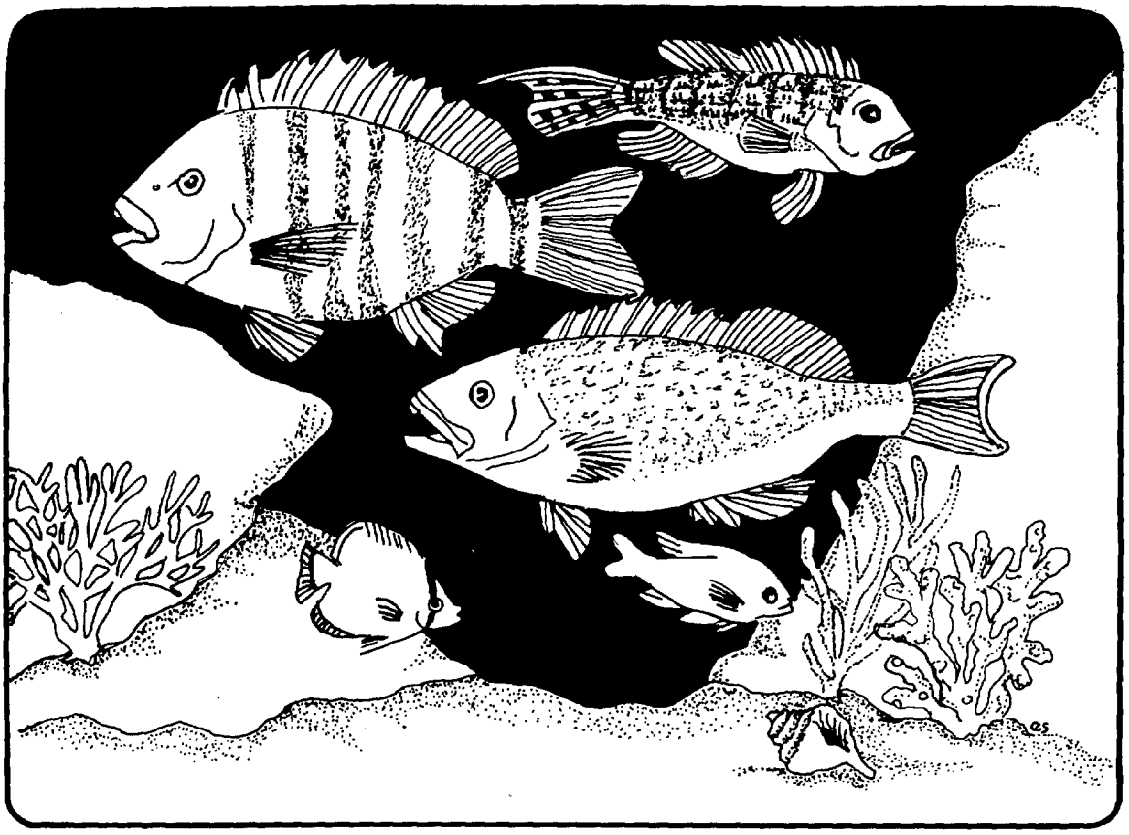
GRAY'S REEF NATIONAL MARINE SANCTUARY: AN EDUCATIONAL HANDBOOK



Prepared by:

UNIVERSITY OF GEORGIA
MARINE EXTENSION SERVICE

National Marine Sanctuary Program
Gray's Reef

GRAY'S REEF NATIONAL MARINE SANCTUARY: AN EDUCATIONAL HANDBOOK

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TABLE OF CONTENTS

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Forward to the teacher:

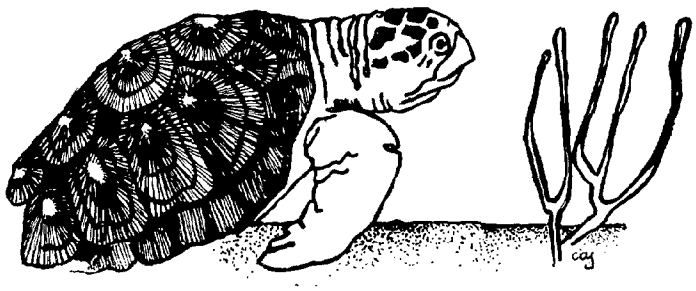
This handbook introduces you and your students to the Gray's Reef National Marine Sanctuary, one of eight National Marine Sanctuaries in the United States, and the only one in Georgia.

A study of the sanctuary can add interest to a science or social studies course. It can be used to illustrate the effects of an area's geology upon the organisms found there, to stimulate discussion of modern environmental problems and the principles of conservation, or merely to introduce students to an ecosystem that most of them find fascinating but know little about.

Gray's Reef National Marine Sanctuary protects one of the largest live bottom reefs on the Atlantic continental shelf. This handbook describes what is known of the geology and biology of Gray's Reef. We first discuss how the Reef was formed and the physical and chemical factors that determine the conditions under which its inhabitants live. Then we consider some of the organisms on and around the Reef, how they live, and how they interact with the Reef and with each other. In addition, Sanctuary management and regulations are discussed and the other National Marine Sanctuaries are described. Terms that may be unfamiliar to the student are underlined in the text and defined in the glossary at the back of the book. Each section also contains suggested activities which may be reproduced for use in the classroom.

If you would like more information on Gray's Reef for your classes, we can supply items such as an educational poster on fish, an offshore fishing map, brochures, and a slide show. For more information, write to:

Gray's Reef National Marine Sanctuary
Interpretive Program
UGA Marine Extension Center
P. O. Box 13687
Savannah, GA 31416



WHAT IS GRAY'S REEF NATIONAL MARINE SANCTUARY?

The last few decades have been marked by growing concern that the resources of our coastal waters are endangered. When pollutants flow into rivers and seas, when buildings, docks, and highways are built along the shore, we do not always notice the damage that may be done. Scientists warn us that if we want our oceans to provide us with seafood, minerals, and recreation in the future, we must learn to protect them. In order to protect the oceans, we must understand them.

Most of the coastal waters on the continental shelf of the South Atlantic Bight, between Cape Hatteras, North Carolina, and Cape Canaveral, Florida, lie above an ocean floor that is covered with loose sediments of sand, silt, and mud. Few animals or plants can live on such a shifting bottom, although the waters above the ocean floor may be alive with animals and plants. Large communities of bottom-dwelling organisms are found only where a hard bottom protrudes above the sand and provides a solid surface upon which plants and animals can grow. Gray's Reef is a "live bottom" reef, on a large hard bottom, conveniently close to our southeast coast (*Figure 1*). To protect this unique environment, the federal government named Gray's Reef a National Marine Sanctuary in 1981. Its rocky outcrops provide a prime habitat for a variety of fish such as black sea bass, snapper, grouper, flounder and mackerel, making Gray's Reef one of the most popular recreational fishing and diving areas off the Georgia coast. Gray's Reef is of particular interest, not only because it is important to the commercial and sports fishing industries, but also because little is known about hard bottoms. Scientists have only recently begun to study these interesting areas.

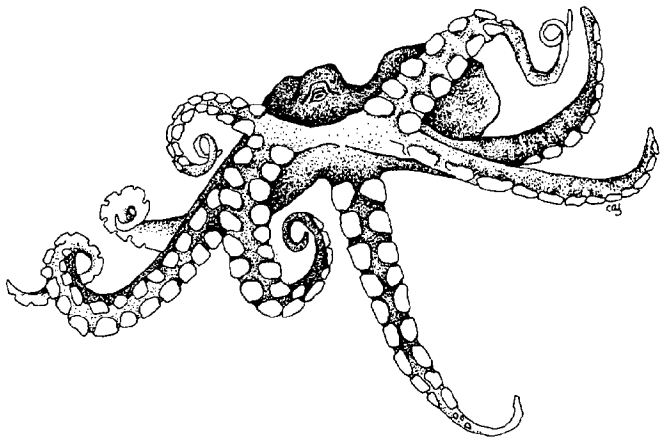
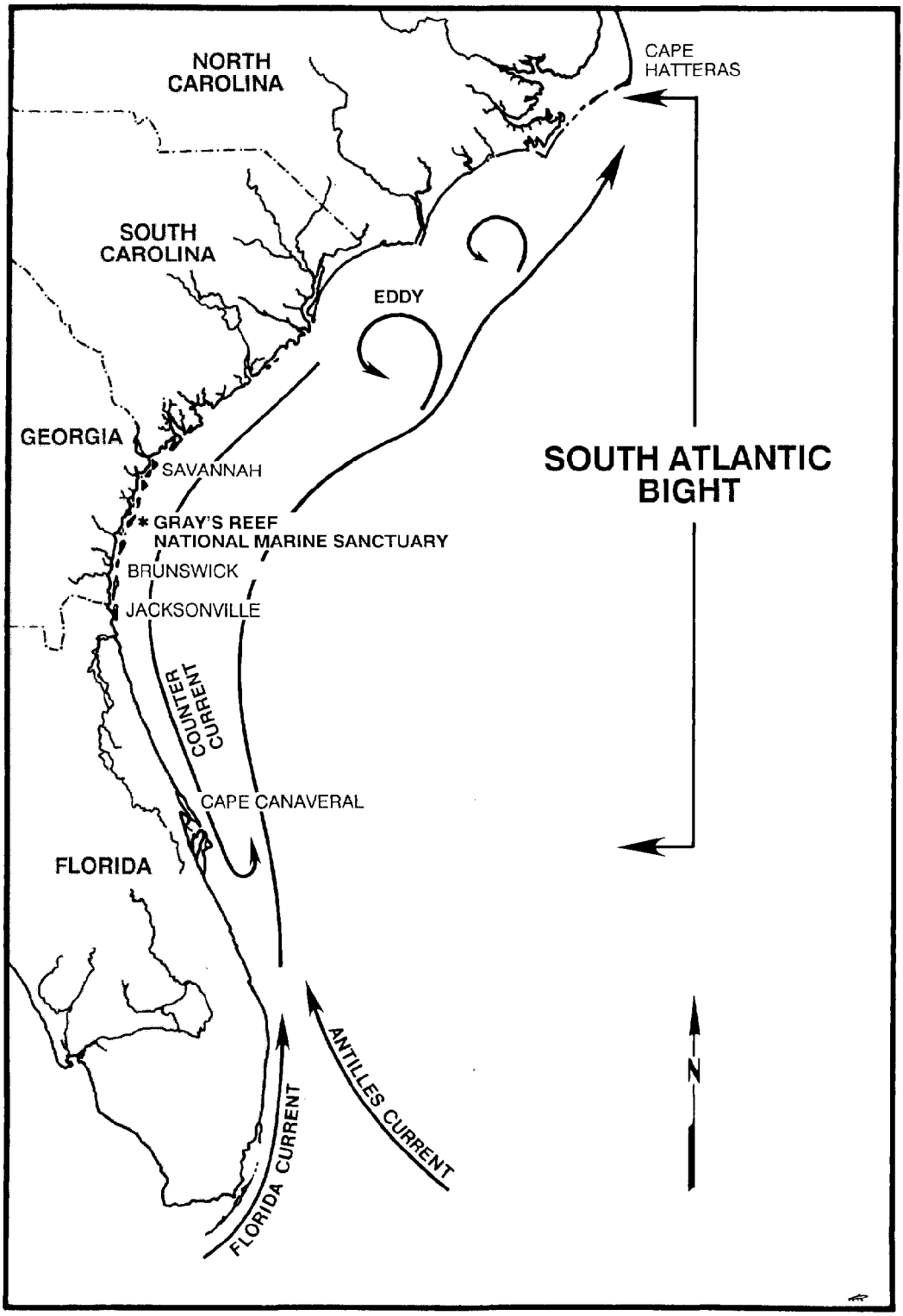


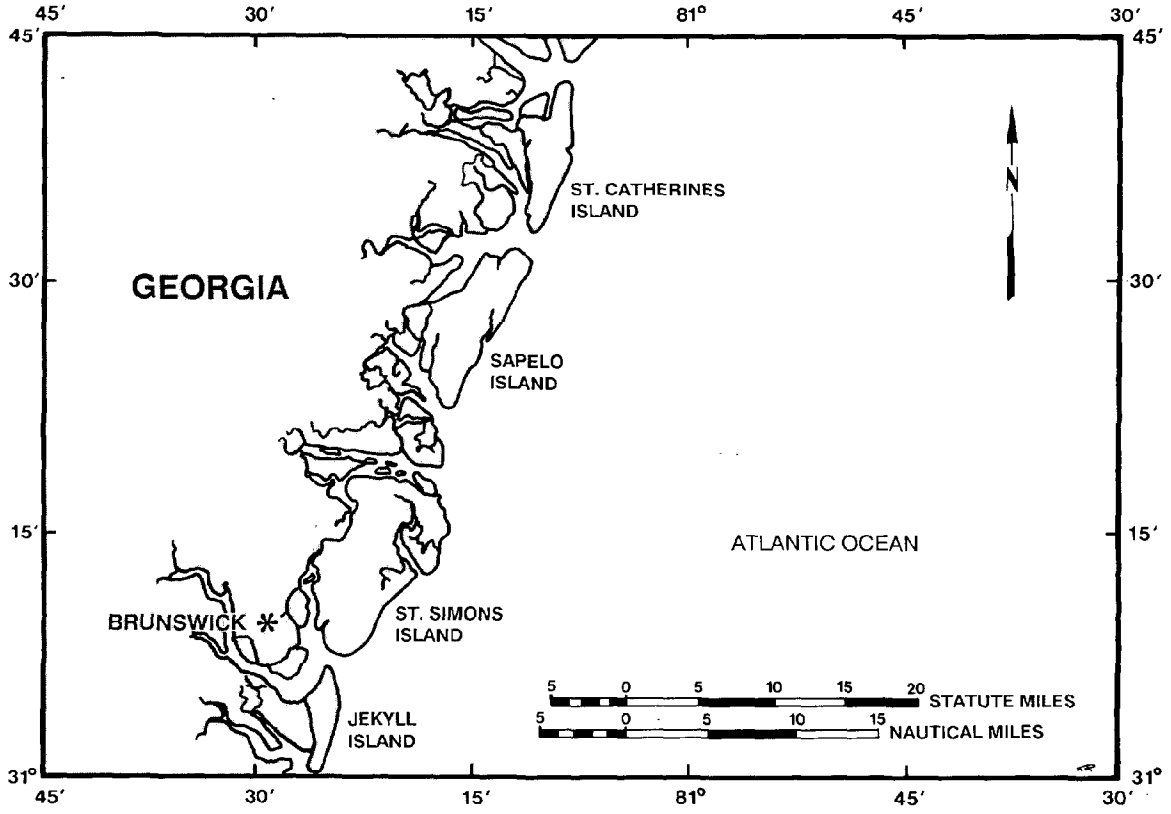
Figure 1.


NORTH CAROLINA
CAPE HATTERAS
SOUTH CAROLINA
EDDY
GEORGIA
SAVANNAH
SOUTH ATLANTIC BIGHT
* GRAY'S REEF NATIONAL MARINE SANCTUARY
BRUNSWICK
JACKSONVILLE
COUNTER CURRENT
CAPE CANAVERAL
FLORIDA
ANTILLES CURRENT
FLORIDA CURRENT
N

ACTIVITY

WHERE IS GRAY'S REEF?

Gray's Reef National Marine Sanctuary is an area of 18 square miles of the ocean floor, including the waters above it. The Reef is 17.5 nautical miles east of Sapelo Island, Georgia, and 35 nautical miles northeast of Brunswick, Georgia. Using this information, mark the approximate position of the Reef on the map below. You can make the map more accurate by plotting the Reef's latitude and longitude: the Reef lies between 31°22' and 31°25' North, and between 80°55' and 80°50' West.



GEOLOGY OF GRAY'S REEF

Gray's Reef is made of limestone laid down during the Pliocene Epoch between 5 and 1.8 million years ago (*Figure 2*). The Pliocene was followed by the Ice Ages of the Pleistocene Epoch. During this time, the earth's temperature dropped and sheets of ice spread southward across North America. The water that formed this ice came mainly from the sea. As a result, the sea level dropped, exposing much of the ocean floor, including the Pliocene limestone of Gray's Reef. The limestone was worn away by wind and water to form caves and ridges. About 6000 years ago, the ice sheets melted and returned their water to the sea. Tides and currents also helped wear away the Reef.

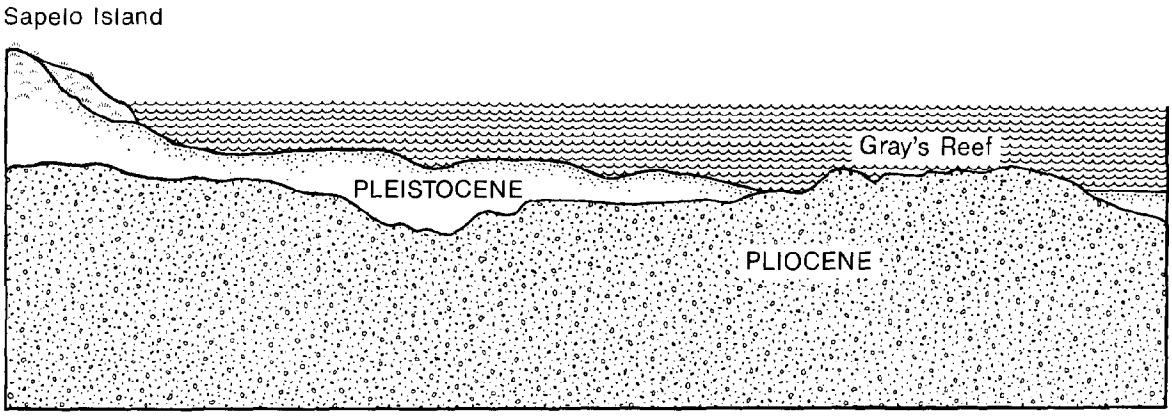
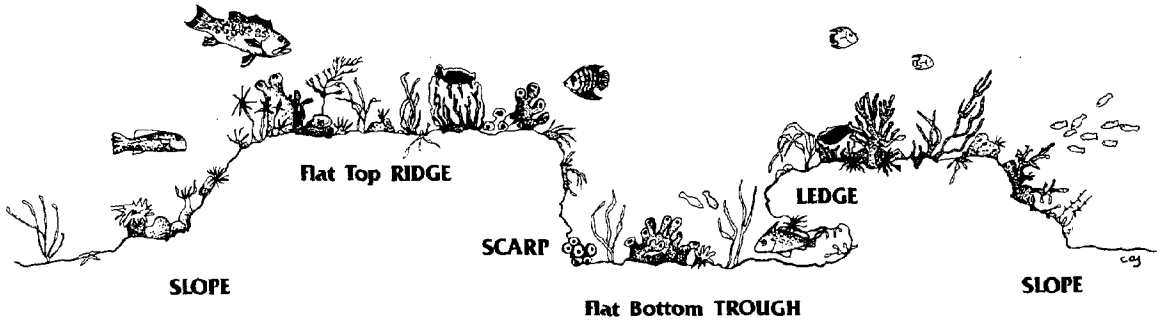


Figure 2. Formation of the Reef

Today the Reef consists of limestone ridges, with sandy flat-bottomed troughs between them. The water over the Reef is 45 to 70 feet deep. As shown in *Figure 3*, the Reef contains gentle slopes, steep scarps, and overhanging ledges. Each of these areas is home to different organisms that are adapted to live in their own particular parts of the Reef.

Figure 3. Different Habitats in the Reef



GEOLOGY ACTIVITY

Bring in a sample of sand from the southeastern coast and observe it under a dissecting microscope.

1. How much of the material observed can be identified as having been part of living organisms?

2. With a dropper, put several drops of diluted hydrochloric acid (HCl) on a small sample of the sand. Observe under the microscope and describe your observations. Note: Limestone ($CaCO_3$) bubbles in the presence of hydrochloric acid as do the shells of most marine organisms.

PHYSICAL AND CHEMICAL OCEANOGRAPHY OF GRAY'S REEF

Oceanographers are people who study oceans. The subjects that interest them include physical oceanography -- the study of physical changes in ocean waters caused by external forces such as heat, gravity and the rotation of the earth. The physical state of the sea is important to marine life, and so is its chemical state. Chemical oceanographers study the inorganic and organic substances found in seawater and the chemical changes that they undergo.

WAVES

Waves, produced by physical forces, affect the accessibility of Gray's Reef by boat. If they are big enough, waves may even disturb the ocean floor, stirring up sand, making it difficult for SCUBA divers to see clearly. Animals and plants living on the Reef are sometimes damaged by these waves.

Waves are caused mainly by winds which, in turn, are caused by uneven heating over the earth's surface. The size of waves formed by the wind depends on (1) the length of time the wind blows, (2) the fetch (*Figure 4*), and (3) the speed of the wind.

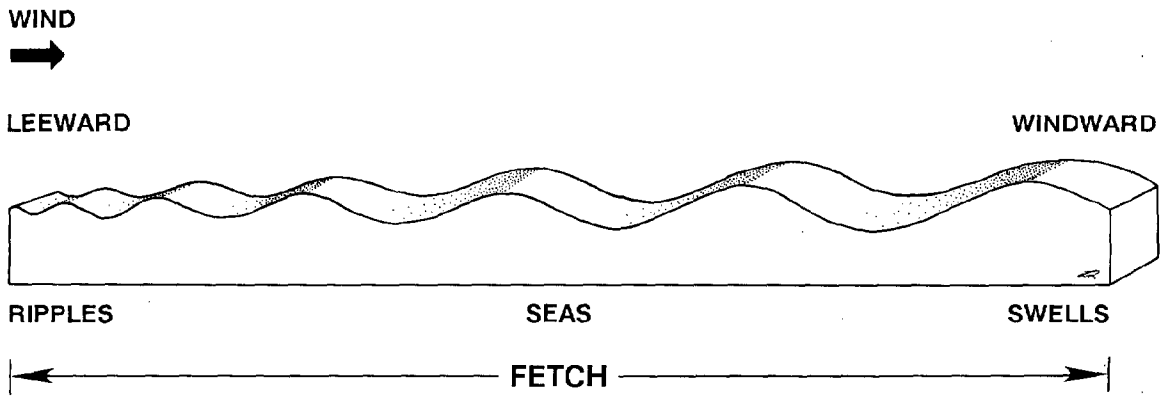


Figure 4. Fetch and Wave Formation

A constant wind, blowing for many days, produces the biggest waves it is capable of only if it blows over a fetch of about 400 miles. Georgia lies not far to the west of Gray's Reef, so a west wind at the Reef can never have a fetch of more than 17.5 nautical miles. No matter how strong a west wind may be, at the Reef it will produce no more than moderate waves (ripples and seas in *Figure 4*). However, east of Gray's Reef, open ocean stretches for 3,000 miles. As a result, strong east winds can produce very large waves. In addition, waves formed by storms hundreds of miles away sometimes reach the Reef as huge swells.

A wave's size determines whether or not it will stir up the bottom of the sea. The size of a wave is described either by its height from trough to crest or by its wavelength. Water within a wave moves in a circular pattern. This movement disturbs the water to a distance of half a wavelength below the water level (*Figure 5*). Since the water at Gray's Reef is about 60 feet deep, a wave must have a wavelength of about 120 feet before it will touch the Reef beneath it. This seldom happens during spring and summer, when winds tend to be light and variable and the sea calm. However, at other times of the year, strong winds sometimes bring huge waves to the area which may even batter the Reef far below the surface.

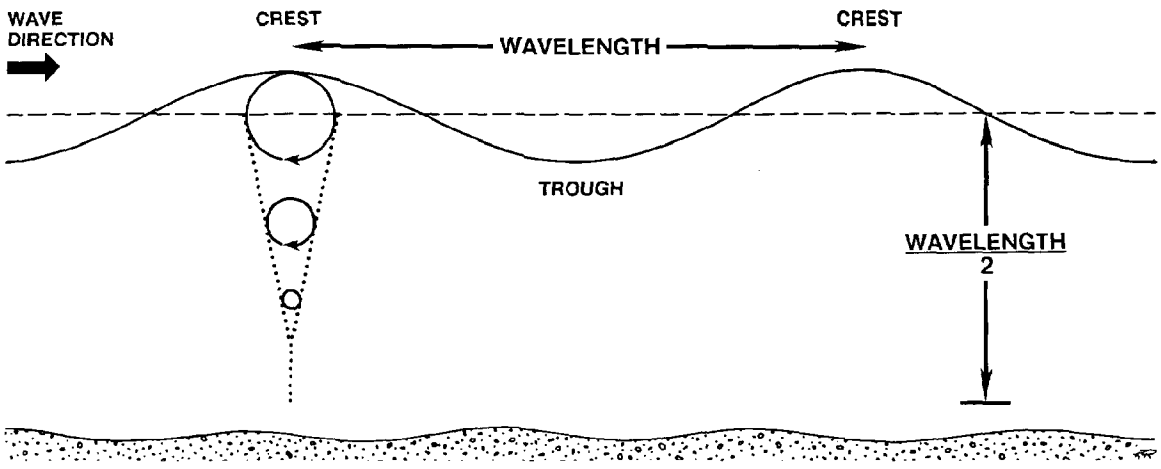
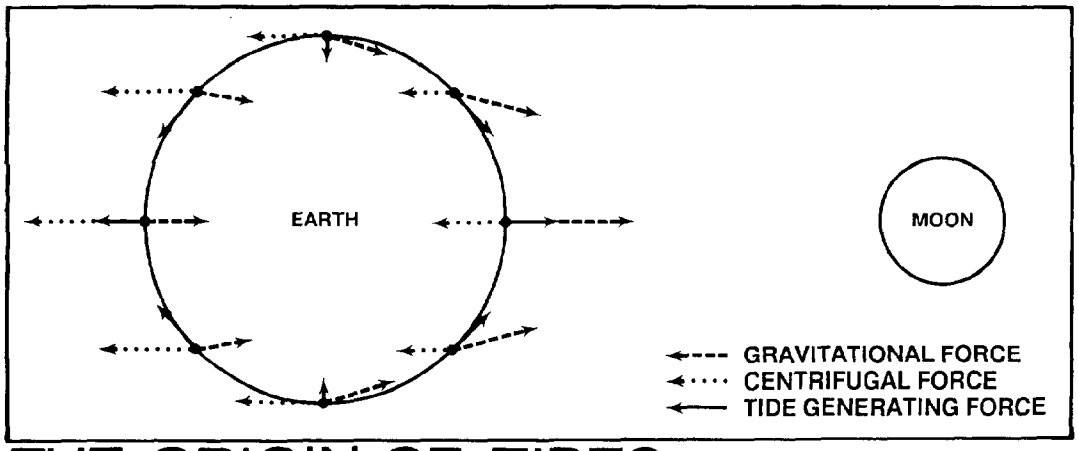


Figure 5. Wave Form and Structure

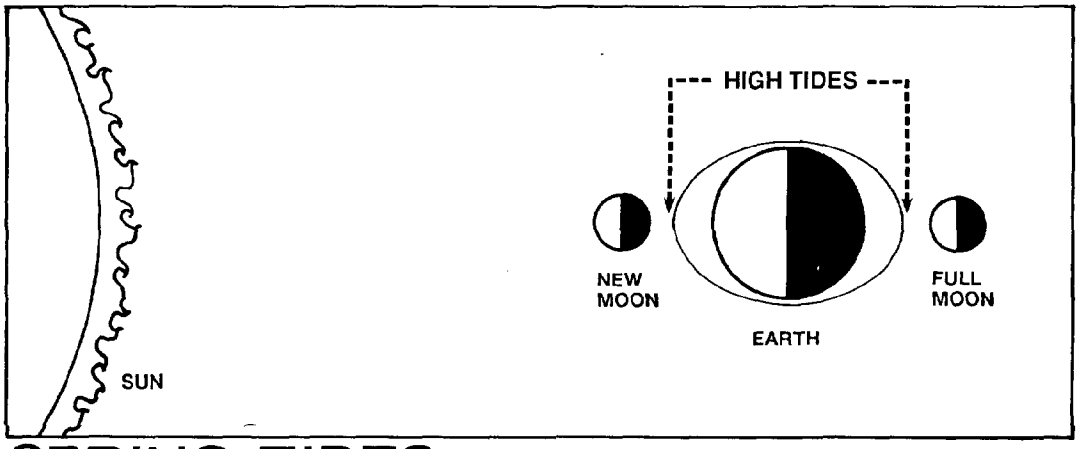
TIDES

Tides are really huge waves caused by the pull of gravity from the moon and, to a lesser extent, from the sun (*Figure 6*). Georgia has semi-diurnal tides, or two tidal cycles a day - two high and two low tides. Near shore, water appears to come in during the flood tide and go out at ebb tide. In fact, high tide is the crest of the tide wave, which is 6 feet higher than the low tide, which is the trough of the tide wave.

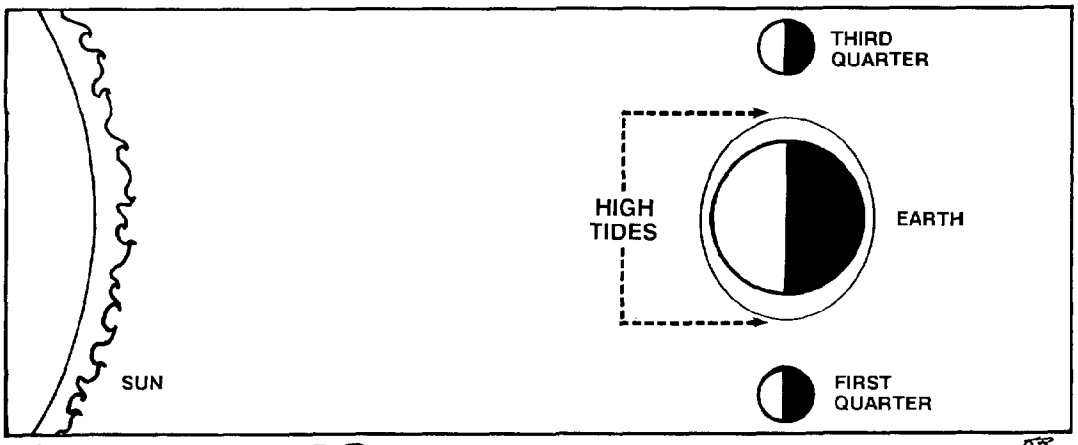
Figure 6. The Physical Forces that Produce Tides



THE ORIGIN OF TIDES



SPRING TIDES



NEAP TIDES

The position of the moon during its month-long trip around the earth alters the height of the tides. When the sun, the earth, and the moon are lined up at the time of a full moon or a new moon, the combined gravitational pull of the sun and moon create spring tides. When the moon is in the first and third quarters, the sun, moon, and earth make a right angle, and the sun and moon pull on the ocean waters from different directions, creating neap tides. Spring tides are bigger, with higher high tides and lower low tides than neap tides.

In addition to gravity, tides are affected by centrifugal force caused by the earth's spinning. As a result of this force, tides have a slightly circular motion.

In shallow inshore waters, tidal currents can greatly affect boating, fishing and other activities on the coast. Offshore, on Gray's Reef, the tide is much less noticeable.

CURRENTS

The energy driving the major ocean currents comes from winds (*Figure 7*). The most notable surface current on the east coast of the United States is the Gulf Stream. Acting like a river of warm tropical waters flowing northward in the Atlantic Ocean, the Gulf Stream affects life and the weather. The Gulf Stream flows about 75

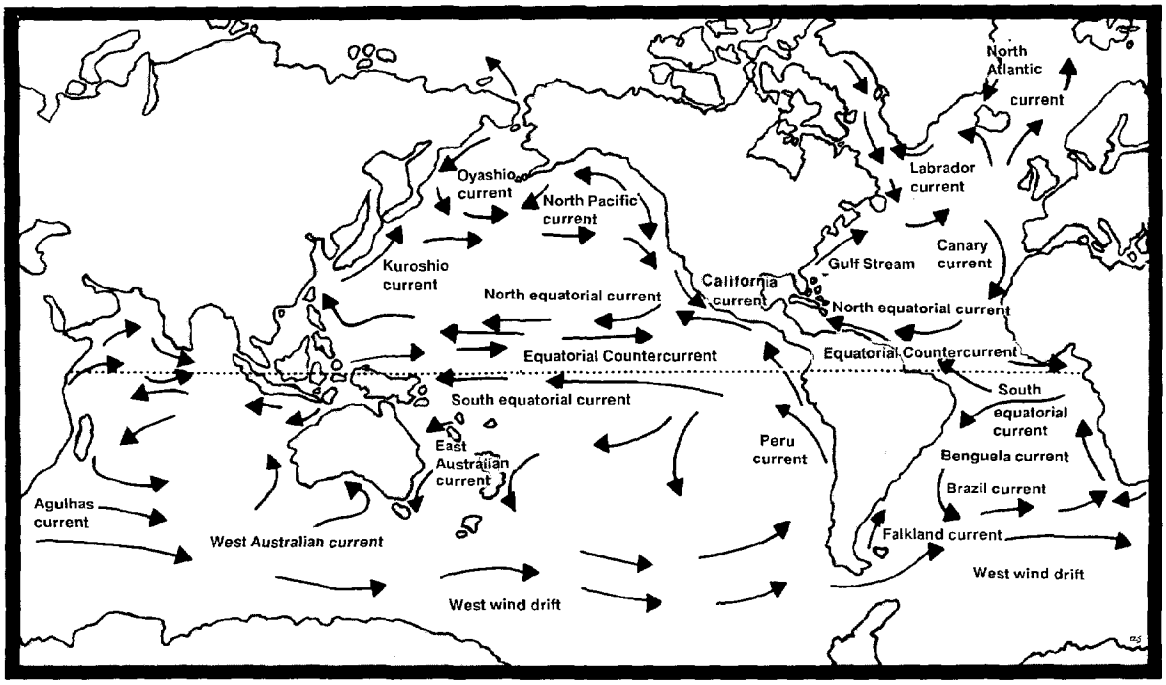


Figure 7. Map of Ocean Surface Currents

miles east of the Georgia coast and Gray's Reef (see *Figure 1*). Meanders and eddies from the Gulf Stream bring plants and animals from more tropical waters to Gray's Reef.

Wherever a major current flows in one direction, a countercurrent generally flows in the opposite direction. Waters along the Georgia coast and around Gray's Reef flow south as a countercurrent to the Gulf Stream. The speed of this countercurrent varies, depending on the direction and strength of the winds, the tides, and the flow of water from rivers on the Georgia coast. Strong tidal currents can make this current flow to the north but the overall movement of water along the coast and across Gray's Reef is to the south.

TEMPERATURE

Gray's Reef is on the relatively shallow inner continental shelf where the temperature varies more, and changes more rapidly, than it does in the open ocean. Water temperatures at the Reef vary with the seasons from a low of about 14^{O}C (57^{O}F) in winter to a high of about 28^{O}C (82^{O}F) in summer.

SEAWATER

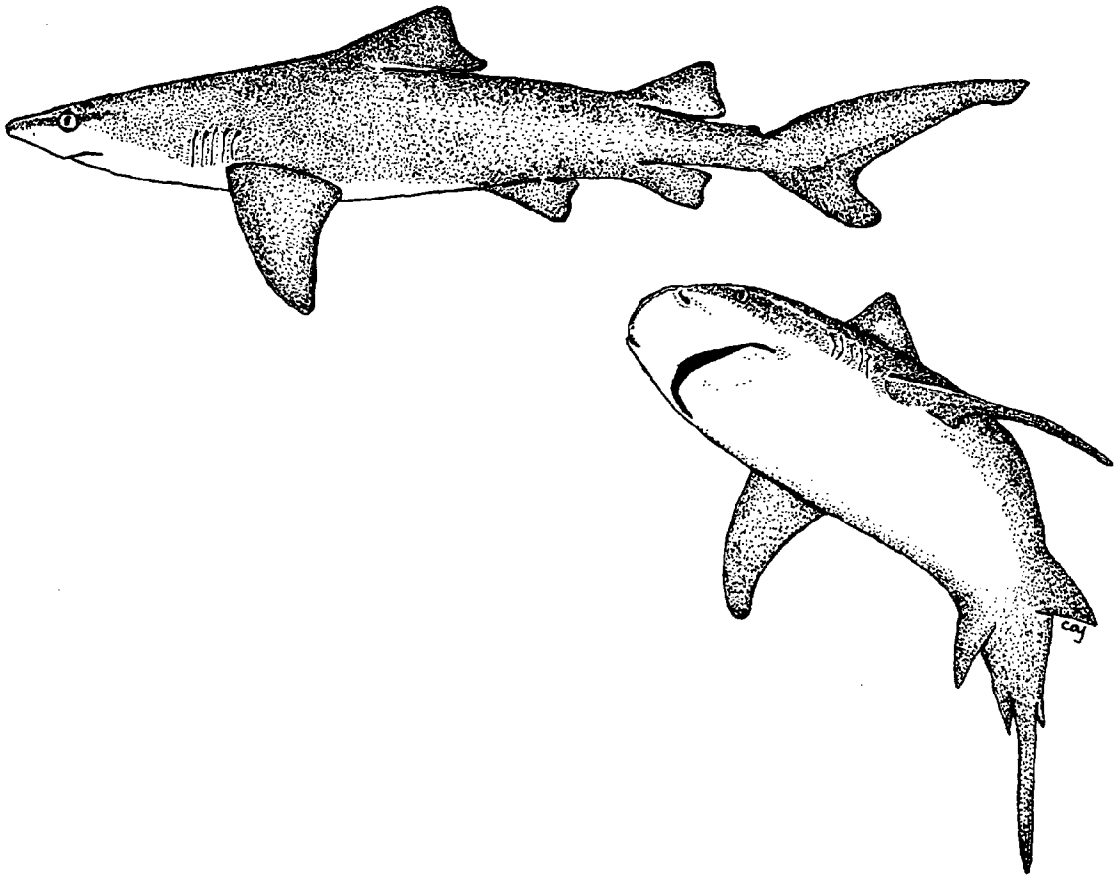
The chemistry of seawater is very important to the organisms that live in it. Seawater is not the same all over the earth. The chemicals it contains vary from place to place. Different plants and animals need different conditions, and the types and numbers of organisms found in a particular part of the sea may be limited by the type of seawater found there. For instance, in many parts of the ocean there is very little nitrate or phosphate, nutrients which all plants need to grow. Where they are in short supply, these nutrients are said to be limiting factors for the growth of phytoplankton.

Seawater is a salty solution containing traces of nearly every element on earth. The saltiness of water is expressed as its salinity: the number of grams (parts) of salts dissolved in 1000 grams (parts) of water. The salinity of the ocean averages about 35 parts of salt per thousand parts of water, which may be written 35ppt or 35^{O}/oo.

In the open ocean, salinity remains quite constant. But Gray's Reef is relatively near the coast. The salinity at the Reef is sometimes lowered by fresh water from the land, particularly in spring when a lot of water comes down the rivers on the coast. The salinity at the Reef is sometimes raised by meanders from the Gulf Stream, which contains warm, salty water. Overall, the salinity at Gray's Reef ranges

from about 34 to 36 ppt. This is much less than the variation nearer to shore where river water has a greater effect. Many ocean animals cannot tolerate the low salinity of inshore waters and so many of the animals and plants found on Gray's Reef are different from the ones found nearer the Georgia coast.

The amount of oxygen dissolved in seawater is another factor that determines where particular marine organisms can live. Animals, plants, and bacteria all use up oxygen in their respiration. The oxygen in seawater comes from photosynthesis by marine plants and from the mixing of air and water at the surface of the sea. There is usually more oxygen in the water in winter since more oxygen will dissolve in cold water than in warm water. Respiration is also at a lower level in the winter. Oxygen levels are high enough for animals life in most parts of the ocean. However, a few places, particularly shallow waters polluted by sewage and with little tidal movement, are anaerobic, areas without oxygen where only a few species of bacteria can survive. The waters at Gray's Reef are well oxygenated. Oxygen is not a limiting factor for the organisms of the Reef.



OCEANOGRAPHY ACTIVITIES

WATER TEMPERATURE

1. Preparation: Put several water samples of different temperatures in beakers. Divide the class into teams of 4 or 5 students, designating one student in each group as recorder of the data (temperatures). Supply each team with thermometers which measure both Fahrenheit and Centigrade temperatures. Each team should also be provided with three beakers of water, one with ice in it, one from the cold water tap, one from the hot water tap.

Each team should measure and record the temperature of the water in each beaker in both Fahrenheit and Celsius. Each team should report their findings to the class.

A. Discuss the difference between the findings of each team.

B. Discuss the difference between the numbers recorded in Celsius and Fahrenheit.

Advanced Activities

Formulas to be used: $^{o}F = {}^{9}/_{5}\,(^{o}C) + 32$

$^{o}C = {}^{5}/_{9}\,(^{o}F - 32)$

(1) Determine the comparable Fahrenheit readings for the known Celsius readings using the first formula.

(2) Calculate Celsius readings from the known Fahrenheit numbers using the second formula.

SALINITY

2. Preparation: Make up 4 solutions of salt water for each team.

(1) Dissolve 1 gram salt into 1000 ml water.

(2) Dissolve 10 grams salt into 1000 ml water.

(3) Dissolve 20 grams salt into 1000 ml water.

(4) Dissolve 35 grams salt into 1000 ml water.

Number or color code each beaker for later identification.

Each team should place their beakers in order from least salty to most salty by taste. Each team recorder should report the results to the class. Compare the results with the number or color code of the teacher.

A. How accurate was this test?

B. Which beaker would you guess is nearest to the salinity of the ocean? (35 ppt)

C. With a standard aquarium hydrometer (found at pet stores), measure the actual salinity.

Advanced Activity

Students may design and make their own hydrometers using standard water/salt solutions and ordinary materials, i.e., wood, lead weights, styrofoam, markers.

3. Collect a sample of seawater and put 500 ml in 4 beakers, 3 uncovered and 1 covered with aluminum foil or plastic wrap. Weigh the water and measure the salinity every day until the water in the the 3 open beakers has completely evaporated.

A. What happens to the weight of each beaker with time?

B. What happens to the salinity in each beaker with time?

C. Graph the results of this test plotting weight and salinity against time.

TEMPERATURE AND RAINFALL

4. A class project: Collect data on daily air temperature, ocean water or freshwater temperatures and rainfall amounts. Information of this kind can be obtained from newspapers or radio or television. Students should plot their findings on a large graph by the day, week, or month.

WIND AND WAVES

5. Keep a journal of wind speed and direction from news sources. Graph wind speed and annotated direction against reported wave heights.

   A. Note the influence of wind speed on wave height.

   B. What is the influence of wind direction on wave height? (Hint: Remember fetch.)

6. Demonstration:

Place a clear rectangular container to act as a wave tank on an overhead projector. Fill the container 1/2 full of water (you can add a little blue food coloring for contrast). Generate small waves by dipping the long edge of a ruler in one end of the wave tank.

   A. Observe the waves as they strike the flat surface at the end of the tank. (Acts like a seawall).

   B. Place different shaped objects in the wave tank and observe the behavior of waves as they strike these objects.

   C. Make a beach of sand or gravel in the tank and compare wave behavior striking the beach compared to striking a flat surface.

7. Collect tide information from a newspaper for one month.

   A. How many high and low tides occur each day?

   B. What is the time interval between successive high tides, low tides and between high and low tides.

8. Collect information on the cycle of the moon the same month as the tidal data.

   A. Predict the occurrence of neap and spring tides based on the cycle of the moon.

B. Compare predictions to the actual heights of the tides shown on the tide charts.

9. On a world map or globe, point out and name the oceans, major seas, and gulfs and note the adjacent continents.

A. Are there physical barriers between the oceans which do not allow mixing?

B. Discuss the most apparent differences between seas and oceans.

10. On a world map draw and name the major ocean currents using a blue pencil to show cold currents and a red pencil to show warm.

A. Discuss what causes the currents.

B. Why are some currents cold and some warm?

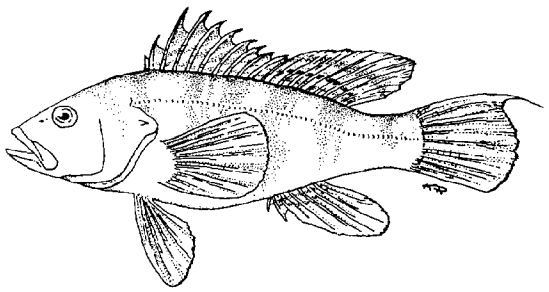
11. Map the prevailing winds of the world.

A. Discuss the position of the prevailing winds compared to the major currents.

B. In what band of prevailing winds do you live?

C. Watch television weather for one week and write down which general direction weather systems travel through your area. Compare your findings to the prevailing winds.

12. Record and graph local rainfall by month. On a blank map of Georgia draw in the major rivers that feed the Georgia coast.

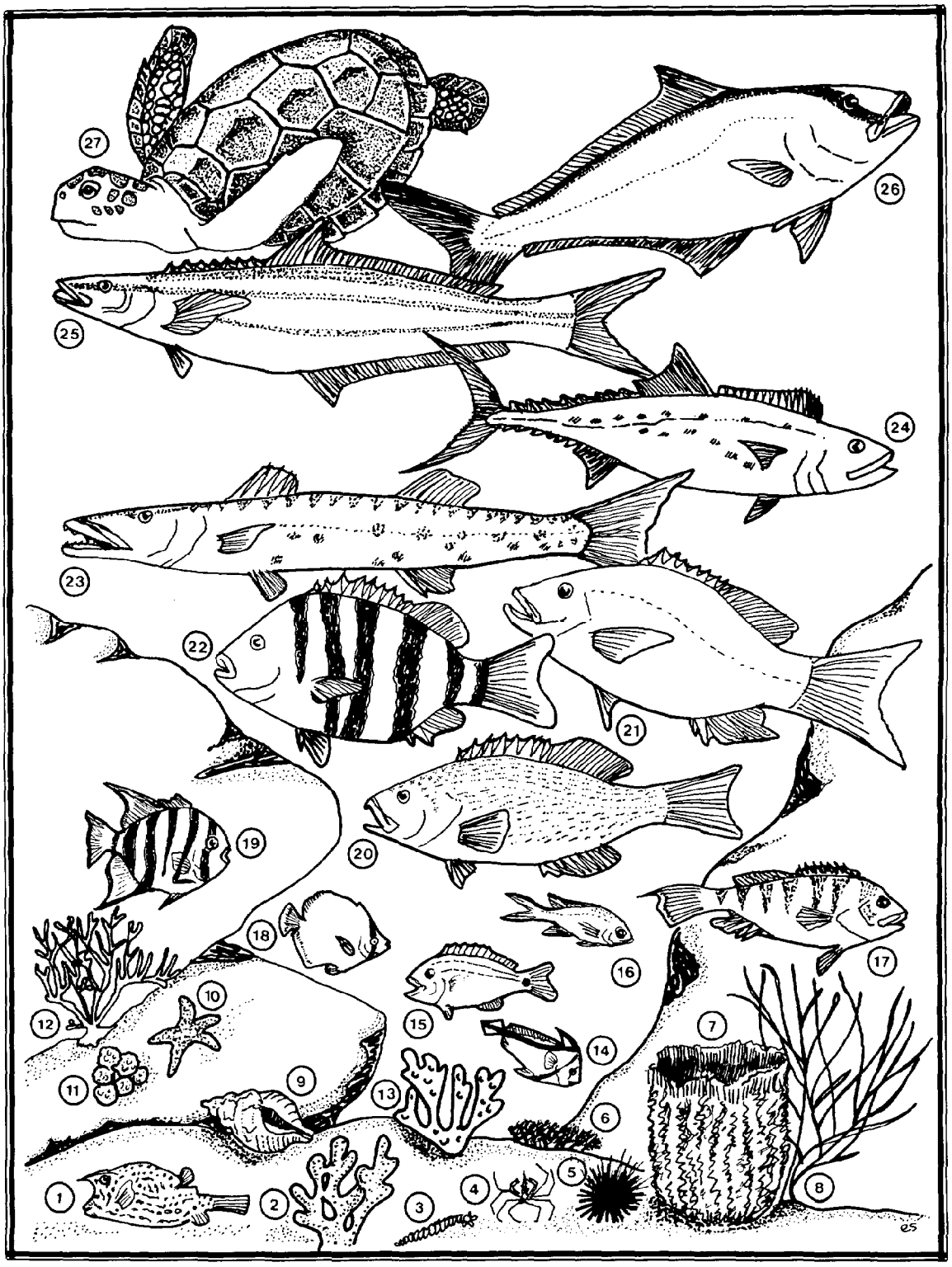


ECOLOGY OF GRAY'S REEF

Ecology is the study of the relationships organisms have with each other and with their physical environment. The physical environment of the Gray's Reef Sanctuary includes the limestone rock and sandy floor at the bottom of the ocean and the water above it. Some of the larger organisms that are often seen in the Sanctuary are shown in *Figure 8*.

Figure 8. Some of the Animals Found in The Gray's Reef National Marine Sanctuary

1. cowfish
2. finger sponge
3. marine worm
4. arrow crab
5. spiney sea urchin
6. feathery hydroid
7. basket sponge
8. sea whip
9. conch
10. common sea star
11. tunicates
12. deepwater gorgonia
13. eyed coral
14. jackknife fish
15. tomtate
16. blue chromis
17. black sea bass
18. reef butterfly
19. spadefish
20. gag grouper
21. red snapper
22. sheepshead
23. barracuda
24. Spanish mackeral
25. cobia
26. greater amberjack
27. loggerhead sea turtle



(Drawing not to scale)

BENTHOS, NEKTON AND PLANKTON

Marine organisms fall into three main groups according to where they live: bottom-living benthos, swimming nekton, and floating plankton (*Figure 9*).

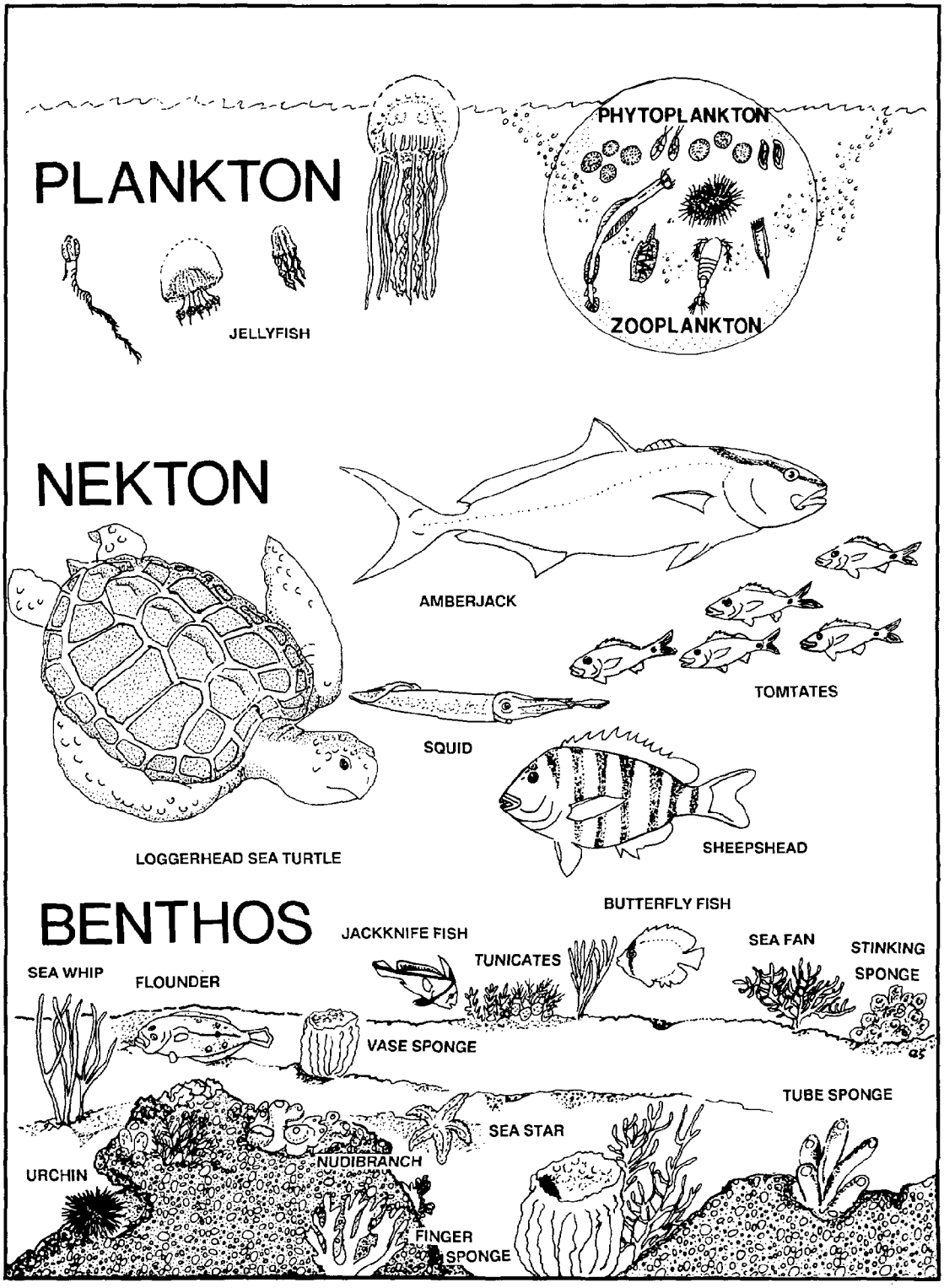
The benthos includes sessile organisms, which live attached to the hard bottom or to sand grains. The main benthic plants are algae, and the animals include sessile sponges and corals. Less firmly attached are animals that crawl over the rock or sand. These include flatworms, segmented worms, sea stars, and sea urchins. In the sandy troughs between the rock ridges, shrimp-like arthropods, such as isopods and amphipods, burrow beneath the surface with brittle stars and sea cucumbers. All the animals mentioned so far are invertebrates. The benthos also contains vertebrates. These include flounders and other flatfish that lie partially buried in the sand.

The nekton is made up mainly of vertebrates, including fish and turtles. But squid, invertebrates related to snails and octopuses, are common. All these swimming animals can move in and out of the sanctuary under their own power but many of them never stray far from the Reef. These include fish such as moray eels, reef butterflies, and blue chromis which live in cavities in the rock.

Other members of the nekton are found in the sanctuary only occasionally. These are pelagic species, animals that travel widely through the open ocean. They include bony fish such as mackerel, tuna, amberjack, and barracuda, as well as several species of sharks, sea turtles, dolphins and whales. These visitors may simply swim through the area, or they may find enough food in the sanctuary to tempt them to stay for a time.

You may not even be able to see the plankton, one of the most important communities of organisms in the sanctuary. Plankton is the group of organisms that float in the ocean and are carried around by currents because they are very weak swimmers. Most of them are so small that a microscope is needed to see them. Some of them are plants (phytoplankton) and some are tiny animals (zooplankton).

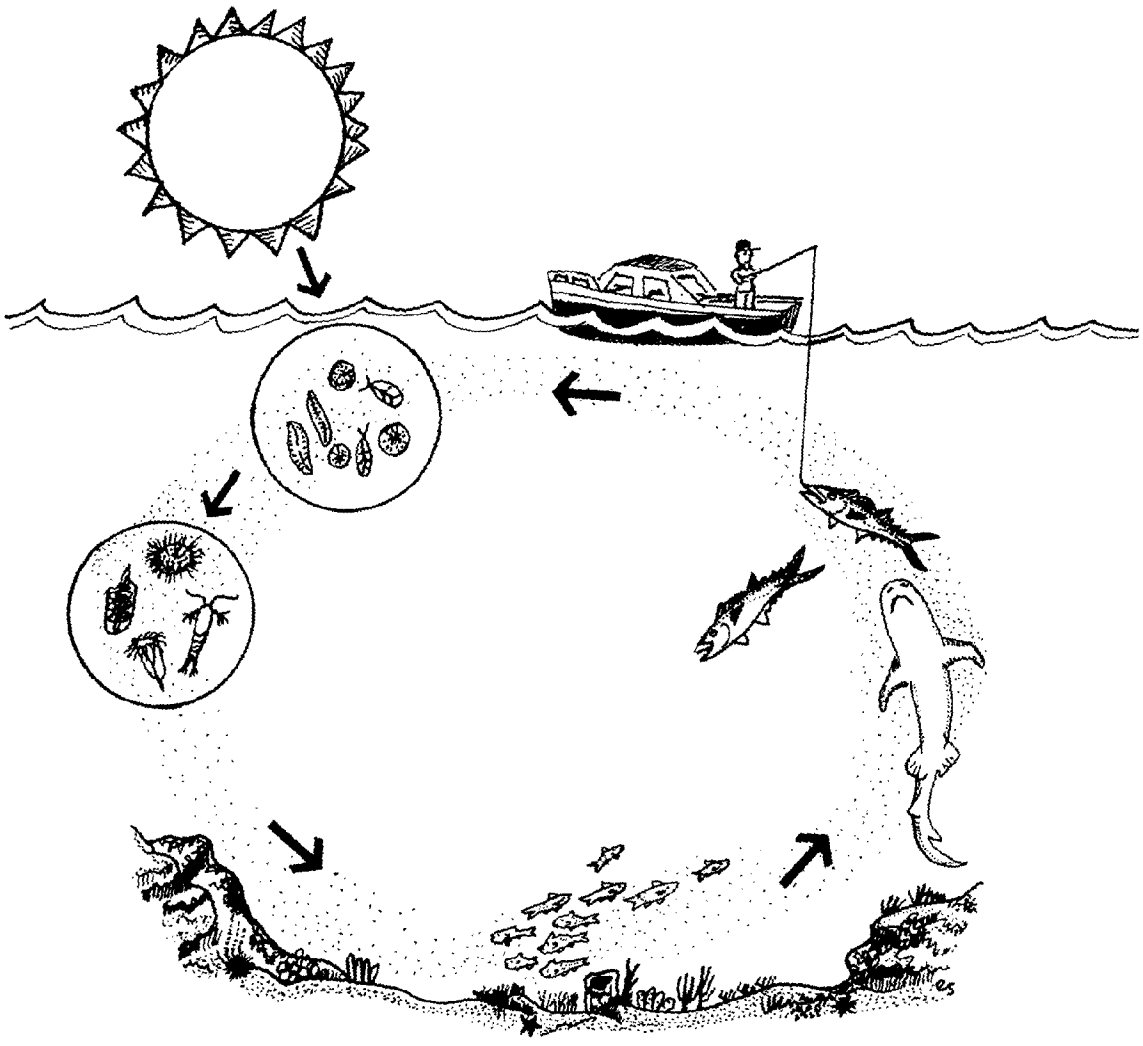
Figure 9. Plankton, Nekton and Benthos



FOOD CHAINS

The organisms in an area feed on each other, and so they are linked together in a "food chain" or "food web." Part of the food web linking the organisms at Gray's Reef is shown in *Figure 10.*

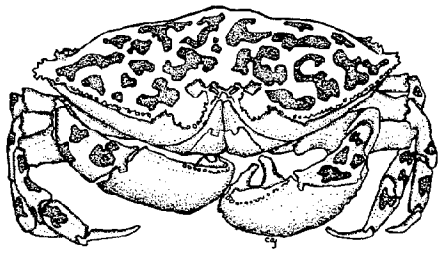
Figure 10. Food Chain of Gray's Reef



Green plants make their food from carbon dioxide and water by photosynthesis. Plants produce most of the food in the ocean, as they do on land, and so they are called producers. Photosynthesis is powered by light energy from the sun. It can occur only near the surface of the sea because water absorbs sunlight: the depths of the ocean are in permanent darkness. Gray's Reef lies only about 60 feet beneath the ocean's surface and so enough light reaches it for plants to live. The producers of the Reef include microscopic algae (one-celled plants) and clumps of larger macroalgae (seaweeds) attached to the bottom. However, more than half the sanctuary's food energy comes from phytoplankton, producers floating in the plankton. Most members of the phytoplankton are microscopic but a few are larger, notably sargassum weed, which drifts through the sanctuary in summer and also acts as a raft carrying its own little community of organisms.

Plants give off oxygen during photosynthesis, and about half the oxygen in the air today has been produced by phytoplankton. Without the oceans' phytoplankton, we should be unable to breathe. Primary consumers are animals that eat producers. On the Reef, primary consumers include members of the zooplankton which eat phytoplankton. Among these are planktonic arthropods and the larvae of relatively large sessile benthic animals such as sponges, and corals. Sponges and corals, along with tunicates, hydroids, and several types of worms that live in tubes, are filter feeders, living on plankton that they filter out of the water and on detritus, particles of dead organic matter. Secondary consumers are animals that eat primary consumers. For instance, small reef fishes, such as wrasses and tomtates, feed on benthic invertebrates. Some of the largest animals to be seen in the sanctuary are filter-feeding secondary consumers. The right whale (see *Figure 11*) lives on krill, arthropods that it filters out of the plankton. Other secondary comsumers are spiny lobsters and slipper lobsters, of particular interest to divers as well as to the native octopus, which is equally fond of shrimp and crabs. Some animals are primary and secondary consumers at the same time because they eat both plants and primary consumers. Examples include many filter feeders and most of the free-living invertebrates, which eat algae and small animals.

Even higher up the food chain are the tertiary consumers, including the larger reef fish such as groupers and snappers, which feed on the smaller fish.



THREATENED AND ENDANGERED SPECIES AT GRAY'S REEF NATIONAL MARINE SANCTUARY

Right whales (*Balaena glacialis*) have been sited at Gray's Reef Natioanl Marine Sanctuary. Because of the abundant oil and bone produced by these large slow-moving mammals, they became the "right" whale to hunt. The right whale, almost hunted to extinction, is now considered an endangered species, protected by international law.

The whale is shiny black in color and does not have ventral pleats or a dorsal fin (*Figure 11*). Right whales are extremely fat, averaging about 70 tons. They feed on small food organisms in the ocean. Unique to these whales are the many callosites (horny, yellowish growths) found on their large bowed mouths and other areas of their heads. The reason for these growths is unknown, but they do serve as a home for parasites such as whale lice and barnacles. The right whale may be the rarest of the great whales.

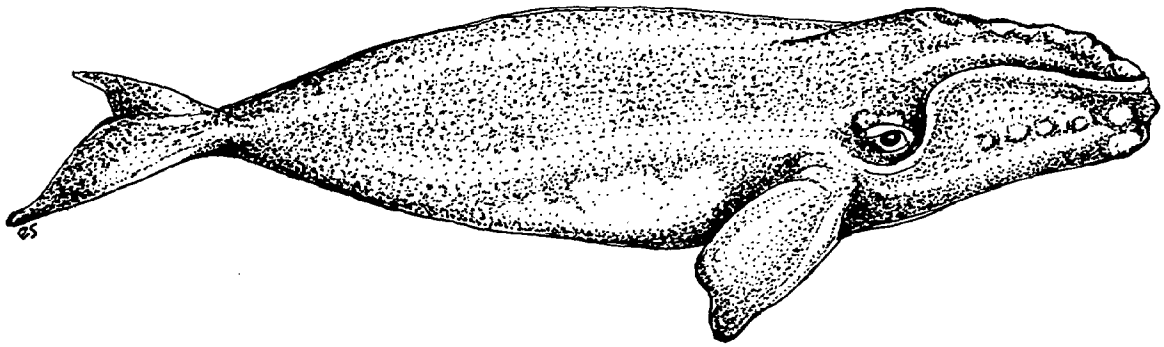


Figure 11. Right Whale

The loggerhead (*Caretta caretta*), a threatened species, is the only temperate zone sea turtle. A frequent visitor to Gray's Reef National Marine Sanctuary, this large turtle, reddish-brown in color with some yellow on head and limbs, is primarily carnivorous. Its strong beak aids it in feeding on hard-shelled crustaceans. The loggerhead turtle, its name referring to its large head, weighs an average of 200 to 350 pounds. (*Figure 12*).

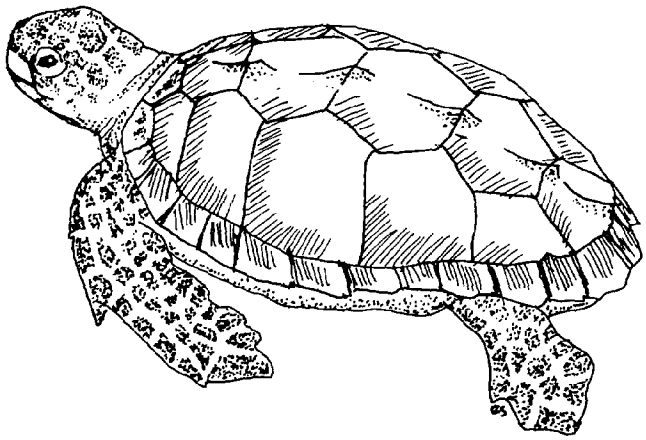


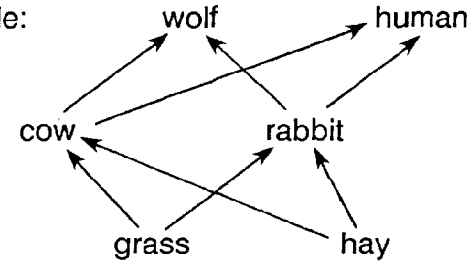
Figure 12. Loggerhead Turtle

Loggerheads mate at sea and lay their eggs on the shore, burying them in the sand. It has been estimated that only one in 10,000 eggs survives to become an adult. The existence of the loggerhead is threatened, not only by natural predators, but also by poachers, shrimp fishing nets, and over-development of coastal nesting places.

ECOLOGY ACTIVITIES

1. List as many ocean animals and plants as you can think of and construct a food web to use them all.

Example:



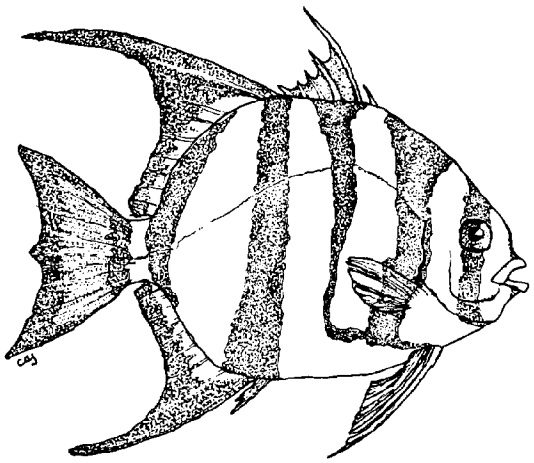
2. Visit the Marine Extension Center on Skidaway Island, Georgia for a one day to one week study of the ocean. Write UGA Marine Extension Service, P. O. Box 13687, Savannah, Georgia 31416, or telephone (912) 356-2496.

3. Visit an aquarium.

4. Collect a variety of marine organisms (shells or alive). Have students in small groups act as aliens and creatively describe in a paragraph what the organism is, how it lives, and where it lives. The written paragraph is then read to the class.

5. Set up an aquarium, marine or fresh.

6. Obtain fresh whole fish, clams, crabs or other seafood from the market. Do an anatomy lesson and then cook and eat the organism.



GRAY'S REEF CROSSWORD PUZZLE

ACROSS

2. Sea organisms that live in or on the ocean bottom are called _____ organisms.

3. An endangered species found at Gray's Reef National Marine Sanctuary is the _____ turtle.

5. These large silvery fish are known for their inquisitive nature, their sharp teeth, and for their reputation for occasionally biting people.

7. The primary food-producing microscopic plant life found in the ocean.

10. A simple sessile animal, living attached to the bottom, whose body is organized around a system of water canals.

12. The outcroppings in Gray's Reef National Marine Sanctuary are composed of a rock called _____.

14. The overhanging reef _____ provide a haven for many fish and invertebrates that like shelter.

16. Sea _____ have stinging cells in the tentacles which surround their mouths, giving them the ability to catch small animals drifting by.

18. After the Ice Age, sea _____ rose covering Gray's Reef to approximately its present depth.

19. A spiny sea animal which crawls along on tiny tube feet grazing on algae.

20. A star-shaped reef dweller.

21. This 8 armed sea creature may be found hiding beneath rock ledges.

22. A large marine mammal that was at one time highly sought by fishermen, who called it the right _____.

DOWN

1. Sea organisms like sponges that are permanently attached to the ocean bottom are called _____ organisms.

4. A snake-like fish that likes to hide in rocky crevices is called an _____.

6. At Gray's Reef, low limestone _____ are separated by flat sandy areas.

8. These small, bushy colonial animals, members of the class Hydrozoa, are also related to corals and anemones.

9. The burrowing Marine _____ varies little from head to tail.

11. Gray's Reef National Marine Sanctuary is made of limestone deposited during the _____ epoch.

13. This is a flat, pancake-like fish.

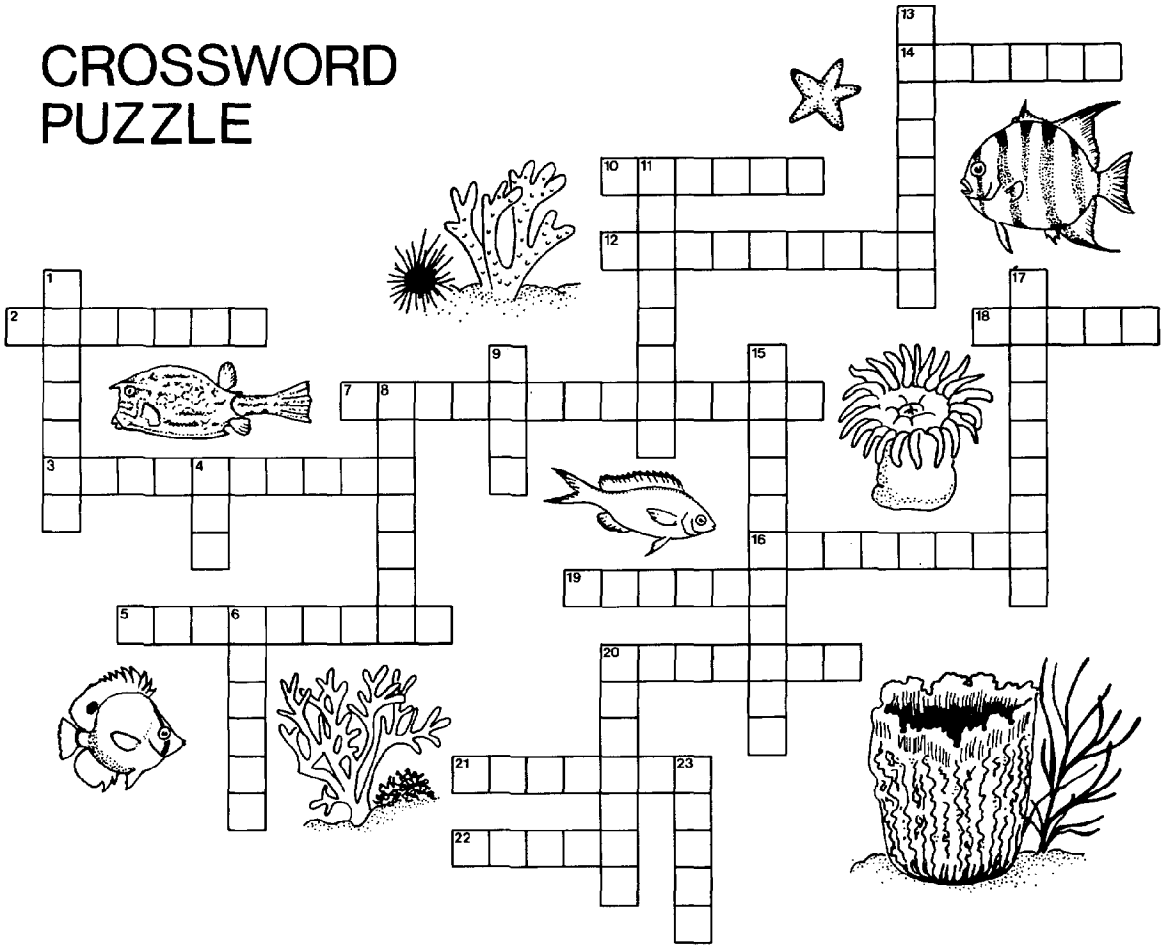
15. Microscopic animals that drift in the ocean are called _____.

17. A gelatinous, free-floating sea animal that is related to corals and anemones, is a _____.

20. The Red _____ is a tasty game fish.

23. _____ divers find a colorful underwater spectacle at Gray's Reef.

CROSSWORD PUZZLE



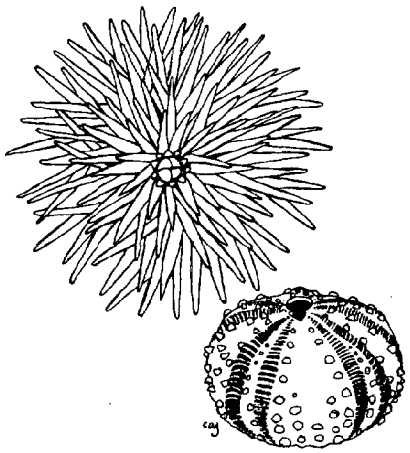
benthic	sessile	seastar
loggerhead	octopus	eel
hydroid	barracuda	ridges
phytoplankton	limestone	sponge
Pliocene	ledges	snapper
zooplankton	urchin	worm
jellyfish	whale	level
anemones	SCUBA	flounder

MANAGEMENT OF GRAY'S REEF

The Gray's Reef National Marine Sanctuary is managed jointly by U.S. Government and State of Georgia agencies. These agencies include the Sanctuary Programs Office of the National Oceanic and Atmospheric Administration (overall management), the U.S. Coast Guard (law enforcement), the Georgia Department of Natural Resources (buoy maintenance and law enforcement), and the Marine Extension Service of The University of Georgia (research coordination and educational and interpretative programs).

The rules for use of the sanctuary are listed below. Sanctuary regulations cover all users. As an example, a marine biologist could take photographs and make observations of the reef, and even collect a few individuals of non-endangered species, but would be forbidden to use a dredge or other sampling device that might damage the reef. A fisherman could catch fish by hook-and-line but could not use traps, nets, poisons or explosives. Endangered or threatened species such as the right whale (*Figure 11*) and loggerhead turtle (*Figure 12*), are protected everywhere, not just in the Marine Sanctuary.

The University of Georgia Marine Extension Center on Skidaway Island near Savannah contains an aquarium representing Gray's Reef, as well as exhibits and other information. It is a good place to visit to learn more about Gray's Reef and about marine science in general. Properly managed, Gray's Reef National Marine Sanctuary and the other similar sanctuaries throughout the nation can preserve a part of the natural world while providing opportunities for recreation, education and scientific study.



NATIONAL MARINE SANCTUARY REGULATIONS

Activities that do not harm or deplete the reources of Gray's Reef, including boating, sport fishing, diving, underwater photography, and research are encouraged. To prevent visual and biological degradation of important Sanctuary resources, certain activities are prohibited. These include the following:

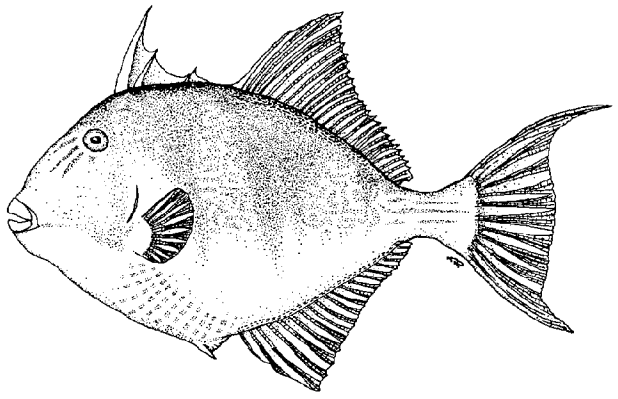
-using wire fish traps, poisons, setting electric charges, explosives, or similar methods to take any marine animal or plant

-using bottom trawls, specimen dredges or similar vessel-towed bottom sampling devices

-altering or damaging any bottom formation, marine invertebrate, marine plant, or tropical fish

-depositing or discharging any polluting material, except fish or fish parts, baits, chumming materials, vessel cooling waters and effluent cooling waters and effluent from approved marine sanitation devices

The U.S. Coast Guard is responsible for the enforcement of sanctuary regulations. Violators of sanctuary regulations are subject to civil penalties of up to $50,000 under public law. Anyone observing a violation is encouraged to report the violation to the U.S. Coast Guard, Group Charleston Operations Center, (803) 724-4383 or the Department of Natural Resources (912) 264-7218. Reports should include type of violation (fish trapping, bottom trawling, etc.) name of vessel and/or boat registration number, date and time of observed violation, and number of persons on board. Under no circumstances should a person attempt to interfere with the violator.



NATIONAL MARINE SANCTUARY PROGRAM

The National Marine Sanctuary Program seeks to preserve marine areas that are outstanding for their "conservation, recreational, ecological, or esthetic values."

The National Marine Sanctuary Program was established under Title III of the Marine Protection, Research and Sanctuaries Act of 1972. The program is administered by the National Oceanic and Atmospheric Administration (NOAA), through the National Ocean Service, Office of Ocean and Coastal Resource Management, Sanctuary Programs Division.

By 1988, 8 areas were designated as National Marine Sanctuaries:

(1) The **U.S.S. Monitor National Marine Sanctuary** - the wreckage of a Civil War ironclad ship which sank in 1862. It lies in 220 feet of water off Cape Hatteras.

(2) The **Gray's Reef National Marine Sanctuary** - a limestone live bottom reef supporting a diverse community of invertebrates, bottom-dwelling fish and sea turtles.

(3) The **Key Largo National Marine Sanctuary** - the largest coral reef off the North American coast, south of Miami. Key Largo is much used by divers and sports fishers.

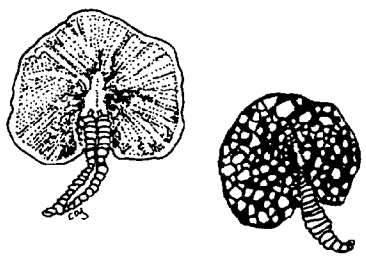
(4) The **Looe Key National Marine Sanctuary** - consists of a portion of the Florida Reef Tract off Big Pine Key that contains spectacular coral formations and diverse marine communities. It is a popular spot for scuba-diving, snorkeling, fishing and boating.

(5) The **Gulf of the Farallons National Marine Sanctuary** - encompasses numerous habitats where marine mammals share the sanctuary with the largest seabird colony in the continental United States. This sanctuary is north of San Francisco.

(6) The **Channel Islands National Marine Sanctuary** - located off the coast of southern California, this area provides safe breeding grounds for seals and sea lions. Extensive kelp beds offer food and shelter for a wide variety of organisms.

(7) The **Fagatele Bay National Marine Sanctuary** - located in American Samoa, this is a pristine environment with a highly productive coral reef community and a collection of threatened and endangered species, including the hawksbill sea turtle.

(8) The **Cordell Bank National Marine Sanctuary** - 50 miles northwest of San Francisco, California, is an underwater mountain lying on a plateau about 350 feet deep. It houses many rare species of invertebrates.



GLOSSARY

algae (singular: alga) - plants with no true roots, stems or leaves; larger ones are called seaweeds.

anaerobic - without oxygen.

benthos - the community of organisms on the bottom of the ocean.

continental shelf - shallow area of underwater land surrounding a continent to a depth of approximately 600 feet.

countercurrent - a current flowing in the opposite direction from a major current.

ebb tide - outgoing or falling tide.

eddy - a current of water or air moving in the opposite direction from a major current.

endangered species - an organism which is in danger of extinction without protection and management.

fetch - the distance wind blows over a body of water.

flood tide - incoming or rising tide.

gravity - force of attraction between two masses: e,g, the earth's gravity attracts all objects on the earth.

habitat - the specific environment occupied by a species of organism.

invertebrate - an animal with no backbone.

larva - the young stage of an animal; usually with different appearance and habitat from that of the adult.

limestone - rock made of calcium carbonate ($CaCO_3$) which may be formed from the skeletons of marine animals such as corals.

limiting Factor - environmental factor which limits the growth, reproduction or distribution of organisms.

macroalga (plural macroalgae) - large alga which can be easily seen, e.g., kelp (whereas microalgae are microscopic).

meander - winding path of a current.

nautical mile - used to measure distance at sea. One nautical mile = 1.15 statute miles.

nekton - swimming organisms such as fish which move freely through ocean waters.

nutrients - food substances necessary for growth or development of a plant or animal.

organic substance - complex carbon-containing substance; often produced by a living organism: e.g., sugar.

organism - a living creature. e.g., a plant, animal or fungus.

pelagic - living in the open ocean.

phytoplankton - plants which drift with the ocean currents, mostly microscopic.

plankton - plants and animals which drift in the ocean currents because they are not strong swimmers.

producers - plants which use sunlight to make food and provide food for other organisms.

salinity - salt concentration of sea water expressed as parts of salt per thousand parts of water (ppt or 0/00) or as a percent (%).

SCUBA - abbreviation for Self-Contained Underwater Breathing Apparatus, used by divers to breathe underwater.

sediments - sand, silt, mud or other particles of rock deposited by water or wind.

sessile - of animals attached to something and which do not move around: e.g., corals, sponges.

solution - a solid substance dissolved in a liquid: e.g., a solution of salt in water.

threatened species - an organism that is not in immediate danger of extinction, but without protection will likely become endangered in the foreseeable future.

vertebrate - animal with a backbone.

wavelength - the distance between two high points (crests) or two low points (troughs) on a wave.

zooplankton - animals which drift in the ocean currents because they are poor swimmers.