<tr>
<th>Name of Habitat</th>
<th>Characteristics</th>
<th>Terrestrial or Aquatic</th>
<th>Challenges</th>
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Introduction

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.

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.

<table>
<thead>
<tr>
<th>Concept, Object, or Process (Usually a noun)</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td></td>
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</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Action or relationship</th>
<th>Example:</th>
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<tbody>
<tr>
<td>Food</td>
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<tr>
<td>Supplies</td>
<td></td>
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<tr>
<td>Raw Materials</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
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</table>

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 Sea-horse, 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: https://rookerybay.org/visit/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

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.