1

Diving Into Ocean Ecosystems

INSIDE:

Objectives

You will be able to:

- Recognize that while most of the planet is covered by ocean, it is not a uniform body of water.
- Give examples of diverse marine ecosystems and their locations on Earth.
- Characterize ecosystem components as abiotic and biotic factors and give examples of how they influence one another.
- Describe the process of biological succession, explaining that marine ecosystems undergo natural, gradual changes over time.
- Discuss how humans affect marine ecosystems both positively and negatively.

Benchmarks

LA.910.4.2.2 The student will record information and ideas from primary and/or secondary sources accurately and coherently, noting the validity and reliability of these sources and attributing sources of information.

SC.912.L.17.4 Describe changes in ecosystems resulting from seasonal variations, climate change and succession.

SC.912.L.17.7 Characterize the biotic and abiotic components that define freshwater systems, marine systems and terrestrial systems.

Engage

The ocean is a huge and mysterious place. Throughout human history, it has always been a source of inspiration. In this course, you will uncover many of the ocean's mysteries, and you will learn that there are many questions still unanswered.

FIGURE 1.1. The wide-open ocean holds many mysteries. Physics, chemistry, biology and Earth science concepts and ideas help scientists solve them.

As you proceed through your study of the ocean in *Marine Science: The Dynamic Ocean*, you will act as a scientist as you ask questions, make observations and draw conclusions based on your observations. Scientists use many tools to learn about the ocean and different strategies to report their findings. You will learn about ocean and satellite technologies; you will see and work with pictures, animations, satellite imagery and models. One important aspect of scientific work is keeping an accurate record of questions, observations, results of experiments and new ideas to test. Most scientists use a *field notebook*, in which they record many of their activities and thinking. Peering into a scientist's field notebook, you would observe labeled sketches, measurements, mathematical calculations and questions. Scientists keep their field notebooks very organized. As they work and evolve their thinking, they refer back to ideas they tried in the past, previous information, data sets and their notes.

You will model the work that scientists do in your exploration of the ocean. Your notebook will hold your ideas, illustrate your thinking and inspire new questions.

1. Think about what you already know about the ocean. What do you picture when you consider its waters? In your notebook, draw a sketch of what you think about when you picture the ocean.

2. Write 4–5 sentences about why you think the ocean is important.

3. Write at least two questions that you have about the ocean. Your questions can be about anything ocean related, including living things, the makeup of the water, how water flows, places in the ocean, etc.

FIGURE 1.2. This Loggerhead Sea Turtle is outfitted with a satellite transmitter. Its release will provide scientists with data based on its movement through the sea.

In the *Marine Science: The Dynamic Ocean* course, you will observe the movements of many marine animals that are tracked by satellite. In most cases scientists attach a small satellite transmitter onto an animal so that they may observe its movements and learn more about its behavior. Life in the ocean is not easy. Marine animals face many challenges, both natural and as a result of human activities. Studying and understanding their movements is the first step in learning to protect them.

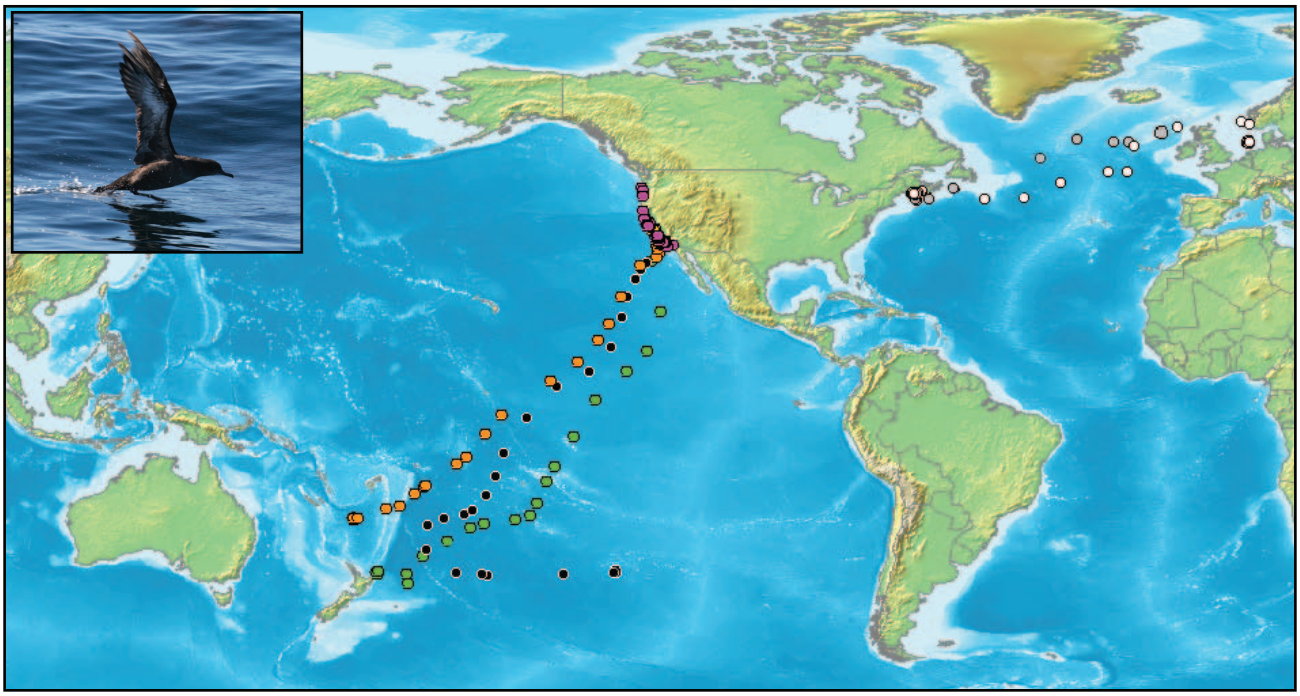

FIGURE 1.3. The map depicts the movements of six independent Sooty Shearwaters. A Sooty Shearwater is a type of seabird.

Each color represents one individual animal and its movement over time. In this case, the animal is a seabird. The map shows the animals' travels over approximately two months. The movement of each animal over a period of time is observed to be thousands of miles.

4. Add at least one question you have about these animals' journeys to the list of questions in your notebook.

Explore

LA.910.4.2.2 The student will record information and ideas from primary and/or secondary sources accurately and coherently, noting the validity and reliability of these sources and attributing sources of information.

SC.912.L.17.7 Characterize the biotic and abiotic components that define freshwater systems, marine systems and terrestrial systems.

Marine Ecosystems Project

In the *Marine Science: The Dynamic Ocean* curriculum program, you will actually study animals and their movements alongside scientists. Some animals will travel thousands of miles, others remain close to home. Regardless of how far each animal travels, it is important to learn about the environments through which they move. You will explore and report on some of the different ocean, or marine, habitats and relate the features of these environments to the needs of the animals.

The ocean covers more than 70% of our Blue Planet. The ocean includes many different ecosystems that range from the depths of the dark seafloor to the sunny surface, from close to shore to thousands of miles away from the coast. Each ocean ecosystem includes living, or **biotic**, and non-living, or **abiotic**, factors that characterize the ecosystem and make it unique. The relationships between interdependent biotic organisms and the physical abiotic factors is very important to the health of the ecosystem and the diversity of life that can exist.

FIGURE 1.4. In *Marine Science: The Dynamic Ocean*, students study animal movements alongside scientist researchers.

Activity

1. Go to the ***Marine Ecosystems Project*** in the e-Tools and select the ecosystem you are assigned. Visit the accompanying website links and read the sources given. You should also use reference materials in the classroom. In your notebook, take notes <u>in your own words</u> that answer the following questions:

e-Tools

   - Describe your ecosystem. Which is it? What would it be like to live in your ecosystem?
   - What are the major biotic factors in your ecosystem?
   - What are the major abiotic factors in your ecosystem?
   - Where in the world can your ecosystem be found? Include a map of the world indicating where your ecosystem can be found.
   - What are the dominant (main) animals and plants in your ecosystem? Include pictures — draw them or print them out — to describe the animals and plants that live in your ecosystem.
   - Describe the habitat in this ecosystem. Carefully consider the various components and determine what challenges an organism might face in your ecosystem (e.g., extreme cold water temperatures, amount of light, etc.).

- How do humans impact this ecosystem? What are some problems that this ecosystem might face in the future because of human activities?
- Identify interesting elements about your environment that you would like to share with the class.

2. Scientists write research papers and create posters to communicate their research, including their observations and findings, and present them at peer conferences and meetings. Other scientists will learn from their colleagues and ask additional research questions. They will often pursue additional research as they seek answers to these questions. This is an important part of the scientific process. Your poster on marine ecosystems will allow your peers to learn from your research and ask additional questions about your work.

   Once your research is complete, report your findings on a poster. The poster must answer all of the questions above. Be creative. Use visuals to help illustrate important points whenever possible. Draw pictures, make charts and tables and so on.

   Keep in mind that the poster you create will be the source for teaching your "classroom scientific community" about the ecosystem.

3. Hang the poster in the classroom.

4. On the ***Classroom World Map***, illustrate the worldwide locations of the ecosystem your group has studied. Label the ecosystem by creating a key.

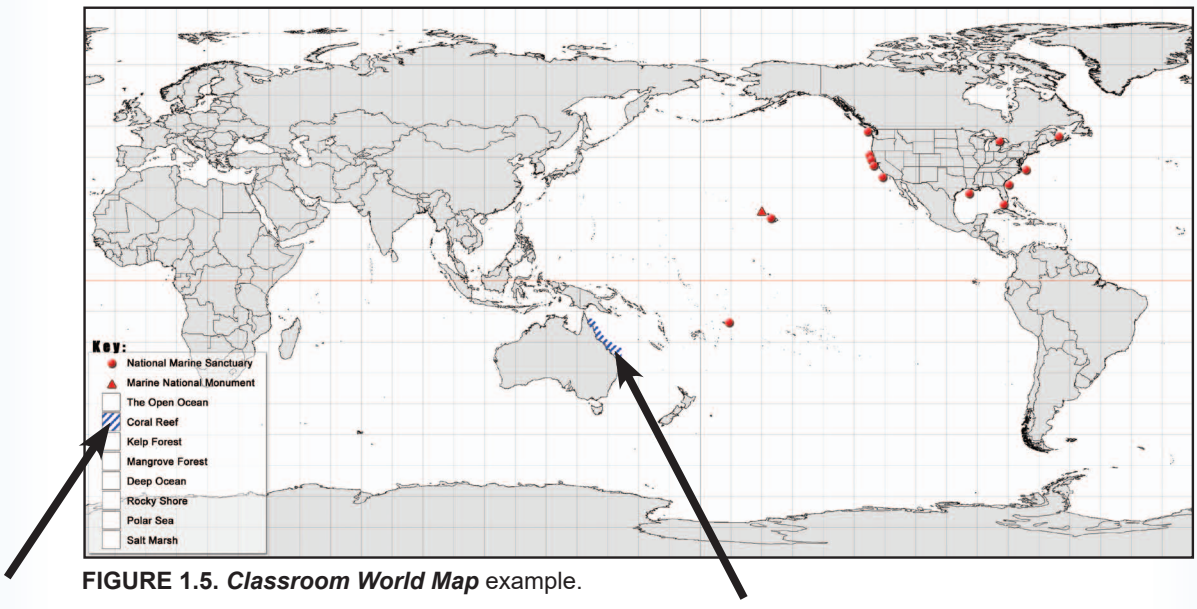

FIGURE 1.5. ***Classroom World Map*** example.

Explain

SC.912.L.17.7 Characterize the biotic and abiotic components that define freshwater systems, marine systems and terrestrial systems.

"Visiting" and Defining Ecosystems

5. You are attending a scientific conference on marine ecosystems. Your goal is to understand the characteristics of each marine ecosystem. Walk around the classroom to visit each poster. When visiting each ecosystem, fill in the information sheet or complete the chart in your notebook.

Marine Ecosystems Information Sheet

Ecosystem	Description of what it is like to live in this ecosystem	Examples of biotic factors in this ecosystem	Examples of abiotic factors in this ecosystem
Coral Reef			
Mangrove Forest			
Deep Sea			
Open Ocean			
Kelp Forest			
Polar Sea			
Salt Marsh			
Rocky Shore			

6. What common characteristics do you notice in all the marine ecosystems? What are some major differences?

7. Based on the similarities, what defines an ecosystem?

8. In ecosystems, biotic and abiotic factors influence one another. Give three examples of an interaction between a biotic and abiotic factor in any of the marine ecosystems you studied (e.g., plants [biotic] need sunlight [abiotic] to produce food).

Elaborate

SC.912.17.4 Describe changes in ecosystems resulting from seasonal variations, climate change and succession.

SC.912.L.17.7 Characterize the biotic and abiotic components that define freshwater systems, marine systems and terrestrial systems.

Changing Ecosystems

All of the living things within an environment comprise a **biological community**. The interaction of the living things (biotic factors) with the non-living things (abiotic factors), along with an energy source, create an **ecosystem**. Ecosystems are dynamic—they constantly undergo change. Seasonal temperature fluctuations, changes in nutrient availability, the life cycles of organisms, and the rise and fall of the tides are just a few of the endless examples of natural changes that take place in marine ecosystems. Each living thing, or **organism**, and each molecule of water, source of nutrients, habitat and so on, plays a role in the health and success of the ecosystem. When one of the abiotic or biotic factors changes, or a new factor is introduced, it can affect the rest of the ecosystem.

Case Study 1 - Whale Falls

View the ***Case Study 1 - Whale Falls Video*** (2:30) from the e-Tools and consider what you are seeing.

e-Tools

FIGURE 1.6. Screenshot of ***Case Study 1 - Whale Falls Video***.

9. What do you observe happening?

10. About how many different types of organisms did you see in the short video segment?

11. Do you think what you are observing is the result of a natural event or the result of human activity? Why?

Whales are a majestic and fascinating group of marine mammals with many interesting attributes. The Blue Whale, for instance, is the largest animal to have ever lived on Earth. Whales have the longest migration of all mammals; Humpback Whales, for example, migrate more than 8,000 kilometers (~5,000 miles). During their lifetimes, whales consume large amounts of krill, fish, crustaceans and other organisms, and play an important role in ocean ecosystems. While the average life span of some species of whales is longer than that of humans and most other marine mammals, they too eventually die. When a whale dies, the carcass sinks to the sea floor, an event known as a *whale fall*.

A whale fall introduces an abundance of nutrients to a specific area of the seafloor, and the result can be a significant change to the ecosystem. Scientists estimate that the skeleton of one 90-ton whale contains 5 tons of oil. The rest of the animal's body provides even more nutrients to the tens of thousands of organisms that visit it. Scientists presently know of more than 400 animal species that feed on whale carcasses, and they suspect there are many more of which they are unaware.

The data represented in the diagrams are meant to summarize the current thinking of scientists who study the progression of changes of the decomposing whales and the surrounding environments at whale falls. Few whale falls have been identified early enough in their decomposition for scientists to follow the progression of organisms feeding on the carcass. This is a very active area of research, and scientists are constantly learning more about these unusual habitats. Researchers consider specific whale falls in shallow, mid-level and deep areas of the ocean. A whale fall's living visitors perform specific tasks. To help understand the progression of organisms that feed on whale falls, we have given them descriptive names based on their roles.

Some organisms are responsible for removing the flesh from the whale. These flesh removers include scavenger species, such as hagfishes, sleeper sharks, crabs and others. They feed on the soft tissue of the whale. Another group of organisms, the colonizers, are those that arrive and stay for extended periods of time, living off the tissue left by organisms in the first group. Colonizers include several species of snails, slugs, worms, shrimp, crabs and other crustaceans. Next are the bone-eaters, organisms that eat the whale bone. They are present for long periods, living off the oil contained in whale bone. A very diverse group of organisms, it includes worms that are able to break down whale bone. Finally, what is left of the whale skeleton is decomposed by more bone-eating worms, or nishers, or is covered by sediments on the seafloor.

The varied species that break down the whale exist at all depths. However, the specific species that arrive and perform the decomposition of the whale carcasses are different depending on the depth of the whale fall. In addition, the time it takes for each stage can vary widely. The data presented on the next page represent examples, and are not necessarily generalized to all whale falls at the noted depths. Part of the reason for this uncertainty is that there has been such a small sample size for scientists to study.

FIGURE 1.7. Humpback Whales travel long distances during their seasonal migration, the farthest migration of any mammal. Their life expectancy is about 50 years.

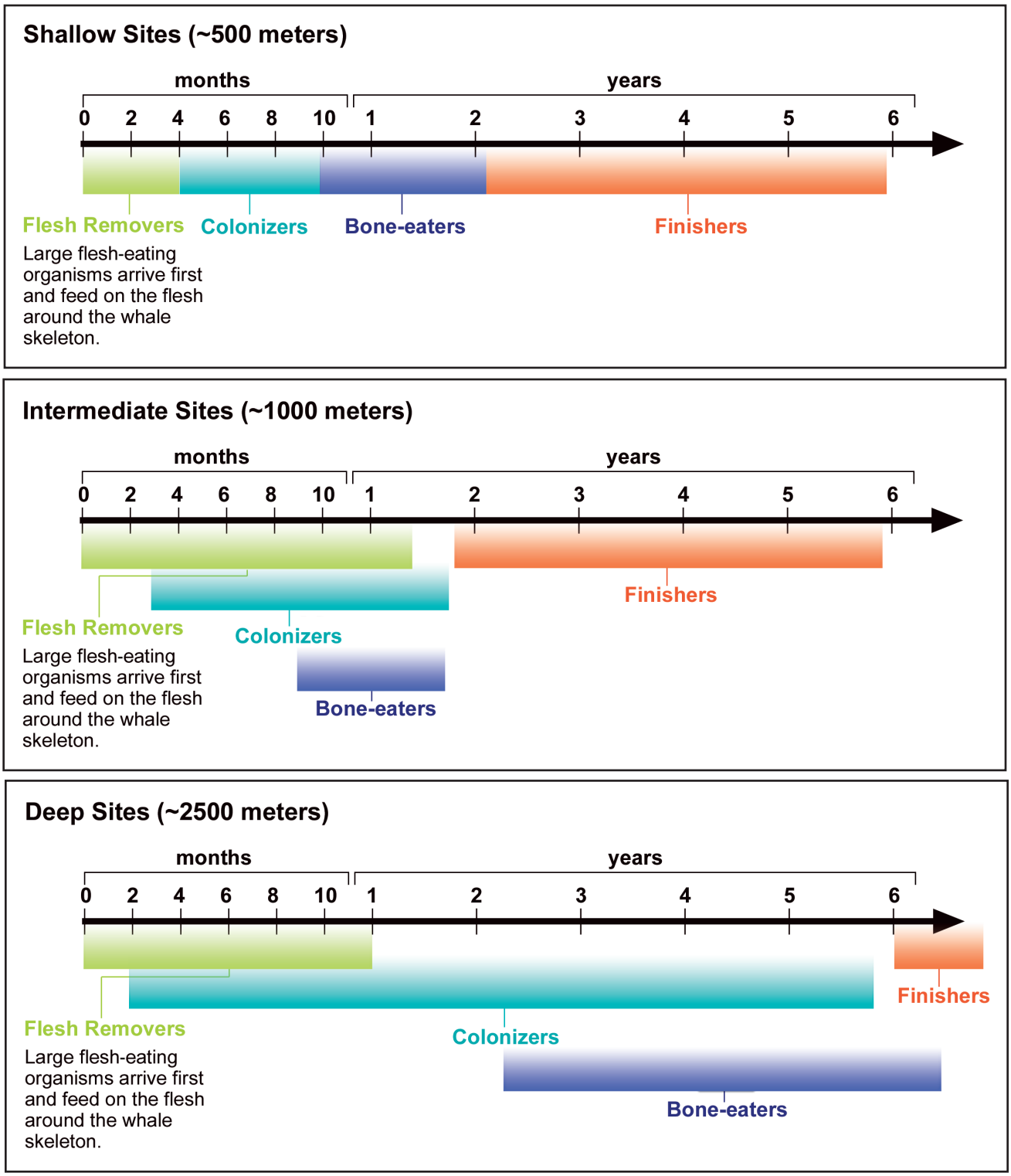

FIGURE 1.8. Diagrams showing whale decomposition at three different depths.

12. Is there a pattern to the order in which organisms visit a whale fall?

The data show that each depth has some variation in the arrival time of groups. For example, organism types in the mid-range versus the deepest sites show some overlap. In shallower sites, organisms visit whale falls without any others. Despite this difference, there is a clear order in which organisms arrive at whale fall sites.

Whale falls are one example of how, after a change occurs in an ecosystem, species progressively replace one another until they reach a stable community, a process also known as **succession**. In this case, the stable community is the seafloor, or **benthic**, ecosystem.

13. What conclusion can you make about the nutrients whale falls bring to the marine ecosystem where they fall?

14. How do whale falls demonstrate succession?

Case Study 2 - Mangrove Restoration

As you learned in your poster presentations of Marine Ecosystems, Mangrove Forests are an important ecosystem for species of fish, plants, birds and other wildlife. Mangrove Forests are found along the coast where freshwater from the land meets saltwater from the ocean, in subtropical and tropical latitudes near the Equator in areas such as Florida, the Caribbean, Australia and India. They cover less than 8% of the Earth's coastlines. The organisms that live in Mangrove Forests are able to survive in water that is slightly salty. Many species rely on the unique biotic and abiotic factors in this environment for breeding, raising their young and finding food. Mangrove Forests are one of the most diverse marine ecosystems and serve many important functions.

FIGURE 1.9. Brackish water is characteristic of a healthy ecosystem. Florida's climate promotes thriving areas and most are located in the southern part of the state.

Very few tree species make up the Mangrove Forests in Florida. The species of trees that grow in the mangrove ecosystem, collectively called **mangroves**, include four main groups: red mangroves, black mangroves, white mangroves and buttonwoods. The mangrove plant community provides a barrier between the ocean and the land. The plants stabilize the soil and reduce erosion from large storms and hurricanes. In addition, mangroves serve as filters for freshwater entering the ocean from the land. Freshwater runoff can contain pollutants and excessive amounts of sediment that can harm ocean ecosystems. Mangroves trap sediments that contain pollutants such as heavy metals (e.g., mercury and lead) and prevent them from being washed into the ocean. If the mangrove forests stay in place, the sediments and pollutants may remain undisturbed for hundreds of years or more.

FIGURE 1.10. Mangrove Forest.

Mangroves are also a significant source of nutrients for marine food chains. Leaves that fall from mangrove trees enter the water and become food for microorganisms. The underwater areas around mangrove roots are utilized by various species for breeding and protection from predators. They are grounds for many commercial species of fish.

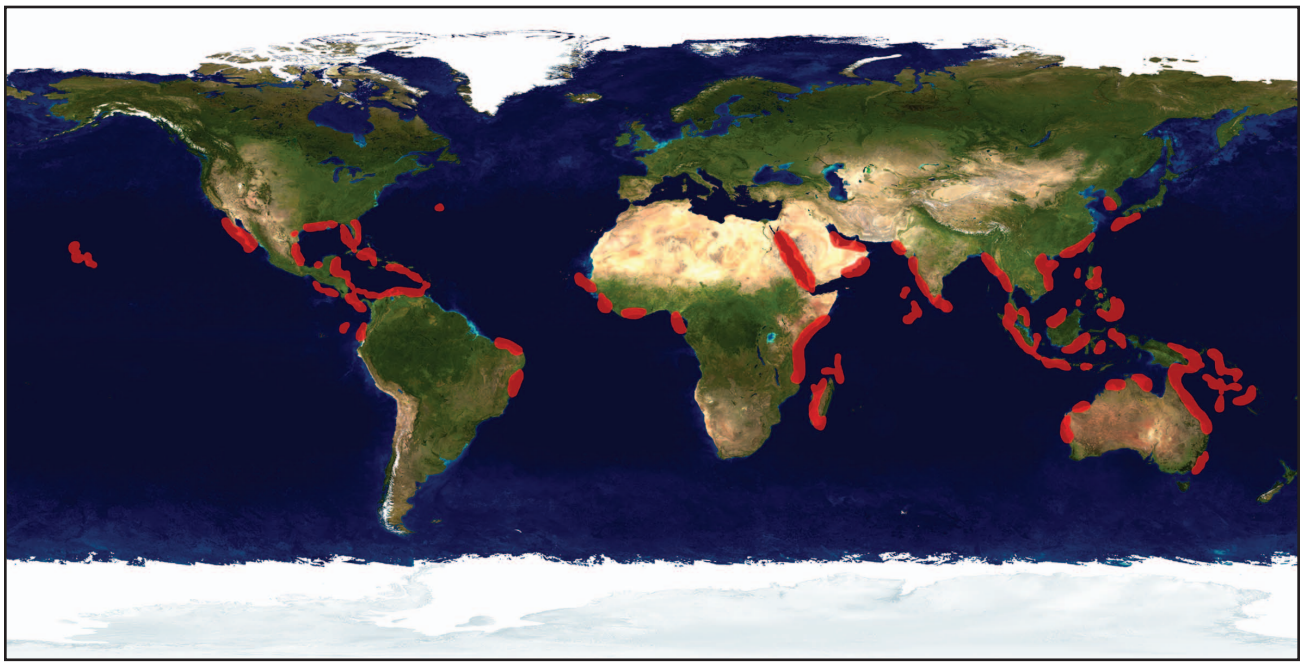

FIGURE 1.11. Global distribution of Mangrove Forests indicated in red on NASA Blue Marble image.

In Florida, mangroves are found from St. Augustine on the Atlantic side of the state and Cedar Key on the Gulf of Mexico side. They stretch southward to the Florida Keys, covering more than half of Florida's coastline.

FIGURE 1.12. Distribution of mangrove forests in Florida indicated in red.

A: Before restoration

B: After restoration

FIGURE 1.13. Mangrove reestablishment at Cross Bayou, Florida.

15. Copy the chart into your notebook. Compare the biotic and abiotic factors in the photographs above.

Photograph	Biotic Factors	Abiotic Factors
A		
B		

16. How do the differences observed between Photographs A and B demonstrate succession?

While the ocean seems very large, human activities on land affect large ocean ecosystems significantly. The ocean's resources are not infinite, and, fortunately, humans are beginning to realize all of us are responsible for protecting our oceans. The United States National Marine Sanctuaries and marine protected areas (MPAs) are illustrated on your ***Classroom World Map***. During the ***Marine Ecosystems Project***, some students "visited" the ecosystems that are found within the Sanctuaries. Now let's learn just what these special places are all about.

What Are National Marine Sanctuaries?

National Marine Sanctuaries are America's underwater treasures. They are a system of 14 marine protected areas that encompass nearly 250,000 square kilometers (more than 150,000 square miles) of marine and Great Lakes waters from Washington State to the Florida Keys and from Lake Huron to American Samoa. These areas have regulations that allow some human activities and do not allow others. Sanctuaries allow both commercial and recreational fishing unless these fishing activities become destructive to habitats. Each sanctuary has different regulations. The rules protect these special habitats. The habitat types are surprisingly quite varied.

FIGURE 1.14. Map showing the locations of National Marine Sanctuaries.

Scientists conduct formal research in sanctuaries to learn more about the ecosystems and the organisms that make them their homes. You can't protect something you don't know about, so research is essential to understanding what lives in the sanctuaries and how marine ecosystems work.

Within their protected waters, giant Humpback Whales breed and calve their young, unique plants and animals flourish and shipwrecks tell stories of our maritime history. Sanctuary habitats include beautiful rocky reefs, lush Kelp Forests, Coral Reefs, whale migration corridors, spectacular deep-sea canyons, and underwater archaeological sites. Our nation's sanctuaries also provide a safe habitat for endangered species, or they can protect historically significant shipwrecks. Ranging in size from less than one square kilometer (~0.4 square mile) to 362,074 square kilometers (~139,797 square miles), each United States National Marine Sanctuary site is a unique place needing special protections.

FIGURE 1.15. Humpback Whale mother and calf.

You may notice from the map above that the largest site within the National Marine Sanctuary system is actually the Papahānaumokuākea (pronounced: pa-pa-HAH-nō-mō-koo-ah-KAY-ah) Marine National Monument, located in the Northwest Hawaiian Islands. Marine National Monuments offer even more protections than National Marine Sanctuaries. For example, commercial fishing is not allowed in the Monument, and tourism is very limited. Papahānaumokuākea was created in 2006 by President George W. Bush and is one of the largest MPAs in the world.

17. Why might the National Marine Sanctuaries be important when studying the paths of marine animals?

Study Spotlight: Florida Keys National Marine Sanctuary

The Florida Keys National Marine Sanctuary was designated by Congress with the passage of the Florida Keys National Marine Sanctuary and Protection Act in 1990. The sanctuary encompasses nearly 10,000 square kilometers (~3,900 square miles) of both state and federal waters surrounding the Florida Keys and the Dry Tortugas. The sanctuary protects nationally significant coral reefs, seagrass meadows and mangrove shorelines and through comprehensive management seeks to conserve the unique natural and maritime heritage resources of the Keys, while balancing the need for recreation, fisheries and other compatible, sustainable activities.

FIGURE 1.16. Map showing location of the Florida Keys National Marine Sanctuary.

The 1990 sanctuary legislation provided a set of "general use" regulations that apply to all sanctuary waters. Examples include: prohibitions on drilling for oil, the removal of live coral or protected wildlife, discharging trash or pollutants, and operating a vessel in such a manner as to strike or injure coral or seagrass. Sanctuary legislation also called for other protective measures—the creation of an Area to Be Avoided to prohibit large tanker vessels from entering shallow waters where they may damage coral reefs and the establishment of the Water Quality Protection Program to promote good near-shore water quality. This program has supported long-term research and monitoring of the coral reefs, water quality and seagrass meadows of the Florida Keys.

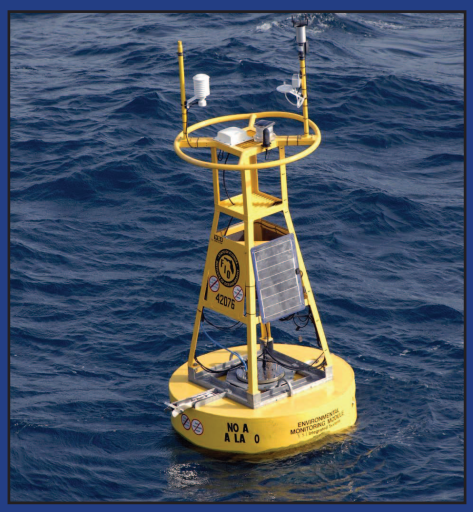

FIGURE 1.17. Marine Protected Personnel and researchers use data from buoys to study coral reefs.

Marine zones are another management tool used by the sanctuary. Zoning is the setting aside of areas for specific activities to balance commercial and recreational interests with the need for a sustainable ecosystem. There are several types of marine zones in the sanctuary, each with a different primary purpose and different protective measures. Large yellow buoys are used to mark the boundaries of these zones in the water. In the bigger picture, the sanctuary itself is a zone that is part of a national system of marine protected areas (MPAs), which also includes several national parks and other protected waters.

FIGURE 1.18. Yellowtail snapper are common reef fish in the Florida Keys.

Evaluate

SC.912.L.17.7 Characterize the biotic and abiotic components that define freshwater systems, marine systems and terrestrial systems.

SC.912.L.17.4 Describe changes in ecosystems resulting from seasonal variations, climate change and succession.

1. Name as many different marine ecosystems as you can.

FIGURE 1.19.

2. Study the photograph to the left (FIGURE 1.19).

   a. Identify three biotic and three abiotic factors in the photograph.

   b. Choose one biotic and one abiotic factor and explain how they interact.

3. Study the images below (FIGURE 1.20) and answer the question that follows.

Before the Burn

One Year After Burn

Two Years After Burn

FIGURE 1.20. The Oak Creek area of the Fishlake National Forest, Utah, before and after a burn.

The whale fall data presented in the **Elaborate** section of the lesson show the succession of organisms at whale fall sites. How do these photos taken before and after a forest fire demonstrate succession in the forest ecosystem?

4. Reflect on your personal interactions with your environment.

   a. Provide one example of something you choose to do that is positive for the environment.

   b. Provide one example of something you choose to do that is negative for the environment.

   c. How do these negative decisions affect marine ecosystems?