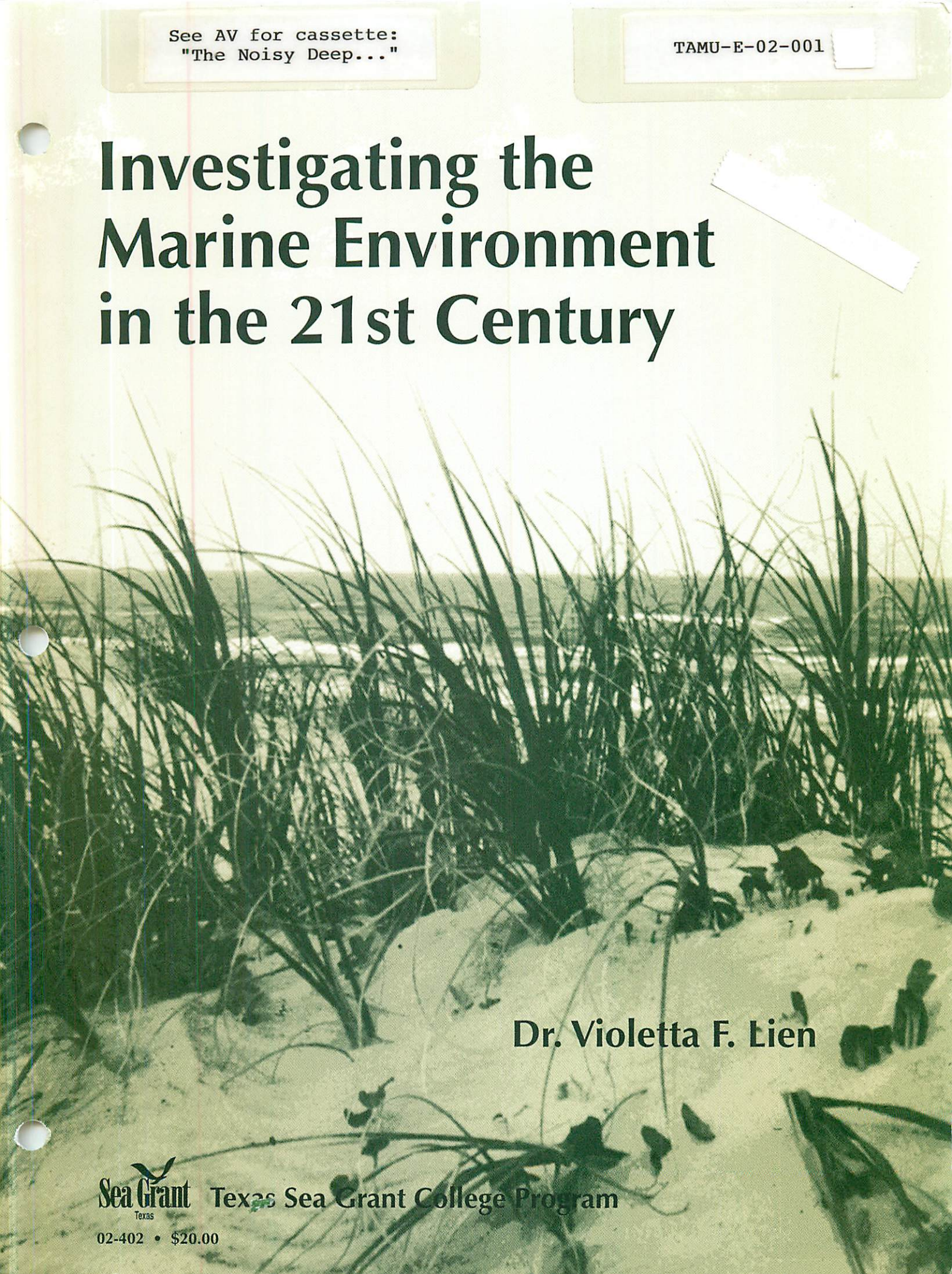
Investigating the Marine Environment in the 21st Century



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Sea Grant Texas
Texas Sea Grant College Program

02-402 • $20.00

Investigating the Marine Environment in the 21st Century

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TAMU-SG-02-402
November 2002

TAMU-SG-02-402
ISBN 1-883550-07-6

$20.00

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Publication of this book supported in part by Project ET/C-38 of Institutional Grant NA86RG0058 to Texas A&M University by the National Sea Grant Office, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Acknowledgements

This book was made possible by the encouragement and special support of several people. First, I wish to acknowledge Amy Broussard not only for supervising and editing this project but in her patience and support of the goals of the project.

Adah Stock of Irving Middle School in San Antonio deserves a special note of thanks for reading and commenting on all the lessons and providing the correlation with the Texas Essential Knowledge Skills.

A note of thanks to Regina Kubelka for her artwork and illustrations.

I wish to acknowledge the cooperation of all the teachers who participated in workshops and contributed suggestions and whose enthusiam was encouraging.

I am especially grateful to my husband, Ralph, and children, Brian, Michael and Michelle, who have been understanding of neglect while I spend long hours on research and the writing of this book.

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Preface

The living ocean drives planetary chemistry, governs climate and weather and otherwise provides the cornerstone of the life-support system for all creatures on our planet, from deep-sea starfish to desert sagebrush. That's why the ocean matters. If the sea is sick, we'll feel it. If it dies, we die. Our future and the state of the oceans are one.

—Sylvia A. Earle

The Apollo moon missions gave us a picture of our home, Planet Earth, for the first time in human history. When the astronauts saw the earth they called it "the blue planet." Our planet is primarily a world of blue water partly concealed by pattern of white vapor clouds that mark the movement of weather systems. The continents are actually islands in an enormous global sea.

Life on earth is water-based. Water runs through the bodies of living organisms as it does throughout the earth. Water actually gives the earth its features from caverns, valleys, canyons, deltas and beaches. It modifies the climate and is the source of extraordinary climatic events such as tropical storms and hurricanes.

The oceans are a fascinating and vital part of our world. The water draws us, capturing our attention and imagination. From prehistoric times to the present, the sea has been an important theme. The sea has inspired myth and legend, classic works of art, music and literature, and numerous television shows and movies. Many terms and expressions of the sea have become part of our language today. In countless ways, large and small, the resources of the sea touch our lives from food to oil and gas in our automobiles, as well as, recreation.

When we examine the history of people and nations, we see that their movement has quite often been in response to presence or absence of water. Only 10 of the 50 states do not have contact with the sea directly or indirectly through inland waterways. Our country has always been a maritime nation and even our major population centers are near water. More than half of our population lives only an hour's drive from the sea. The ocean offers military, recreational, economic, artistic and intellectual outlets of unlimited scope.

Texas is legendary in its ties to the land. Most people think of Texas as a land of ranches, cows, cowboys and oil wells rather than a land of windswept beaches and soaring seagulls. However, coastal Texas is of fundamental importance to the state. Texas has a coastline of more than 360 miles, which is one of the longest coastlines in the United States and is one-twelfth of the coastal United States. The Gulf of Mexico, the world's ninth largest body of water, is an important resource for both the United States and Texas. The Gulf waters supply more than 50 percent of the nation's seafood, and the coastal wetlands serve as a nursery and refuge for 70 percent of all Gulf species of fish and shellfish. More than 400 species of birds spend time in the Texas coastal zone. Of the United States' offshore oil and gas production, 90 percent comes from the Gulf of Mexico and 40 percent of the total United States refining capacity is located along the Gulf. The Texas portion of the Gulf shore alone has 65 percent of the nation's petrochemical capacity. The importance of the Gulf coast today and for the foreseeable future is evident by the fact that more than one-third of the state's population and economic activity is concentrated in that one-tenth of Texas that is the coastal plain, within 100 miles of the Gulf Coast.

Despite the importance of the Texas coastal zone and the fact that our planet is largely covered with salt water, the public and students know very little about what science has discovered, or has yet to discover, about the sea. Today, we recognize the importance of the sea as an integral and sustaining part of our planet, yet we are not "literate" about the marine environment and its resources. Wise interaction with the marine environment depends upon an informed public that is literate about the oceans. Studies on students' knowledge of marine and aquatic related topics indicate a critical need for an increased emphasis on the marine environment.

The purpose of this marine education resource manual is to fill the void in available marine education materials. The activities are designed to help students become more knowledgeable about the marine environment and its resources through emphasis on the Texas coastal zone and the Gulf of Mexico. The activities are designed for use in both traditional and integrated science courses, but also provide marine activities for social studies, language arts and mathematics courses or for interdisciplinary thematic units. The book provides current, in-depth information for classroom use and is correlated to the Texas Essential Knowledge Skills in science, mathematics, social studies and language arts. It also will meet national standards in science, mathematics, social

studies and language arts. It provides marine activities to incorporate in the teaching of systems; form and function; constancy and change; and properties, patterns and models.

Being a resource manual for teachers, this book contains many more activities than a teacher can use in a year. Each teacher is encouraged to select those activities most applicable to the individual's objectives. The book can be utilized in a variety of ways.

- Lessons can be used separately or can be incorporated into existing lessons to provide marine examples.
- Lessons can used as a basis for a unit.
- The book can be used for a semester-long course.

Although the manual was designed for middle school, the activities can be adapted and incorporated into upper elementary and high school classes as well.

This marine resource manual is designed not only to contribute to teachers' and students' knowledge of the marine environment but also to skills that are needed. Process skills, higher-order thinking, sound reasoning, problem-solving, interactive communication skills and inquiry are stressed. According to the enGauge project[1] on 21st century skills, the core skills are:

1. Digital-Age Literacy
   - Basic scientific, mathematical and technological literacies
   - Visual and information literacies
2. Inventive Thinking
   - Adaptability/ability to manage complexity
   - Curiosity, creativity and risk taking
   - Higher-order thinking and sound reasoning
3. Effective Communication
   - Teaming, collaboration, and interpersonal skills
   - Personal and social responsibility
   - Interactive communication skills
4. High Productivity
   - Ability to prioritize, plan and manage for results
   - Effective use of real-world tools
   - Ability to create relevant, high-quality products

The book provides activities that can be used to develop these skills with your guidance. However, as the teacher you are the key to the use of the activities. You will facilitate and guide the students' learning and thinking. The activities are not designed to be worksheets or cookbook laboratory activities, but as guides to inquiry or problem solving. Use the questions as your guide to facilitate the students' thinking and problem-solving skills through discussions, activities, projects and presentations. Encourage the students to work in cooperative groups to conduct inquiries on the marine topics and use the available technology in their research and presentations of their findings.

The activities are designed so that equipment and materials should not be a limiting factor. However, if you have technological tools, equipment and software (computers, graphing calculators, CBLs, probes, interfacing equipment, scanners, digital cameras, Pagemaker, Powerpoint, Excel, Inspiration, Hyperstudio, etc.) available incorporate their use in the activities.

Use this book as a resource to take your students on a voyage to Earth's final frontier and to facilitate their becoming marine "literate" and developing skills for the 21st century. Remember much of the ocean remains a mystery, from currents and hurricanes to its many amazing creatures. Our study of the sea has unlocked an unimaginable wealth of knowledge and resources, yet much remains to be learned. Your students can be the future discoverers. As many have noted, what we do or do not do today will determine the fate of this water planet, and of humankind.

We've made the investment needed to venture into the skies, and it has paid off mightily. We've neglected the oceans, and it has cost us dearly. This is the time to do for the oceans in the 21st century what our predecessors did for space.

—Sylvia Earle

[1](Lemke, C. 2001. *21st Century Skills.* Naperville, Ill: NCREL. http//www.ncrel.org/enguage/skills/skills.htm.)

Topic 12 — Marine Environments of the Texas Coast

Topic 12: Marine Environments of the Texas Coast

The ocean as a habitat is very different from that of land. On land organisms are exposed to large temperature variations while marine organisms are only exposed to temperature variations if they are in the coastal environments. Niches are relatively easy to identify on land. In the open ocean they are a challenge to identify. In the ocean most photosynthetic cells in the sea compete for the same inorganic nutrients. Most producers in the marine environment are the single celled phytoplankton and are in constant motion. Terrestrial plants are immobile. On land organisms need structural support while the ocean provides organisms a great deal of buoyancy.

Life in the ocean is extremely diverse and unevenly distributed on the bottom and in the water column. Much of the rich life of the ocean is not apparent because many of the plants and animals are microscopic. The oceans consist of an astonishing variety of habitats populated by very diverse organisms. The food web of the sea is based on protein. Carbohydrates dominate the land food webs. Marine populations are usually limited by food, while land populations are limited by water. Marine environments, like land environments, are classified in terms of relative productivity and energy flow. The open ocean is like grassland; coastal areas are similar to forests; zones of updwelling and estuaries are like rain forests.

The size and complexity of the marine environment makes it a difficult system to classify. It can be separated into two broad units, the benthic and pelagic divisions. These are subdivided into smaller categories based water depth, light availability, and tidal exposure. Each division of the ocean environments is inhabited by characteristic groups of marine organisms.

The activities in this unit focus on the different zones of the marine environment with special emphasis on the environments of the Texas coastal zone and Gulf of Mexico. The energy flow of food chains and food webs of the marine environments are included.

Activity 1: What Are the Zones of the Marine Environment?

TEKS: Science: 8.12

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- Identify the zones of the marine environment.
- Construct a chart on the characteristic of the zones of the marine environment.
- Explain the abiotic characteristics of each zone and how they affect the organisms that live there.

Background:

1. Prepare a large cross section of the marine environment on a bulletin board. As each of the zones are studied, pictures or sketches of representative organisms can be added to the zones or have each group of students prepare a poster-size cross section of the marine environment. Point out that the marine environment can be separated into two broad units, the benthic and pelagic divisions and these in turn may be subdivided.
2. Discuss the characteristics of each zone and how these affect the organisms and how organisms adapted to each zone. Interrelationships exist between the physical and biological aspects of an environment. The relationships are complicated because organisms adapt to, and in turn actively change, their environment. There is a constant back and forth interplay between the organisms and the physical and chemical setting.
3. Have the students complete the chart on the characteristics of the zones of the marine environment. Note the patterns of each abiotic factor and how it affects marine life. Photosynthetic organisms must remain in the upper region of the ocean where solar energy is sufficient to support photosynthesis. Temperature is a universal factor that determines the existence and behavior of living organisms. The high heat capacity of water limits marine organisms to a much narrower temperature range than land temperatures. The distribution of various forms of marine life is closely related to geographic differences in seawater temperatures. Surface water temperatures are highest near the equator and decrease toward both poles. This establishes marine climatic zones. In the Gulf, there are at least two distinct zones, the Carolinian and the Caribbean influence. Organisms living below the sea surface are constantly experiencing the pressure created by the weight of the water above. Oxygen is necessary for the survival of most organisms so its concentration strongly influences the distribution of marine life. Oxygen is used by organisms in all areas of the marine environment. Oxygen consumed near the bottom can only be replaced by oxygen from the surface.
4. Nitrate and phosphate are the fertilizers of the sea. These and smaller amounts of other nutrients are used by photosynthetic organisms living near the surface and are excreted back into the water

at all depths as waste products of the organisms that consumed the photosynthetic material. The vertical distribution of dissolved nutrients is usually opposite that of dissolved oxygen. Oxygen is normally produced near the surface by photosynthesizers. Oxygen is consumed and nutrients are excreted by organisms at all depths.

5. Note that the ocean is also in constant motion, providing a near uniform medium for living organisms. Discuss that this mixing minimizes variations in salinity and temperature. It also helps to move swimming and floating organisms and eggs, spores and larvae. It helps to move body wastes, food, nutrients and essential elements. These processes include wave action, tides, currents and vertical water movements. Note that the limits of the intertidal zones are defined by tidal fluctuations of sea level along the shoreline.
6. Discuss the pattern of each abiotic factor and how it affects each zone. Note how organisms adapt to the variations of the abiotic factors in each zone. Discuss how changing the abiotic factors (warming of ocean water, salinity changes due to droughts or hurricanes; motion of ocean water due to hurricanes; increase of nutrients from fertilizers and sewage; increase of pollutants, etc.) would impact the marine environment.

Activity 2: What Are the Groups of Marine Organisms?

TEKS: Science: 8.12

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- Identify the groups of organisms by their lifestyle: plankton, nekton and benthos.
- Construct a table to compare the different lifestyles of marine organisms.

Background:

1. Point out that all classification systems are artificial and have one purpose, which is to provide a way to treat information from a complex natural system in a useful way. A simple way to classify marine organisms is according to where they live and what their life is like. Sometimes the distinctions between the major groups are not clear. For example many fishes hatch from eggs as zooplankton and develop into nektonic animals as their size increases and their ability to swim improves. However, the system is useful to referring to major groups of marine organisms living under similar conditions.
2. The useful way of broadly classifying the marine organisms is by lifestyle. Stress that the plankton float passively and drift with the ocean currents. By contrast, the nekton are active swimmers, moving easily through the water. The benthos live in contact with the bottom and are either attached to it, move freely on it or live within the substrate. Discuss the lifestyle of each group and where they are found. Discuss abiotic and biotic factors that affect their lifestyle and, in turn, their survival.

Activity 3: What are Some of the Marine Communities and Ecosystems of the Gulf Coast?

TEKS: Science: 8.12,7.12

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20

SS: 6.3,7.8,8.10, 6.6,7.9

Learner outcomes: After completing the activities, the students will be able to:

- Use a map to locate coastal features and identify the abiotic factors in each.
- Differentiate between bays and lagoons; environmental conditions on the inner and outer side of the barrier islands; Cosmopolitan, Carolinian and Carribbean organisms.
- Identify the role of tidal inlets and passes to the coastal marine environments and the lifestyle and cycle of organisms

Background:

1. If topics 8 and 9 have not been studied, then it is be advisable to cover Topic 8, Activities 6, 7, 8, 12, 14 and Topic 9, Activity 4. Divide the class into cooperative groups and each group completes one of the above assigned activities. The group presents what they learned about the physical factor to the class.
2. Use the maps to locate and identify the different Gulf of Mexico coastal features. Ask each group of students to analyze each feature and prepare a three column chart listing each coastal feature, its abiotic factors and impact on organisms. Use the questions in the activity to guide the analysis and discussion.
3. Habitats on the outer side of the barrier islands receive more abuse from waves, currents and shifting sand, but undergo less abrupt changes in salinity and temperature than habitats on the bay side. Sandy beaches and rock jetties are the major habitat types on the outer coast while mud flats, salt marshes and oyster reefs are the major habitats in the bays.

4. Ask the students to look at the maps and hypothesize what the different marine environments along the Texas coast would be like if the passes and inlets did not exist. Include a discussion of the impact on the marine organisms. Would the organisms be the same or different? How would if affect the lifestyle of the organisms?
5. Stress the importance of the tidal inlets and passes on the abiotic factors (salinity, nutrients, temperature, nutrients, toxic substances, etc.) as well as on the lifestyle of organisms. Note that ninety-five percent of the marine organisms that live in the Gulf use the tidal passes to move between the bays and estuaries and the Gulf during their life cycle. If the tidal passes did not exist, these organisms might not be able to exist in the Gulf.
6. Point out that fauna of the northern Gulf of Mexico is of three major types. The Carolinian species are found from North Carolina to the Gulf of Mexico. Point out that DeSoto Canyon is the boundary. Two factors are involved, the sediments on the Florida side of the canyon favor Carolinian species and the Loop Current which transports warm Caribbean water and larvae of Caribbean species along the Florida coast. To the west of DeSoto canyon, the sediments from rivers (Mississippi and others) provide a different substrate and high turbidity. The high turbidity discourages the eastern species. The Caribbean species are found from Corpus Christi to St. Petersburg, Florida. These species usually arrive as larvae carried north along the coasts of Mexico and Florida or across the Gulf from the Yucatan. Cosmopolitan species are found around the world. They are brought into the Gulf by ships that visit the Gulf coast ports. Some species like the Portuguese man-of-war and the by-the-wind sailor are carried across the Gulf by currents and wind.

Activities 4 - 11

1. Activities 4-11 examine each of the different marine environments. Each activity provides information, questions and activities to guide the students' analysis of the environment and the organisms found in that environment. If time is a factor, assign each activity to a team of students. Provide the students with the following information.
   a. There are concerns about Gulf coast and Gulf of Mexico marine environments. No one or group of scientists is an expert on all the marine communities and ecosystems in the Gulf.
   b. Information is available on the different environments but it has not been analyzed as a whole to compile an overall picture of the entire Gulf of Mexico marine environments and their interaction and the problems the environments' face.
   c. A conference, The Gulf of Mexico Marine Environments in the 21st Century is planned. Teams of scientists have been invited to make presentations. Your team will make a presentation on your assigned marine environment.
   d. The conference presentation format requires that each presentation must inform the conference participants about the following:
      1. abiotic factors of the environment;
      2. biotic components of the environment;
      3. adaptations of organisms to the conditions of the environment;
      4. interaction between the biotic community and the abiotic factors;
      5. problems facing organisms in the environment, and
      6. issues that are impacting that environment.
      7. formulate plans for preventing or resolving the problems facing the marine environments.
   e. Conferences require an oral presentation to all the conference participants. This could include the use of transparencies or a Powerpoint presentation or slides.
   f. A written paper is also required. This paper is available to conference participants. Often it is published as part of the conference proceedings.
   g. Conferences also have poster sessions. Where the research is summarized on poster boards with illustrations.
   h. Each team will plan and work cooperatively to research their assigned environment. They are to become the experts on it and prepare their presentations for the conference

      Point out to the students that conferences of this sort are held by the scientific community to: share what is known about a specific topic; to update everyone attending on the latest research findings; provide opportunities for discussion by participants; and even to put forth proposals for action.
2. Communication skills are very important in the scientific community. You may wish to team with English teachers to assist in this research and communication project. Determine what your requirements and guidelines are for the project. Instead of a research project it may be a public information project where the students will use skits, multimedia or other means of communicating the same information to an audience of local citizens or students in the lower grades. Each team may also create segment of a mural depicting the marine environments of Texas and the Gulf.
3. If your school is along the Texas coast, then the

written report may be in the form of a column for a local newspaper. Contact the local paper to see if they are open to this and what their requirements/restrictions are. It may also be the compiling of a booklet to inform the public. In this case, then the research needs to include specific local examples.

4. The goals of these activities are for the students to research additional information about the environments to identify the abiotic and biotic components and their interaction, as well as, the zones of the environment. In addition, they are to identify problems or potential problems of that particular environment. The students should be able to effectively analyze the information about the marine environment and effectively communicate the information to a selected audience. The students should be able to evaluate the problems and propose possible ways to resolve or prevent the problems.

Activity 4: What is Life Like in the Sandy Beach Ecosystem?

TEKS: Science: 6.2,6.3,6.4,,7.2,7.3,7.4,8.2,8.3,8.4, 6.12, 8.12

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20, 6.24,7.24,8.24

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- research the abiotic and biotic components of the sandy beach ecosystem.
- analyze the interaction of the biotic community and the abiotic factors.
- formulate proposals or plans to address problems facing the sandy beach ecosystem.
- communicate information about the sandy beach ecosystem to the public.

Background

1. Topic 7 - Beaches and Dunes is a source of additional background information. If activities 8 and 9 have not been completed previously, these should be included to provide an understanding of how organisms survive in the sandy beach.
2. Stress that most organisms on the sandy beach escape the physical hazards of this environment by burrowing. Almost all of the biotic community lives underground and out of sight. Some minimize the changes by moving up and down the beach with the changing tide. Others avoid the surf by living above it and only returning to the water to wet their gills or to obtain bits of food left by the ebbing tide. Note each organism has specific adaptations that aid its survival in this harsh environment.
3. Discuss the impact of hurricanes, driving on the beach, grading the beach to remove debris washed in by the tides, oil spills and trash, construction, shoreline stabilization and large numbers of people on the sandy beach ecosystem. Ask the students to think of other problems and to design a plan to ensure that the sandy beach ecosystem is protected.

Activity 5: What is Life Like on the Jetties and Groins (the Rocky Shore)?

TEKS: Science: 6.2,6.3,6.4,,7.2,7.3,7.4,8.2,8.3,8.4, 6.12,8.12,7.11

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20, 6.24,7.24,8.24

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- research the abiotic and biotic components of the jetties and groins.
- analyze the interaction of the biotic community and the abiotic factors.
- formulate proposals or plans to address problems facing the jetties and groins.
- communicate information about the rocky shore ecosystem of the jetties and groins to the public.

Background

1. The Texas jetties are roughly triangular in cross section, with a base of 50 meters and a top of about 4 meters. Small granite rocks weighing 15 to 200 pounds formed the base with blocks up to 3 tons forming the core. Boulders weighing from 6 to 10 tons from the top of the jetty. The granite is from central Texas quarries. The largest blocks fit loosely together so the gaping crevices between them provide a habitat for a variety of intertidal life. The rocky shore communities are due to effectiveness of larval dispersal by oceanic currents. This is one of the simplest rocky shore communities. This may be due to the fact that jetties and groins are recently colonized, because of the limited tidal range of the Gulf, because this is a transition region between temperature and tropical or because of all of these or other factors.
2. The biotic zonation on the jetties and groins has three units. A supralittoral fringe characterized by periwinkles; a midlittoral barnacle zone; and a sublittorial zone characterized by several species of macroscopic and epiphytic algae. The zonation

is greater on the seaward end of the jetties. This community gradually changes in species makeup from northern to the southern jetties, largely because of the temperate to tropical transition. Stress that wave exposure is an important factor influencing the distribution of the organisms. There is a difference from the seaward end of a jetty to land end. There is also a difference in the side that faces the tidal inlet and the side facing the open sea. Temperature variations occur from the landward to the seaward ends of the jetties and between the Gulf and inlet sides.

3. Discuss the impact of hurricanes,debris washed in by the tides, oil spills and trash, and large numbers of people on the jetties. Ask the students to think of other problems and to design a plan to ensure that the jetty community is protected.

Activity 6: What is life like in the Estuarine Ecosystem?

TEKS: Science: 6.2,6.3,6.4,,7.2,7.3,7.4,8.2,8.3,8.4, 6.12,8.12

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20, 6.24,7.24,8.24

SS: 6.3,7.8,8.10,6.7,7.10

Learner outcomes: After completing the activities, the students will be able to:

- research the abiotic and biotic components of the estuarine ecosystem.
- analyze the interaction of the biotic community and the abiotic factors.
- formulate proposals or plans to address problems facing the estuarine communities and ecosystem.
- communicate information about the estuarine ecosystem to the public.

Background:

1. The tidal fringe or estuarine wetlands can have vegetation like the salt marshes or be unvegetated like the mud flats. This ecosystem includes the salt marshes, the mud flats and the oyster reef community. Estuarine organisms live in a slowly dying environment. They even contribute to its death with their tissues, skeletons, shells and feces. Organisms in these environments must cope with the constant rain of sediments that can clog their gills, snuff out their lives and even bury them in a muddy grave. Organisms must be able to survive rapidly fluctuating salinities and temperatures. To survive the, organisms must be quick, hardy or both. The best adapted organisms are the active swimmers, crawlers and burrowers. For sessile organisms, the estuarine environments is a difficult place to live.
2. The bayshore vegetation will vary from the northern Texas coast to Laguna Madre. Some plants occur throughout the region, others occur in only one area. A rich variety of birds occur in these areas and very few are restricted to a particular habitat. Many species are permanent residents, but more are only seasonal residents. A variety of fiddler crabs and other crustaceans are found at or near the water's edge. Bivalves and gastropods are also numerous in these environments. Many crustaceans are found in the sea grass beds. There are many organisms that live in the mud that is anoxic. These organisms have developed mechanisms to pump water through their burrows or tubes for oxygenation and respiration. The majority of these animals are filter feeders. They have developed various techniques to remove food particles form the water or sediments as it moves into the area. The incoming water brings in oxygen and cleans the area, and is a source of nutrients.
3. Discuss the impact of droughts and hurricanes on these marine environments. Human activity is the major threat to these wetlands. Agriculture, industrial development, and urban and suburban growth have resulted in the greatest losses of wetlands. Discuss how the environments are effected by land subsidence, construction, dredging of channels and canals; dams on rivers, runoff pollution and oil and chemical spills. Point out that the estuarine area along the Texas coast has decreased by about 13 percent since the mid1950s.
4. Another issue is that motor boats cut very visible lines across the bottoms of Texas bays and flats as the boats travel to and from fishing locations. Operators also cut large circles in the bottom as they attempt to pull the boats back up out of the shallow water and get them running at full speed again. This is destroying fragile, shallow water grass beds and bottom habitats. Although the grass will grow back, it can take 5 to 6 years for some species. The highly prized turtle grass is a fragile, slow growing grass that is great for fishing. However, it has been damaged by boats. Then more vigorous growing grasses replace it. This changes the community. There has been a substantial decline since the mid-1970s in the sea grasses important to the nesting and hiding habitat for gamefish, crabs, shrimp and their young. Dredging and water quality also contribute to the decline of sea grasses. The damage could eventually result in a collapse of the ecosystem. Some groups are suggesting limiting boats to driving lanes. Ask the students to think of

other problems and to design a plan to ensure that the estuarine ecosystem is protected.

Activity 7: What is life like in the lagoon ecosystem?

TEKS: Science: 6.2,6.3,6.4,7.2,7.3,7.4,8.2,8.3,8.4, 6.12,8.12,7.11

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20, 6.24,7.24,8.24

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- research the abiotic and biotic components of the lagoon ecosystem.
- analyze the interaction of the biotic community and the abiotic factors.
- formulate proposals or plans to address problems facing the lagoon ecosystem.
- communicate information about the lagoon ecosystem to the public.

Background:

1. The Laguna Madre of the Texas coast is the most studied hypersaline lagoon in the world. It was created by the formation of Padre Island about 5,000 years ago. At one time the Rio Grande flowed into the southern part of the lagoon. However, during the last 4,000 years the Laguna Madre has been without significant river input. Without this inflow there is little fresh water to dilute the salt water. The high summer temperatures evaporate some of the water. As a result the waters are hypersaline. The salinities range from 2 ppt to 86 ppt. The highest salinities are in Baffin Bay, which was created as a drowned river valley estuary. It is the remains of an earlier river discharge that is no longer significant, which indicates there was more rainfall in the past. The Intracoastal Waterway, completed in 1949, provides some exchange of water. This exchange could have been greater but a landfill causeway completed in 1950 to connect Padre Island to the mainland limited the exchange of water. The ultimate fate of all coastal estuaries is to fill with sediment. Unlike others, the Laguna Madre is not being filled with sediments from rivers. It is being filled with wind-driven sand from Padre Island and washovers from storms.
2. Point out that salinity is the primary limiting factor in the hypersaline lagoon. Organisms must be able to tolerate not only increased salinity but also fluctuations in salinity. Also in a normal estuary, salinity increases from the tidal inlet to the Gulf, but in the hypersaline environment it is the opposite. Salinity increases from the Gulf into the central portion of Laguna Madre. Even in moderately saline environments, the osmotic imbalance between body fluids and the environment places a constant demand on the organism. At 40 ppt, osmotic is present. At 50 ppt and above, only a few of the hardiest plants and animals are capable of surviving. Also there are rare periods of rapid decreases in salinity due to intense rainfall from storms. Therefore the area is characterized by low species diversity. The area is more like a biological desert, not devoid of life, but containing a few hardy, adaptable species often in large numbers.
3. The construction of the Intracoastal Waterway and the Mansfield cut have increased the circulation of normal seawater through much of Laguna Madre. This is especially true in the Redfish Bay area. Seagrass meadows are more extensive in the Laguna Madre than in most other Texas estuaries and account for high productivity. Many of the invertebrates associated with seagrass beds occur in the lagoon. The algae and sea grasses provide abundant food for the grazing fishes, which, in turn, are fed upon by the sport and food fish species. During normal years, when the salinities in Redfish Bay fluctuate between 40 and 60 ppt, the area is a highly productive fishing ground. During dry years when the salinities rise above 70 ppt, there are large fish kills in Redfish Bay. Eventually the excessive salt is flushed out by a hurricane or drought breaking rains. Then the fishery is restored.
4. For the mangrove community, even mild winter freezes limit the mangroves along the Texas coast. One example of a Texas mangrove is the Laguna Madre side of South Padre Island near the causeway and fishing peer. These structures have created flat shore of mud that is ideal for mangroves. However, even here occasional freezing temperatures will kill them.
5. Discuss the impact of hurricanes, droughts, freezes, dredging of the intracoastal waterway, boating in the seagrass beds and agricultural and residential runoff on the lagoon ecosystem. Ask the students to think of other problems and to design a plan to ensure that the ecosystem is protected.

Activity 8: What is life like in the Open Waters?

TEKS: Science: 6.2,6.3,6.4,,7.2,7.3,7.4,8.2,8.3,8.4, 6.12,8.12,7.11

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20, 6.24,7.24,8.24

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- research the abiotic and biotic components of the open Gulf ecosystem.
- analyze the interaction of the biotic community and the abiotic factors.
- formulate proposals or plans to address problems facing the Gulf ecosystem.
- communicate information about the Gulf ecosystem to the public.

Background:

1. The open water of the bays, tidal inlets and Gulf has two groups of organisms, the plankton and nekton. Both groups can be divided into several subgroups based on taxonomy, size, stage of life or preferred place in the sea. The nekton consist primarily of the fishes, marine mammals, and cephalopods. The plankton varies from the ultramicroscopic bacteria to fungi to large jellyfishes. Size does not determine membership in the plankton but the inability to swim against a current does.
2. There are around 550 species of fishes from the marine and estuarine waters of Texas. Many live offshore, but a large number also enter the bays. Some spend their entire life in the estuaries.
3. Most of the species of phytoplankton are microscopic in size. A few are macroplankton. One of these is Sargassum, a large brown alga. The sargassum floats because of gas-filled floats that keep its large fronds suspended near the sea surface where there is sunlight for photosynthesis. It does not provide food for herbivores. Instead, the mass of intricate, intertwined fronds supports an unusually rich and diverse community that depends on it for existence. More than 50 species of encrusted, attached and swimming organisms have adapted to life in the floating sargassum. Some mimic the color and patterns of the fronds to such a degree that they are perfectly camouflaged.
4. Discuss the impact of hurricanes, coastal development, shipping, oil spills, pollution and agricultural and residential runoff on the Gulf waters. Ask the students to think of other problems and to design a plan to ensure that the Gulf waters are protected.

Activity 9: What is life like in the Offshore Bottom Ecosystem?

TEKS: Science: 6.2,6.3,6.4,,7.2,7.3,7.4,8.2,8.3,8.4, 6.12,8.12,7.11

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20, 6.24,7.24,8.24

SS: 6.3,7.8,8.10, 6.7,7.10

Learner outcomes: After completing the activities, the students will be able to:

- research the abiotic and biotic components of the offshore bottom ecosystem.
- analyze the interaction of the biotic community and the abiotic factors.
- formulate proposals or plans to address problems facing the offshore bottom.
- communicate information about the offshore bottom environment to the public.

Background:

1. The offshore bottoms ecosystem is diverse consisting of the organisms that live on the surface of the sediments and others that burrow into the substrate. The shrimp, crabs and other animals living on the surface are sensitive to differences in water depth, temperature and salinity. The various worms, clams and other animals that burrow are sensitive to sediment texture. The sand grains and shell fragments are used in the construction of burrows. Therefore particle size affects the ease of burrowing and the durability of burrows. Animals that construct permanent burrows prefer the coarse sediments. Also the grain size reflects the local current patterns that distribute the sediments and transport food along the bottom. Most of the food in this environment is organic matter carried to the Gulf by rivers or from plankton near the surface that sinks to the floor.
2. Point out that the common means of obtaining food is by deposit feeding. That is simply swallowing the sediment and the digestive tract removes the nutrients. Undigested material is extruded as feces. It may occur by either directly swallowing the sediments or indirectly by using tentacles or a proboscis to catch the sediment as it falls from the surface. Filter feeding involves the extension of tentacles vertically to intercept food drifting with the currents across the bottom. Predators feed on the living organisms in and on the substrate. Most of the organisms are polychaete worms. Amphipods, anemone or surf clams are also part of the bottom population.
3. The shrimp are mobile and elusive. They are most active at night; during the day the pink and brown shrimp often burrow in the substrate. In addition to the brown, pink and white shrimp there are also the seabob, sugar, rock, mantis,caridean and

sergestid shrimp. The bottom also includes a variety of bivalves, snails, crabs, amphipods, brittle stars and the elusive octopus.

4. Discuss the impact of non source point pollution, industrial discharge (such as that of Formosa Plastics Corporation in Calhoun County), oil spills, discharge from waste treatment plants, dredging, hurricanes and agricultural and residential runoff on the Gulf waters. Ask the students to think of additional problems and to design a plan to ensure that Gulf bottom environments are protected.

Activity 10: What is life like in the Coral Reef Ecosystem?

TEKS: Science: 6.12,8.12,7.11

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20, 6.24,7.24,8.24

SS: 6.3,7.8,8.10,6.7,7.10,6.23,7.23,8.32

Learner outcomes: After completing the activities, the students will be able to:

- research the abiotic and biotic components of the coral reef ecosystem.
- analyze the interaction of the biotic community and the abiotic factors.
- formulate proposals or plans to address problems facing the coral reef ecosystem.
- communicate information about the Flower Gardens coral reef ecosystem to the public.

Background:

1. Reef-building corals and the biota they support are not common in the western Gulf. A greater number of coral reefs and banks occur in the eastern Gulf and Caribbean. Most of these coral reefs occur between latitudes of 24 to 28 ° N. Other corals are found in the Gulf. The reef building corals require warm, clean, shallow marine water of normal salinity and hard substratum on which to attach. They seem to do best between 23 to 35° C. They are sensitive to water turbidity so are only found a considerable distance away from rivers. All these factors do not readily exist in the Gulf so the environment is poorly suited to reef building corals.
2. Corals are carnivores that feed on suspended materials, primarily zooplankton. During the day the corals lie contracted, but the polyps emerge in the evening or on cloudy days to feed. They also require well illuminated water since reef building corals depend on light. To learn more about the corals, see Topic 13, Activity 9, What is so unusual about coral and the coral reef?
3. The Flower Garden coral reefs are the site of an invertebrate spawning each summer. The mass spawning event includes at least 10 species of corals, worms, sea stars, and sponges. It occurs eight days after the full moon in August. These reefs at present are isolated from many destructive human practices such as pollution, runoff, overfishing and dense coastal development that have damaged almost a third of the Earth's reefs. The health of the coral community is an indicator of the health of the reef. Scientists are working to understand the species and the basic reproductive biology of corals. The Flower Garden is an excellent research site because human practices have not affected it.
4. Coral reefs—some of which have been alive for up to 2.5 million years—play a crucial role in many marine ecosystems and their loss would place thousands of species of fish and other marine life at risk of extinction. According to experts, more than a fourth of the world's coral reefs have been destroyed by pollution and global warming. The 9th International Coral Reef Symposium warned that governments must reverse global warming trends, cut pollution and crack down on overfishing. It noted that in some areas of the world fisherman use dynamite to blow reefs apart or cyanide to poison them to catch fish. In other areas, untreated sewage and other wastes are pumped directly into the oceans. Scientists point out that the loss of the reefs would not only be a major blow to the environment, but would also threaten the survival of a half billion people around the world that rely on reefs for food and income. The reefs bring in an estimated $400 billion a year in fishing and tourism revenues.
5. Discuss the impact of dredging, pollution, oil spills, residential and agricultural runoff, global warming and dropping anchors on a coral reef. Ask the students to think of additional problems associated with coral reefs and to design a plan to ensure that coral reefs are protected.

Activity 11: What is life like in the Artificial Reef?

TEKS: Science: 6.12,8.12,7.11

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20

SS: 6.3,7.8,8.10

- research the abiotic and biotic components of the artificial reef ecosystem.
- analyze the interaction of the biotic community and the abiotic factors.
- formulate proposals or plans to address prob-

lems facing the artificial reefs.

- communicate information about the artificial reefs to the public.

Background:

1. The oil platforms and sunken ships are the substrate for the formation of artificial reef habitats. Artificial reefs are an example of succession and the interrelationships of biota. There is an orderly progression of organisms arriving at the artificial reef. This could be compared to the succession of organisms into a land area that has been destroyed by fire or a volcanic eruption. The orderly progression is related to the food chain and to the need for a place for attachment or protection which may be provided by other organisms.
2. Stress that the colonization of an artificial reef is by organisms that arrive on the currents with the arrival of the barnacles being a major factor. Changes in the biota on the surfaces of the offshore platforms occur frequently but no predictable patterns are found. Change is a result of the short life span of most fouling organisms. With the exception of the barnacle, fouling species rarely live for a year. However, the surface is not uncovered since new colonists arrive as the current flows past. These planktonic larvae in the currents vary with the season. Once they are established, the organisms have mechanism to prevent further colonization. New larvae that arrive are physically attacked or eaten. This explains the sudden increases in populations and the disappearance of others. So each time one visits the artificial reef the organisms may differ.
3. Compare and contrast coral reefs and artificial reef ecosystems. Discuss what might affect the life on the artificial reefs. Should the artificial reefs in the Gulf be increased or not? Should they be protected? Discuss the pros and cons and propose a policy for artificial reefs.

Activity 12: Why are the Dives different?

TEKS: Science: 6.12,8.12,7.11

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20,

SS: 6.1,7.7,6.3,7.8,8.10, 6.22,7.21,8.29

Learner outcomes: After completing the activities, the students will be able to:

- compare and contrast two dives and make inferences about the dives.
- construct a hypothesis to explain the differences in the two dives.
- determine what evidence will be needed to support the hypothesis.
- construct a scenario for the appearance of an ecosystem in a future dive.

Background:

1. Human activities are impacting the marine environments. The description of the two dives provide the students with an opportunity to assess the impact of human activities on the marine environment.
2. Students are then asked to describe what the marine environment will be like in the future and provide supporting evidence for it. Use this as the basis for a discussion on the future of the marine environment and what actions they can take to prevent the destruction of these environments.

Activity 13: What are the Major Living Components of Marine Ecosystems?

TEKS: Science: 6.12,8.12,7.11,7.12

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20,

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- analyze how matter and energy is transferred in the marine environment.
- classify organisms as producers, consumers, omnivores, scavengers, detritivores, and decomposers.
- summarize the role of each group of organisms in the transfer of matter and energy.

Background:

1. Relationships between different organisms can be described by their trophic associations. This involves determining what an organism eats and what eats it. Living organisms require two fundamental things from their food, matter and energy. Matter is needed for growth and reproduction. Energy is needed to maintain the ordered chemical state that distinguishes living from nonliving. Point out that the transfer of matter and energy for use in metabolism has resulted in a close interdependence of the major categories of marine organisms. The autotrophs or producers are capable of absorbing solar energy and through photosynthesis building high energy organic substances, such as carbohydrates. To do this autotrophs use inorganic nutrients, primarily nitrate and phosphate along with water and dissolved gases. The consumers and decomposers are unable to synthesize their own food from inorganic substances. They must depend on the producers.

2. Provide the students with the marine organism cards and use the questions to guide the students in their grouping of the cards and noting the patterns: autotrophs occupy the first trophic level; animals that feed on autotrophs are primary consumers; all primary consumers are herbivores; herbivores are the second trophic level; secondary consumers are carnivores that eat the herbivores; secondary consumers occupy the third trophic level; the tertiary consumers are carnivores that eat carnivores. The decomposers exist on detritus, the waste products and dead remains of organisms. They are part of the microbial loop in a food web.
3. Have students apply their knowledge of the categories (producers, consumers, decomposers) of marine organisms by classifying the organisms described in the different marine environments (Activities 4-11).

Activity 14: How Does Energy Flow in Marine Ecosystems? Or Who's for Dinner?

TEKS: Science: 6.12,8.12,7.11,7.12,6.8

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- interpret the data using the marine organism cards to determine how energy flows in a food chain.
- construct food chains using the marine organism cards.
- select a marine ecosystem and diagram food chains found in the ecosystem

Background

1. Guide the students in using the marine organism cards to build food chains. The instructions are similar to playing a game of "straight" dominoes. Use the questions to guide the students' understanding of the categories of organisms; patterns of trophic levels; and the pattern or sequence of energy flow in the food chain.
2. Use on the the ecosystems described in Activities 4-11 to diagram several patterns of energy flow in food chains. Ask the students to hypothesize as to the impact of the death of various organisms to the flow of energy in that ecosystem.

Activity 15: How does energy flow in the Ecosystems of Food Web? Or Who Eats Whom?

TEKS: Science: 6.12,8.12,7.11,7.12,6.8,8.14

Math: 6.8,7.9,8.8

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20,

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- use the marine organism cards to simulate the energy flow in a marine ecosystem food web.
- use the marine organism cards to construct food webs.
- construct food webs and determine the impact of various actions.
- apply their knowledge of food webs to construct a food web of one of the marine ecosystems (lessons 4-11).

Background:

1. The paths that nutrients and energy flow through in the living portion of the ecosystems is referred to as food webs. They may be grazing food webs, food webs that begin with autotrophs and progress through a succession of grazers and predators or they may be detritus food webs that are based on waste materials and dead bodies from grazing webs. In most cases the first trophic level of the marine food web is the microscopic plankton. Because few animals are adapted to feed on organisms much smaller than themselves, marine herbivores are usually small. Large marine animals are carnivores and usually occupy the higher trophic levels. In contrast to the land ecosystems, the plants of the first trophic level are large. As a result, most large land animals are herbivores.
2. Marine communities seldom have straight line food chains. The food web is a more accurate description of the complex feeding relationship of marine organisms. The feeding relationships are complex because an animal may be a primary consumer at the third trophic level or when it consumes a different organism it may be at the fourth trophic or even at the fifth tropic level. The level will vary with the organism that it consumes.
3. Rather than using string to create the food web on the table, have each student take a card from the marine organism deck. They are to make a nametag, representing the organism on the card taken from the deck.
   a. Each student should wear one of these name tags.

b. Using string, connect the students to show the organisms that interact with each other (either by eating another organism or being eaten by one). This will illustrate why the energy relationships in an ecosystem are more like a web than a chain.

c. What would happen if. . . ? This exercise is a continuation of the activity above. The effect of substances or actions on the food web can be illustrated. To illustrate the effect, drop the strings representing organisms killed or affected by actions in number 3.

4. Survival can also be played. This game should be played outdoors. Set up the area for the simulation to represent the different areas of the marine environment.

a. Each player takes a marine organism card.

b. Each player becomes that organism for the duration of the game by wearing a name tag representing the organism drawn. The nametag should be large enough to be seen from a distance.

c. The organisms eat (players tag) the organisms in its diet, while trying to avoid being eaten (tagged) by other organisms (players).

d. The player who has tagged the largest number of fellow players and has not been tagged is the winner.

e. After the first game, ask the students to discuss ways to improve upon the simulation to make it more realistic. The variations are unlimited.

1. Set a certain number of each type of organism.
2. Restrict the students' movements as related to the organisms' ability to more.
3. Allow the students to search for and eat food only in a manner similar to the habits of the organism they represent.
4. Create different habitat zones in the area of the simulation so the students can only move in the areas that their organism does.

5. Have the students select one of the ecosystems from lessons 4-11 and diagram its food web.

Activity 16: How much energy is needed to make a dolphin?

TEKS: Science: 6.12,8.12,7.11,7.12,6.8,8.14

LA: 6.10,7.10,8.10,6.13,7.13,8.13,6.20,7.20,8.20,

SS: 6.3,7.8,8.10

Learner outcomes: After completing the activities, the students will be able to:

- use the data from the "Make a Dolphin" simulation, to explain the patterns in a food pyramid.
- use information about an ecosystem to construct a food pyramid.

Background:

1. Tell the students that they will be participating in a simulation to investigate the energy transfer between trophic levels in a marine food chain. After completing the simulation ask the students to identify patterns.
2. Stress that the flow of energy in the ecosystems is in one direction. It is from the sun through the autotrophs or producers to consumers and decomposers. Living organisms like most energy consuming systems are not efficient. Less than 1 percent of the solar energy available at the sea surface is absorbed by autotrophs. A portion of the energy captured in photosynthesis is used for cellular maintenance, growth and reproduction. Therefore, only a small portion of the energy produced by photosynthesis is available to consumers. A similar decrease in available energy occurs between herbivores and carnivores. Studies place the efficiency rate of energy transfer from one trophic level to the next at between 6 percent and 20 percent. A widely accepted average efficiency is 10 percent.
3. Also in the marine environment the size of the organism increases with each trophic level. The smallest organisms are in the first level and the largest are in the highest level. At the same time the greatest number of individuals are in the first trophic level and the numbers decrease toward the higher levels. Use the questions in the lessons to guide the students in their understanding of a food pyramid. Ask the students to explain why the pyramid is a better reflection of the energy transfer than the food chain.
4. Have the students select one of the ecosystems from lessons 4-11 and diagram a food pyramid. Discuss the impact of lesser numbers of organisms available at a trophic level and the impact on the ecosystem.

1. What Are the Zones of the Marine Environment?

Marine Ecologist _____ **Team** _____

The marine environment makes up more than 70 % of the Earth's surface. That and its complexity make it a difficult system to classify. The oceans have two principal life zones: the coastal zone and the open sea. The coastal zone is relatively warm, nutrient-rich, shallow water that extends from the high-tide mark on land to the edge of the continental shelf. The continental shelf is the submerged part of the continents. The coastal zone represents less than 10% of the oceans; however, it contains 90% of all ocean species. This zone is the source of most of the ocean's productivity per acre. The open ocean extends outward from the edge of the continental shelf. The open sea contains about 90% of the world's ocean area, but has only about 10% of all ocean organisms. You and your team are going to determine the physical characteristics of these zones in the coastal and open ocean regions.

Procedure:

1. The marine environment is a very large system and is also very complex. It can be classified in a variety of ways. One way to designate particular marine environments is based on physical characteristics, such as water temperature, water depth, available light, dissolved oxygen and the availability of nutrients. The environments in which the pelagic and benthic organisms live can be grouped into four major ecological zones: Intertidal or littoral zone, the sublittoral, bathyal and abyssal zone. Locate each zone on Figure 1.1. In what ways do the zones differ?

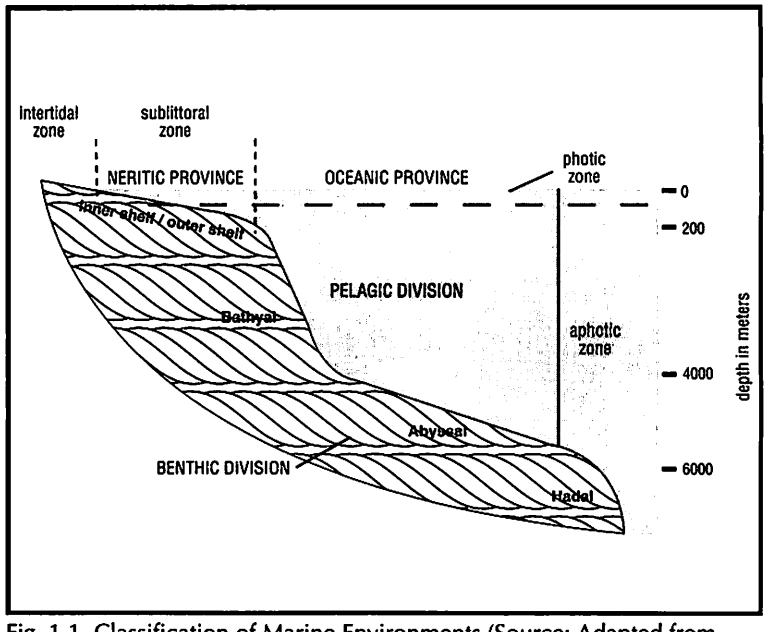


Fig. 1.1. Classification of Marine Environments (Source: Adapted from Hedgpeth 1957)

2. Examine the diagrams (page 614) of the abiotic (nonliving) factors in each zone. What patterns do you notice?

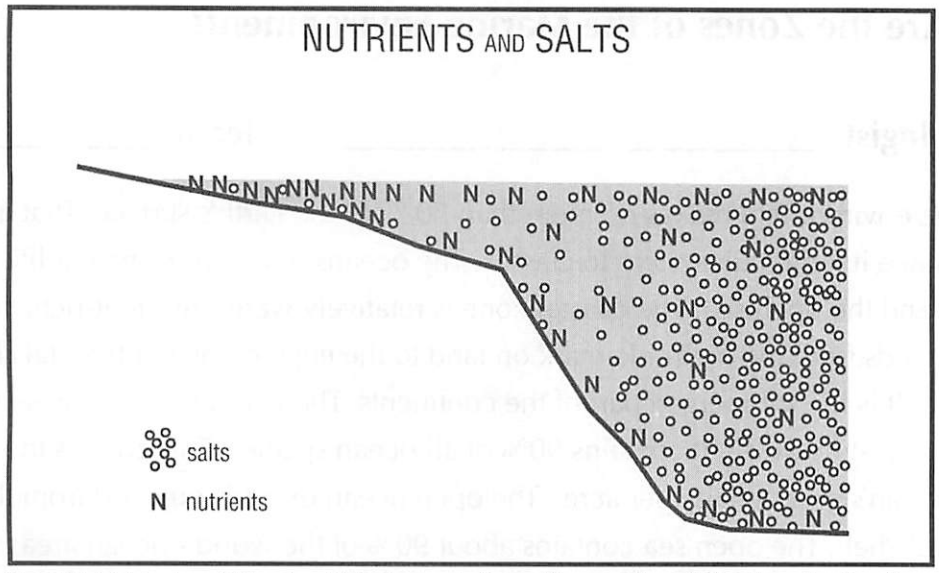


Fig. 1.2. Nutrient and Dissolved Salt Concentrations. (Source: Lien. 1979. Investigating the Marine Environment and Its Resources)

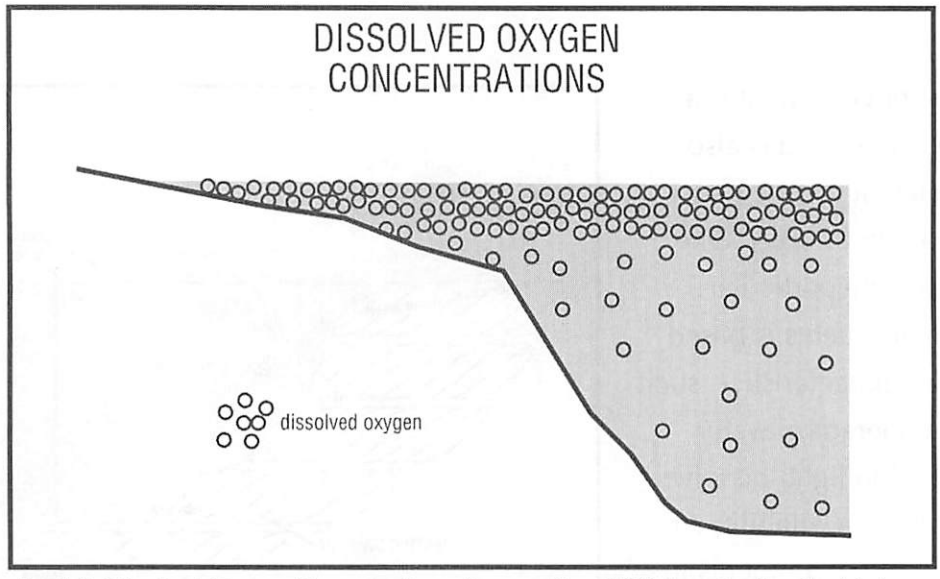


Fig. 1.3. Dissolved Oxygen Concentrations. (Source: Lien. 1979. Investigating the Marine Environment and Its Resources)

3. The intertidal zone is the part of the seashore located between high and low tide. Organisms of the intertidal zone are covered with salt water at high tide and uncovered at low tide. In addition to withstanding the change in water level, they must withstand the pounding of the surf. This zone is crowded with life since nutrients and oxygen is readily available. Why are nutrients and oxygen in high concentrations in this zone?

4. The temperature can vary depending on the latitude and season. Explain why this zone has great variations in temperature?

5. The salinity of the intertidal zone will vary depending on river run-off, precipitation and evaporation. Explain how each affects the salinity?

6. Explain why the intertidal zone is the region of constant change and how this affects the organisms living in this zone?

7. The sublittoral zone is the zone from the low tide mark to the edge of the continental shelf. Locate it on Figure 1. How will the physical conditions in it compare to those in the littoral or intertidal zone?

8. The bathyal zone is the region from the continental shelf to the start of the abyssal zone, which begins at approximately 2000 meters. The abyssal zone refers to the abyssal plains and other ocean bottom areas from 2000-3000 meters to 6000 meters. The region below 6,000 meters is primarily the deep ocean trenches and is the hadal zone.
How do these zones differ?

9. On a separate sheet of paper, make a chart similar to Table 1. Complete the table using the figures of the abiotic factors and the information about each zone.

Table 1: Characteristics of the Zones of the Marine Environment

Marine Zone	Location	Light	Salinity (Dissolved Salts)	Oxygen	Nutrients	Temperature	Organisms
Intertidal (Littoral)							
Sublittoral							
Bathyal							
Abyssal							

10. The zones are also located in the photic (lighted) zone where light intensity is great enough for plant or phytoplankton growth. Which zones are in the photic areas?

11. Which zones are located in the aphotic (unlighted) zone where light is absent? What organisms would not be found in these zones?

12. What effect would the amount of nutrients have on organisms? In which zone(s) are the most nutrients found?

13. Where is the most dissolved oxygen found? The least?

14. Marine organisms can be assigned to groups based on depth and lifestyle. For example animals may be bathypelagic. What does this mean?

15. What is the different between animals that are bathypelagic and those that are bathybenthic?

16. Summarize the relationship of the marine zone and the abiotic factors. Explain how this affects the organisms found in each zone.

17. What will be the impact of pollutants from the watersheds of rivers in each zone?

2. What Are the Groups of Marine Organisms?

Marine Biologist _____ **Team** _____

One way to classify marine organisms is according to their lifestyle. Using this method, all marine organisms can be grouped into one of three basic groups. You and your team are going to analyze the three groups.

Procedure:

1. Because of the amazing number of plants and animals in the oceans, it is easier to study them by dividing them into groups based on their lifestyle. Those in the pelagic group are the plants and animals that float or swim in the open ocean. The pelagic organisms can be divided into two groups, plankton and nekton. Organisms that live on the sea floor are the benthos. Read the section on these marine organisms.

2. Examine the diagram of the distribution of the marine organisms (Figure 2.1). Note the pattern. Compare it to the Figure 1.1, Classification for the Marine Environments in Activity 1.

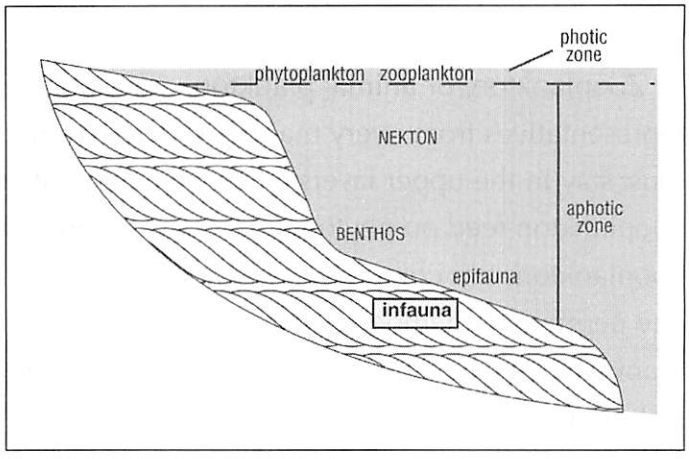


Fig. 2.1.Distribution of Marine Organisms.

3. Divide a sheet of paper into six columns to make a table on the three groups of marine organisms. Label the columns as follows: Name of group, Zone where found, Organisms in the Group, Plants or Animals or Both, Mobility of Organisms, and Other information. Use the information from the reading to complete the table.

4. Use the table to answer the following questions:
   a. Which group of organisms is found in more than one zone?
   b. How does each group get its food?
   c. Why are plankton found in the surface waters?
   d. Why are few infaunal organisms living on the rocky surfaces?
   e. If the bottom of the continental shelf is dredged, which group is affected?
   f. Why are the plankton called the smallest but mightest?

5. Write a summary statement about the three groups of organisms.

Marine Organisms - Plankton, Nekton, and Benthos

The plankton exist in nearly every natural body of water throughout the world in such large numbers that they cannot be counted. Their name comes from the Greek word, *planktos*, which means, "to wander". Plankton are the drifters of the sea since they have little or no ability to swim horizontally and are moved by the ocean currents and tides. Some have remarkable abilities to swim vertically. They are mostly microscopic, however, some can be large like the jellyfish whose tentacles may be over 15 meters long and bell 2 meters in diameter. Phytoplankton are the most important organisms in the marine world. Most forms of life depend on them either directly or indirectly since they use the incoming light energy to make food. They also produce about 70 percent of the oxygen in the Earth's atmosphere. They may be small, but without them there would be very little life on Earth.

They are divided into two groups: the phytoplankton and the zooplankton. Phytoplankton means plant plankton. There are two main groups of phytoplankton: diatoms and dinoflagellates. All phytoplankton require sunlight to produce food so they must live in the upper layers of the sea.

Zooplankton, or animal plankton, are strangely shaped with representatives from every major group of marine animals. They must stay in the upper layers of the ocean to obtain food. Some zooplankton feed on phytoplankton while some eat each other. The zooplanktons are composed of temporary and permanent members. The permanent members are those who spend their entire life as plankton. These include the foraminifera, radiolarians, tintinnids, siphonophores, ctenophores, some rotifers and the crustaceans, which are the most abundant. The temporary members spend only part of their lives as drifters, as the larvae of sponges, corals, worms, mollusks, echinoderms and fishes. When these plankton become adults, they become either nekton or benthos.

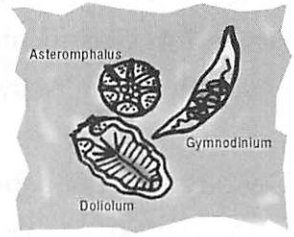


Fig. 2.2. Plankton

The nektons are the large, actively swimming, marine animals. There are no plants in the group. Nektons are strong swimmers so they can move freely from place to place. The ocean currents or tides do not affect them. They are not evenly distributed in the ocean. Nektons are found where their food is available. They decrease in numbers as one goes deeper in the sea. Members of this group, besides the fish, are the marine mammals (whales, porpoises, dolphins, seals, manatees), sea birds, turtles and cephalopods, such as the squid. They can chase their food, flee if

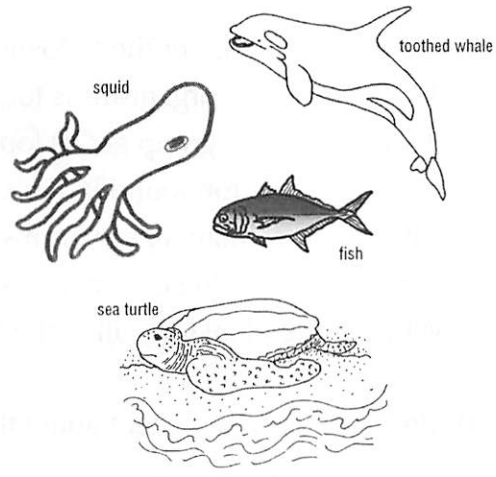


Fig. 2.3. Nekton

endangered and cover large distances in migratory journeys. Their size, habit of gathering in schools and their abundance over the sea make them the most important marine food resources available for harvesting by humans.

The benthos includes the organisms living on the sea bottom. They include plants and animals. The seabed has a variety of habitats, each with its own unique environment and biological conditions. The bottom substrate may vary from hard rock, boulders and stones, to softer sediments of sand, mud or clay. Rocky areas provide a stable surface for them to attach. Many organisms such as algae, barnacles and mussels spend most of their lives attached to a hard bottom. They do not move around once they attach themselves. The cracks and crevices provide them shelter from other organisms and the force of the waves and currents. The soft substrates provide a burrowing habitat for large numbers of animals. The benthos can be divided into the epifauna, organisms living on the sea bottom, and infauna, organisms living in the sediments.

Temperature, dissolved oxygen, depth and the kind of bottom (mud, sand or rock) determines which benthic organisms are found in an area. Some are attached to the bottom, like the sponges, barnacles, oysters, mussels, corals, eelgrasses and seaweed (algae). Others creep or crawl along the bottom. These include crabs, snails, shrimp, some bivalves and crustaceans. Some burrow into the sediment like most clams, worms, some crustaceans and echinoderms. Benthos are found in all depths from the shallow waters along the shoreline to the deepest trenches in the ocean. The deep-sea benthic organisms include sponges, brittle-stars, snails, worms and crustaceans. Fish are also present. Very little is known about those that exist in the hydrothermal vents on the ocean floor, however, more is learned with each expedition to the ocean floor.

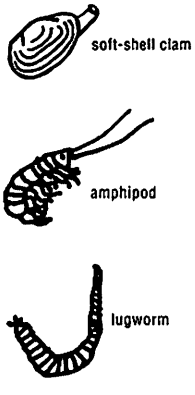


Fig. 2.4. Benthos

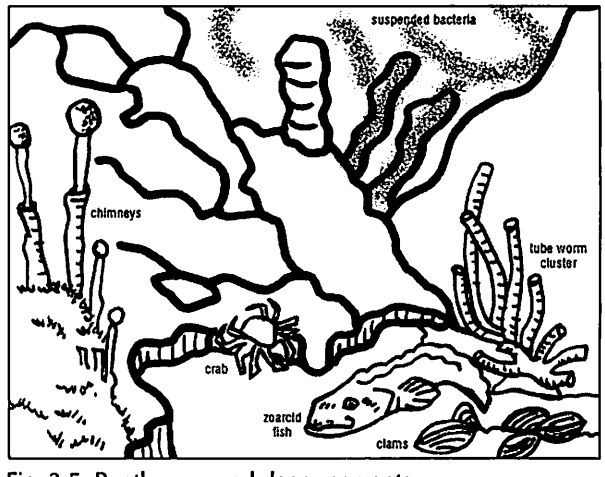


Fig. 2.5. Benthos around deep sea vents.

3. What Are Some of the Marine Communities and Ecosystems of the Gulf Coast?

Marine Ecologist _____ **Team** _____

The land, as well as the marine environment, is composed of many communities and ecosystems. A community is the populations of all species living and interacting in an area at a particular time. Ecosystems are the communities of different organisms interacting with one another and with the nonliving (abiotic) physical and chemical factors in a particular location. Your team is going to analyze the marine environments and marine life of the Gulf.

Materials: Texas Highway map

Procedure:

1. The Texas coastal zone consists of numerous marine environments. The sculpting of the coastline by various physical and climatic processes has created a variety of distinct ecosystems with distinct physical factors with their own diverse communities of organisms. Use the Texas highway map and locate the different coastal features: bays, barrier islands, Laguna Madre and the passes between the islands. Where are they located?

2. Which areas are exposed to the waves and tides?

3. How would this affect the organisms that live in these environments?

4. Which areas are protected from the waves and tides?

5. Turn the map over and examine the following areas: Rio Grande Valley Area, Brazosport Area, Corpus Christi Area, Beaumont-Port Arthur-Orange Area and the Houston-Texas City-Galveston Area. Which coastal features does each area have?

6. During the last Ice Age, about 18,000 years ago, sea level was 300 to 400 feet lower than it is today. The shoreline was more than 50 miles farther out in the Gulf. The coastal rivers cut deep valleys into the coastal plain. As the climate warmed, sea level rose as a result of the melting glaciers. The flooded valleys became the bays. The sea level rise also resulted in the formation of large sand bars that developed into barrier islands. Examine each bay on the map and locate the rivers entering the bays. Which river valleys were flooded to form the bays?

7. How would the rivers affect the salinity of the bays? How would the salinity in the bays compare to the Gulf water?

8. The barrier islands protect habitats in the bays from the severest effects of waves and currents. The bay ecosystem includes the mud flats, salt marshes, bay water and the oyster reef community. Imagine you are in a plane looking down on the barrier island; this is the view for Figure 3.1. Note the location of each environment.

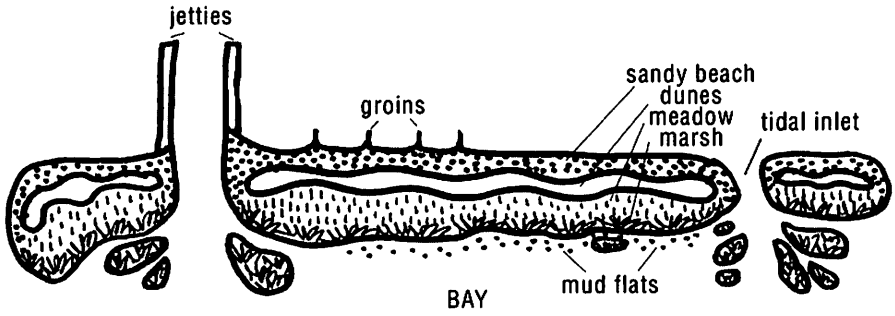


Fig. 3.1. Major Coastal Environments. (Source: Beachcomber's Guide to Gulf Coast Marine Life)

9. As a result of the protection from the barrier islands, the movement of the water is slowed. Fine particles carried from the rivers and bayous into the bays settle to the bottom. This produces a muddier bottom than is found on shore facing the Gulf water. How would this affect the organisms?

10. The bays are shallow. How will this affect the temperature of the water and the organisms that live in these environments?

11. The oyster reef communities are found in shallow areas that are below the tide level. What will happen to these communities if the level of the water in the bays changes?

12. Laguna Madre includes mangrove and sea grass bed communities. Locate Laguna Madre on the map. It is a lagoon. How does a lagoon differ from a bay?

13. Use the area maps and find the tidal inlet or passes for each bay or lagoon. During high tide in what direction will the water move? In what direction will the water move during low tide?

13. Ninety-five percent of the marine organisms that live in the Gulf spent a part of their life cycle in the bays and estuaries. What is the role of the tidal passes in this? What *would be* the impact if the tidal passes were closed?

14. The barrier island "flats" is the region that extends from behind the barrier island dune fields to the bayshores. The distance across the island may be a few hundred meters to several kilometers. Locate this area in Figures 3.1 and 3.2. What are the environmental conditions of this area? What factors would affect this environment?

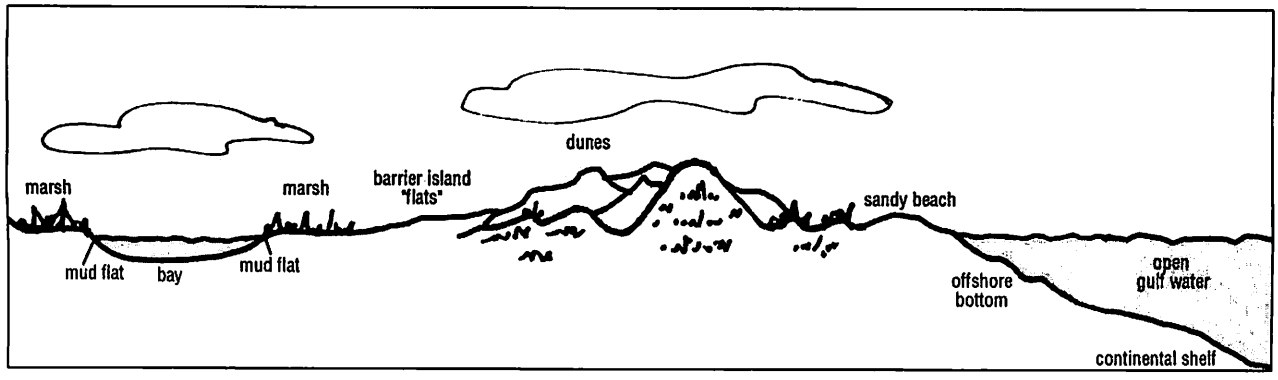


Fig. 3.2. Cross Section of Major Coastal Environments.

15. Habitats on the outer side of the barrier islands receive more abuse from waves but undergo less change in salinity and temperature compared to the habitats on the bay side of the islands. The shoreline environment is above the high tide mark and includes the sand dunes. Locate this area in Figures 3.1 and 3.2. What factors affect the environments in this area?

16. The intertidal zone, which includes the areas between the high and low tide marks, includes the following ecosystems: rock jetties and groins, sandy beaches, estuaries and salt marshes, lagoons and the oyster reef, mangroves and sea grass communities. The sandy beaches and rock jetties and groins are on the outer coast (between the barrier island and the Gulf). Locate these on Figure 3.1. What are conditions like in these environments?

17. The offshore environment of the open water includes the sargassum community and the flotsam and jetsam communities. Under the water of the continental shelf is the offshore bottom environment, which is the shrimping grounds. Also out in the Gulf, at the edge of the continental shelf, are the coral reefs. See Figure 3.3. How would each of these environments differ?

18. Northern Gulf of Mexico organisms include three different groups: Carolinian, Caribbean and cosmopolitan. The cosmopolitan species are those found around the world. They are brought into the Gulf by ships. These include barnacles, hydroids, serpulid worms and other species that attach to the hull of ships. Even mud crabs and isopods are often found in the crevices of ships, especially wooden ones. The organisms of the eastern and western

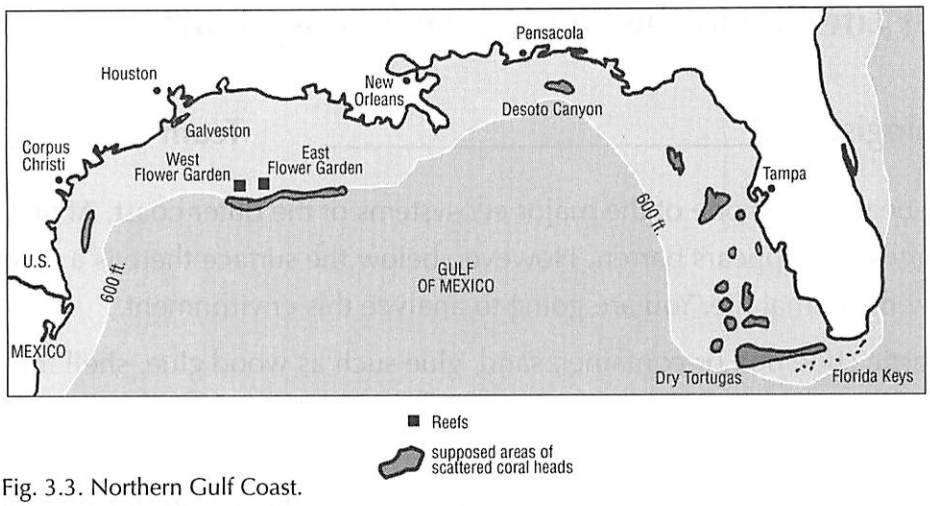


Fig. 3.3. Northern Gulf Coast.

portions of the northern Gulf are separated near Desoto Canyon. Locate Desoto Canyon on Figure 3.3. East of Desoto canyon, the bottom is calcareous from fossil and coralline deposits. The bottom sediments west of the canyon are predominantly silts and sands from the erosion of the continent. These sediments are transported into the Gulf by rivers. The largest river is the Mississippi. The sediments differ in grain size, density, pore space and organic content. How might this affect the organisms found in each area?

19. Another factor that contributes to the differences in organisms is the Loop current, which transports warm Caribbean water and larvae of Caribbean species northward along the Florida coast. So not only is the sediment type similar to the Caribbean, but a wide variety of tropical larvae are carried into the area. Sponges, reef building corals and algae are found in this area. The water west of Desoto Canyon is very turbid and these animals are not found in the western Gulf. What is a possible reason?

20. The climate of the Gulf Coast is highly variable. Hurricanes, northers, severe thunderstorms, droughts and freezes are sporadic events that may have tremendous effects on the organisms. Explain how these might affect organisms in the coastal ecosystems and communities.

4. What Is Life like in the Sandy Beach Ecosystem?

Marine Ecologist _____ **Team** _____

The sandy beaches are one of the major ecosystems of the outer coast. At first glance, the intertidal sandy shore appears barren. However, below the surface there is a diverse community of burrowing animal life. You are going to analyze this environment.

Materials: Plastic shoe box or container, sand, glue such as wood glue, shell fragments

Procedure:

1. The sandy environment will have lower diversity than other environments since the sand holds less organic matter, food and nutrients. The sandy beach is a harsh environment for organisms. They must deal with pounding surf, abrasive sand, periods of wetness and dryness, temperature changes and exposure to the sun. Another major factor is that on a sandy beach there is no solid substrate. There is nothing for the animals to hold on to and avoid being washed by the waves or the tides. How might animals survive in this area?

2. If you are walking on a beach you will not see many animals. Most sand beach animals escape these physical factors by burrowing. Much of community lives underground out of sight and some species move up and down the beach with the tide. Examine Figure 4.1 and note where these organisms live.

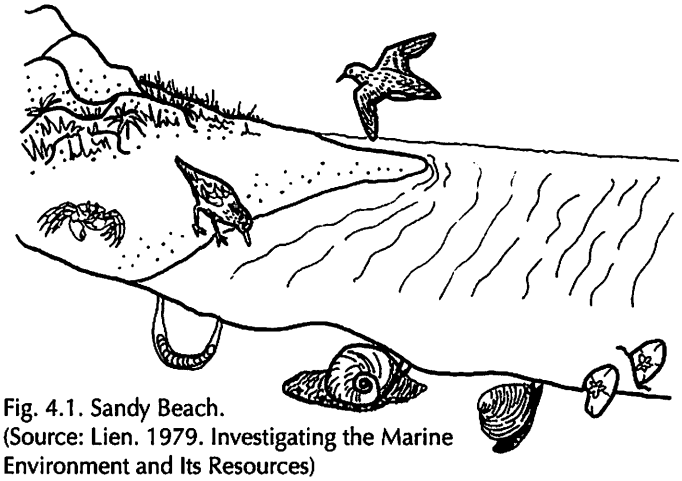


Fig. 4.1. Sandy Beach.
(Source: Lien. 1979. Investigating the Marine Environment and Its Resources)

3. The beach can be divided into vertical zones. On a separate paper, sketch a profile of the sandy beach like that in Figure 4.2. As you read about this environment, indicate on your sketch where you would find each organism.

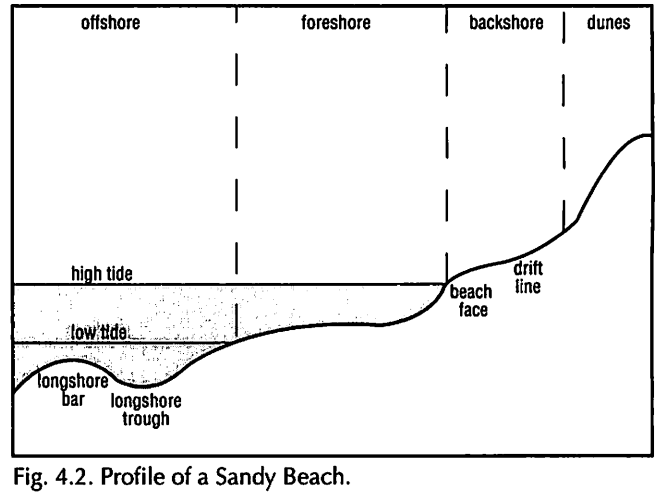


Fig. 4.2. Profile of a Sandy Beach.

4. The dunes are important nesting grounds for several shorebirds, terns and gulls. In the zone of the dunes to

the high tide level, there are plants like the silvery beach croton, waving sea oats, railroad vine, Sea puslane, yellow beach evening primrose and others. Animals in the area include rattlesnakes, lizards, spotted ground squirrels, kangaroo rats, mice, insects and other rodents such as gophers and rats. What is the physical environment in the dunes?

5. The supralittoral zone begins at the base of the dunes to the high tide line. No plants are found in this area. What is physical environment like in this area? Why are plants not found in this area?

6. The ghost crabs are the most obvious animals of this area. They eat the burrowing mole clams and bean crabs, but are also scavengers eating dead fish and the remains of animals found on the beach. The tiger beetles are another common resident of this area. How do the ghost crabs survive in this environment where it is hot, windy with blowing sand in the summer or cold in the winter?

7. The surf zone between the tides (littoral) has no large plants. Why are plants not found in this area?

8. In this area, during high tide the surf constantly pounds the area with water and sand. At low tide the area is exposed to the air and the drying sun or the cold in winter. Yet this habitat is home to many invertebrates that burrow into the bottom because the excellent water circulation in the surf brings in large quantities of marine phytoplankton. These microscopic plants support large populations of burrowing marine invertebrates. At high tide, some burrowing clams dig out to feed. Others poke tubes above the sand surface to pull in water that contains their food. The burrowing animals construct different types of burrows and live at different depths. Why do they live in burrows? How would the burrows protect them?

9. Marine organisms can only use materials found on the beach and secretions they produce to make their burrows. Using a plastic shoebox or larger container with moist sand to a depth of 5 cm to 8 cm or more, construct a burrow in the sand that worms like the polychaetes could use. Test your model burrow by pouring water over the top of the sand and creating waves/surf. How well did your burrows work? Summarize what you have learned about burrows in the sandy beach.

10. The marine invertebrates are so abundant that they directly or indirectly feed surf fishes and shorebirds. This area is inhabited by the bean clam or coquina, mole crab, lettered olive and moon snail, hermit crabs, auger shell and tube building worms. Since many of

the intertidal animals hide by burrowing, why is a good clue to their presence in an area the sight of feeding shorebirds such as sandpipers and sanderlings?

11. Examine Figure 3.3 of the bird's beaks and the location and type of organism they eat. Note how each kind of bird has a different type of beak. How does this help it survive?

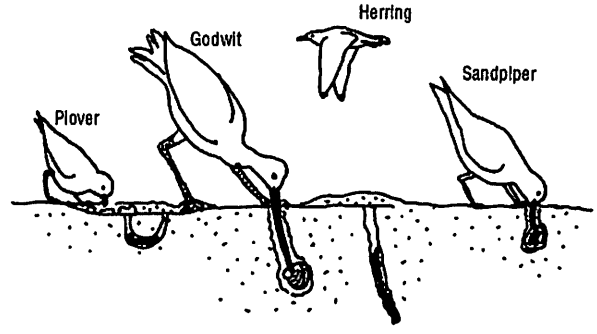


Fig. 3.3. Birds feeding on a sandy beach.

12. In the zone below low tide level (sublittoral), the sand dollar, Scotch bonnet, starfish, sea star, sea pansy and yellow and purple sea whips are found. Also calico, blue and other crabs, murex, banded tulip, several species of shrimp and clams, octopus and fish such as trout, redfish, drum, galtop catfish, pompano, croaker and others are found. Fish eating birds such as gulls, terns, cormorants, ospreys and pelicans are also found in this area. In some areas, the beach is also the nesting site for sea turtles. Use the library and Internet to research specific organisms found in this area or to gain more information about life on and under the sandy beach.

13. Construct a table similar to the one below. Add the information for each zone in the sandy beach.

Table 1: Abiotic and Biotic Components of the Sandy Beach

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and Biotic Components

14. To summarize and communicate what you have learned about the sandy beach, prepare an interview or skit with some of the organisms in each zone to present to the class or to students in an elementary class. Include in the interview or skit information about the:
    a. abiotic factors
    b. biotic components
    c. interaction between the biotic community and the abiotic factors.

5. What Is Life Like on the Jetties and Groins (the Rocky Shore)?

Marine Ecologist _____ **Team** _____

There are no natural rocky areas along the Texas coast as in other parts of the country. Until inlet protecting jetties and breakwater groins were built about 100 years ago, there was no rocky shore marine life in the northwestern Gulf. The Texas rocky shores are limited to man-made jetties and groins designed to control the movement of sand. You are going to analyze this environment.

Materials: Paper, spray bottle, water

Procedure:

1. Organisms living in or on the jetties and groins are exposed to severe physical stresses from waves and currents. These structures provide the only solid substrate where algae (seaweed) can grow. The marine algae are rather limited, possibly because of the predominantly sandy and muddy shore and the great variations in temperature and salinity. Red algae species are the most abundant followed by green algae. Brown algae, such as kelps, is absent from the Gulf coast. Only a few brown algae are found. If it were not for the man-made jetties and groins there would be very few algae on the Texas coast. Refer to Lesson 3 to determine their location. The jetties are built along inlets to prevent sediments from filling in the channel. The jetty and groin environment requires hardy individuals to survive the stress of breaking waves with sand, strong currents, changing tides, sudden changes in temperature and salinity and exposure to the sun and wind. Examine Figure 5.1, the Rocky Shore (Jetties and Groins) environment. What do you notice?

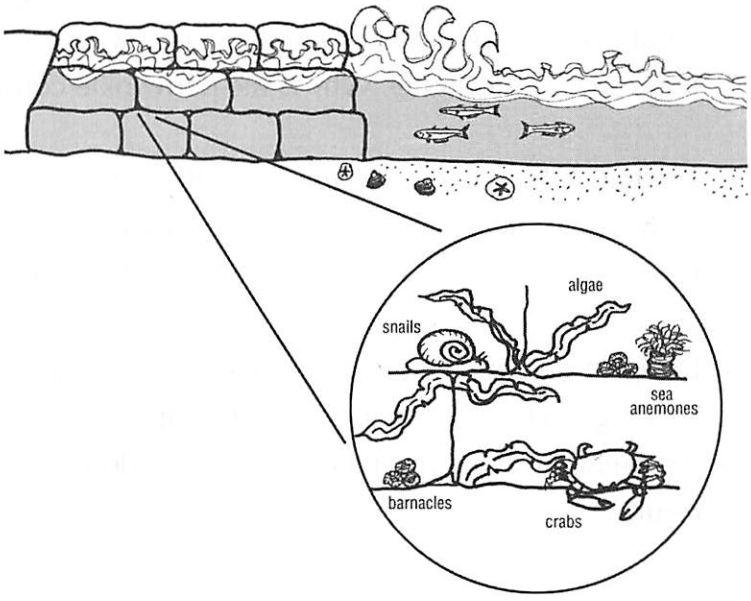


Fig. 5.1. Rocky Shore Environment (Source: Lien. 1979. Investigating the Marine Environment and Its Resources)

2. On a separate paper, sketch a profile of the jetties and groins like that in Figure 5.2. As you read about this environment, indicate on your sketch where you would find each organism.

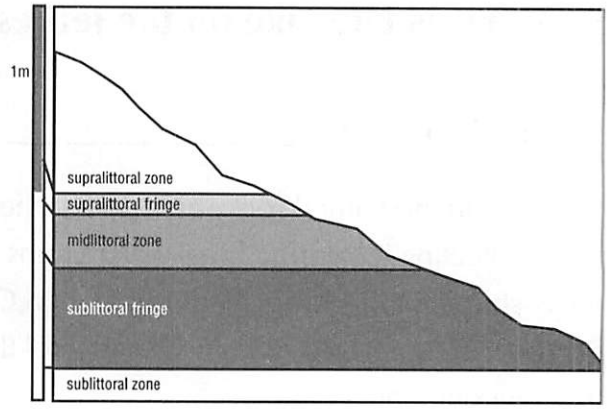


Fig. 5.2. Profile of the Jetties

3. The jetty inhabitants do have common features with other rocky shore organisms around the world. They live in definite vertical zones. On top of the jetties there is the splash or supralittoral zone that gets wet only from the spray of the breaking waves. The zone is exposed to the heat of the sun in the summer and the cold of the northers in the winter. Few algae can tolerate the dry, harsh environment, but *Bangia and Enteromorpha* do occur here. Here periwinkles cling to the jetty boulders above or among the upper zone of barnacles. The periwinkles are grazing snails, using a file-like radula to scrape algae from the rocks. In softer rocks the radula will scrape small pits and crevices while grazing. Later the snails will crawl into these spaces for shelter. Why is the periwinkle considered a "bio-eroder"?

4. The fragile barnacle, *Chthamalus*, is the common acorn barnacle found at the higher levels of the jetties. It is generally about 0.5 cm, but its size and shape will vary depending on its food supply and upon how crowded it is. How does crowding affect its size?

5. Design an experiment to determine if the barnacle's small size and crowding are helpful in keeping it moist. Use paper to represent the barnacles and spray water on the paper to represent the spray from the waves. How do you plan to investigate this? What were your results?

6. The remaining animals of this zone are those that can move in and out of the area at will. The most obvious is the isopod or rock louse, *Ligia exotica* that looks like a cockroach. It stays in the cracks and is mostly nocturnal, but will come out on cloudy days and near dusk. It feeds on the algae and scavenges on dead organisms and litter left by humans. It has an interesting mix of aquatic and terrestrial adaptations. The rock louse has very sensitive humidity receptors. How does this help the rock louse survive?

7. Below this is the mid-littoral zone that is submerged during nearly all high tides and exposed during nearly all low tides. What are the physical conditions in this zone that organisms must survive?

8. Barnacles are the most common organisms in this zone. The barnacles screen plankton from the water with their featherlike legs. These legs are pulled in behind the plates so that it can keep moist for several hours. However, if the barnacle does not get wet from the returning tide or the spray from waves for a long time, it will die. Barnacles are filter feeders that are permanently attached to the rocks. How is being permanently attached (glued) to the rocks an advantage in this environment? What is the disadvantage of not being able to move?

9. The drill or rock shell, a predator of the barnacles and young oysters on the jetties, lives in this zone. Their shells are used by hermit crabs that are found near the water line along the jetty. The hermit crab is a scavenger, feeding on a wide variety of material including algae, bodies of organisms that wash upon the rocks, and fishing bait. Attached to the shells of both snails and hermit crabs on the jetties may be the half-folded dove snail. Sea anemones are found in the crevices of the rocks. The cancellate cantharus is another small snail found on the jetties. During low tides, stone and porcelain crabs can be seen in the pools between the boulders. They are also in this zone along with the limpet. The limpet has a flattened, uncoiled shell, which is two or three centimeters in diameter and is found on the rocks in this zone. A large muscular foot covers most of the area underneath the shell, providing firm attachment to the rocks. How does the limpet's design help it thrive on the exposed wave-swept rocks where the surf is crashing?

10. Sea lettuce, *Ulva* and *Enteromorpha* species of algae are found in this zone. Their presence indicates that the shore is washed by nutrient enriched waters. Where are the nutrients coming from?

11. The lowest zone, the sublittoral, is uncovered only during the lowest tides. Sea whips, small corals, sea urchins, several species of sponges, hydroids and tunicates are found on the subtidal jetty rocks. A number of relatively small amphipods and isopod crustaceans live in the wave cast debris of the lower jetty.

12. Most of the animals on the jetties either filter plankton from the water (barnacles) or graze on algae or diatoms that grow on the rocks (zebra periwinkle, limpet). Some are scavengers searching for scrapes of food left by the tide or fishermen. Why is the lifestyle in the jetties primarily filter feeding, grazing or scavenging?

13. During the late spring and early summer, sea hares pass through the channel and graze on the algae. Many of the shorebirds, including various egrets, herons, willets, sandpipers,

dowitchers, turnstones, terns and gulls are frequent visitors to the jetty. Why are they visiting the jetty?

14. A variety of fishes occur in the waters around the jetties, but most are not permanent residents. They are in the inlet or Gulf waters adjacent to the jetty. These are the spadefish, gray snapper, redfish, sheepshead, Florida pompano, the jacks, needlefish, halfbeak and the hardhead catfish. The spotted jewfish frequents the crevices in the deeper waters of the outer jetty. Some fish are associated with the jetty, either seeking protection or feeding on the invertebrates, algae or detritus that occur there. These are the blennies, damselfish, and the sergeant major. Octopi will take shelter in the crevices of the jetties. Select some organisms and use the library and Internet to gain more information about life on the jetties and groins.

15. Construct a table like the one below. Add the information for each zone in the jetties and groins.

Table 1: Abiotic and Biotic Components of the Jetties and Groins

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and BioticComponents

14. To summarize and communicate what you have learned about the jetties and groins, prepare an interview or skit with some of the organisms in each zone to present to the class or to students in an elementary class. Include in the interview or skit information about the:
    a. abiotic factors
    b. biotic components
    c. interaction between the biotic community and the abiotic factors.

6. What Is Life Like in the Estuarine Ecosystems?

Marine Ecologist _____ **Team** _____

Estuaries are semi-enclosed, coastal areas where freshwater rivers meet the sea. These coastal wetlands have a tremendous biologic and economic value. Texas wetlands provide the nursery grounds for over 95 percent of the recreational and commercial fish species found in the Gulf of Mexico. They provide the breeding, nesting and feeding grounds for more than one-third of all threatened and endangered animals species and many endangered plants as well. The wetlands provide permanent or seasonal habitats for a great variety of wildlife, including 75 percent of North America's bird species.

In the coastal wetlands, seawater is diluted by the freshwater from streams and rivers feeding the estuaries. Many bays, inlets and sounds can be considered estuaries. Freshwater from the land run-of is nutrient rich. The water flow decreases as the estuary widens and becomes shallower, the sediment from the river settles out and is deposited as mud or sandbanks. Physical forces of tides are at work constantly changing the chemical make-up of the water. If the area is protected and force of water is reduced, plants can grow forming salt marshes. You are going to investigate estuarine environments around the bays— the salt marsh and mudflats and the oyster reef community.

Materials: Texas Highway map, Stream table or similar container, grass, sand, water

Procedure:

Part I: What is life like in the Salt Marshes?

1. Estuaries are constantly changing because of the local physical, geological, chemical and biological factors. The size and shape of the estuaries are influenced by the amount of fresh water and sea water entering the estuary and by the geological history of the area. Large rivers may form offshore deltas of sand and mud like the Mississippi River delta in Louisiana. Most of the Texas estuarine wetlands are in river valleys that flooded when the sea level rose between 18,000 and 4,000 years ago. When the sea was lower, the rivers cut deep valleys across the coastal plain. These estuaries formed as nearshore sand and mud were moved by coastal wave action to build an obstruction, or barrier island, in front of the coastal area fed by one or more coastal streams or rivers. Use the Texas highway map and locate the mouths of the Brazos, Colorado and Rio Grande Rivers. The bays of these rivers have been completely filled in with sediments. Other rivers have yet to fill in the bays into which they flow. Which rivers are emptying into bays?

2. Examine Figures 3.1 and 3.2 in Lesson 3. Where are the salt marshes located?

3. The estuaries can be vegetated, forming salt marshes, or without vegetation, forming mud and sand flats. They are found between the open saltwater of the bays or Gulf and the uplands of the coastal plain and barrier islands. Salt marshes are generally not found on the Gulf-facing beaches. The water energy is too great from the waves and tides for salt marsh plants to grow. These wetlands may be several miles wide covering thousands of acres. They also occur in small strips just 10 to 20 feet wide. The blending of land and sea creates the salt marsh. The marsh begins to form when waves shape sand into offshore barriers. Tidal creeks cut through these protective barriers, flooding the area behind them with seawater daily. Cord grass of the *Spartina* genus grows in this area protected from the battering waves. Its growth slows the tidal currents and they drop their load of material to form a floor of nutrient-filled mud. Use a stream table or similar container, sand, water with sediments and grass to construct a model to demonstrate how the cord grass would slow the tidal currents and cause the nutrients to be dropped. Describe what you observe.

4. The salt-tolerant grasses of the marsh produce vast amounts of organic material by photosynthesis. The salt mashes are among the most organically productive ecosystems on earth. Their productivity may equal tropical rain forests and coral reefs. The best farmland produces only half as much life as the salt marsh. Based on your model what are the roles of the marsh grasses in making this area so productive?

Fig. 6.1. Profile of a Salt Marsh. (Source: Lien. 1979. Investigating the Marine Environment and Its Resources)

5. Construct a table similar to the one below. Read the section on salt marshes and examine Figure 6.1. Use the information to complete the table.

Table 1: Abiotic and Biotic Components of the Salt Marshes

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and Biotic Components

The Salt Marshes

Fed by both salt and fresh water, the salt marshes are the nurseries for many marine organisms as well as the sources of nourishment for myriad's of sea and land creatures. Nearly all commercially valuable seafood owes its existence directly to the marsh. This ecosystem is a factory for human food.

The strands of cord grass are a prominent feature of the salt marsh. How often the area floods, for how long it is flooded and the salinity level are the important variations that control the type of plants. In the high marsh, salt meadow cord grass is more common. In the lower marsh, salt marsh cord grass is more common. Additional plants include salt grass, salt marsh bulrush and needle grass rush. Cattails and bulrushes are found along the edge of channels through the marsh. Many animals seek refuge on and among its sturdy stalks. One of the most abundant is the marsh periwinkle, which climbs the cord grass to escape the rising tide. When the tide recedes, it descends and crawls about on the mud, grazing on plant matter and other detritus. The marsh snail, horn shell, mussels and worms also are in the mud in the base of the cord grass. The stone crab is present, cracking open clam, snail and hermit crab shells for a meal.

The fiddler crabs, shifting through the mud and sand for edible material, is one of the most common crabs in the salt marsh. The marsh crabs, pulmonate snails and amphipods also use the debris for food. Land crabs are also present in the salt marsh.

The tidal creeks of the marshes are the nurseries for the young of many species of crustaceans (shrimp), crabs and fish. Some species of fish spend their entire lives in the area, while in other species only the young remain. Phytoplankton, plankton and planktonic larva also are present. The grasses, phytoplankton and mud algae are the key producers of the salt marsh.

Only relatively few marine animals can adjust to the rapid salinity changes which occur in the salt marsh. The marsh vegetation supports many migrants. This includes such mammals as the opossum, mink and raccoon that visit the water's edge to eat mussels and crabs. The muskrat is a permanent resident in the less saline parts, where its food, such as bulrushes and cattails is abundant. Deer also visit the marsh to graze. The diamond back terrapin lives in the

marsh, feeding on dead fish, marine worms, fiddler crabs and small mollusks. The American alligator feeds on fish, snakes, turtles, frogs, muskrats, nutria, swamp rabbits, rats and anything it can catch. Bobcats, raccoons, skunks, mink and river otters also live in the marshes.

Many species of birds are found in salt marshes, but only a few species are characteristic of the marsh and either reproduce there or frequent it often. The ducks, geese and swans, more than any other group, characterize the marshland. Other common ones are certain rails, sparrows, teals, certain shorebirds, marsh hawk, redwing blackbirds, marsh wrens, herons and bitterns.

The salt marsh is where the incoming tide stirs up nutrients and recharges stagnant pools with oxygen. Organisms ride in with the tide, As the tide recedes, it flushes out dissolved materials and carries decaying plant material as well as living plants and animals to join the offshore food web. Birds move in to eat creatures left exposed on the mud. This makes the salt marsh a cradle of life for an estimated 95 percent of all fish and shellfish landed by sport and commercial fishermen along the Gulf coast. Many economically important finfish and shellfish use the estuaries and the salt marsh during at least a part of their life cycle. Shrimp, crabs and oysters along with red and black drum, seatrout, southern flounder, bay anchovy, striped mullet, bay silversides, killifishes, gobies and waterfowl spend time in the estuaries.

5. To summarize and communicate what you have learned about the salt marshes, prepare an interview or skit with some of the organisms from the salt marsh to present to the class or to students in an elementary class. Include in the interview or skit information about the:
   a. abiotic factors
   b. biotic components
   c. interaction between the biotic community and the abiotic factors

6. Select some organisms and use the library and Internet to gain more information about salt marsh life.

Part II: What is life like in the mud flats or muddy shore?

1. Large areas of the Gulf coast bays are covered by only a few inches of water at low tides. These areas are composed of rich muds that are exposed at low tides. The areas that are too shallow to form salt marshes are the mud flats. They are not flat, however; the bottom is shaped by currents, waves and burrowing animals. Examine Figures 3.1 and 3.2 in Lesson 3. Where would you find the mudflats?

2. Construct a table similar to the one below. Read the section on the mud flats and examine

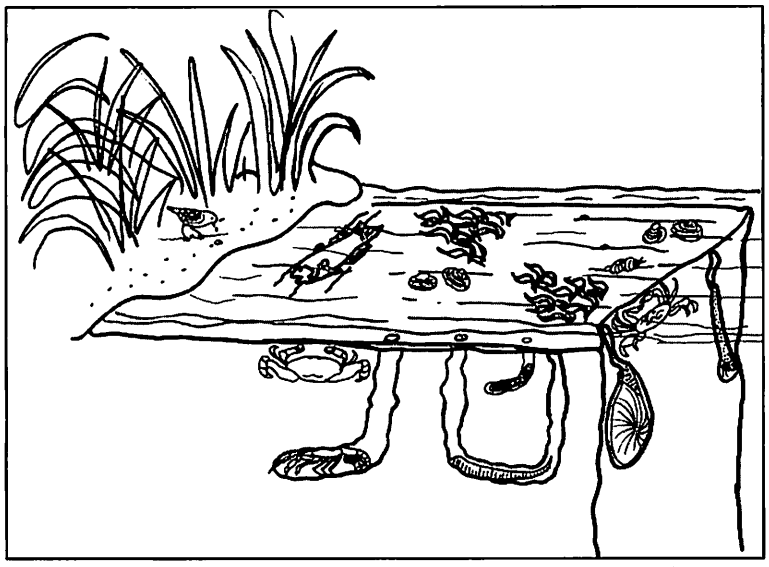


Fig. 6.2. Profile of a Mud Flat. (Source: Lien. 1979. Investigating the Marine Environment and Its Resources)

Figure 6.2. Use the information to complete the table.

Table 2: Abiotic and Biotic Components of the Mud Flat

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and Biotic Components

Mudflats or the Muddy Shore

A feature of the mudflats is the anaerobic condition that exists just below the surface. Here the oxygen lacking muds serve as a habitat for many species of anaerobic bacteria. Some of the bacteria produce hydrogen sulfide, the gas that has the rotten egg smell. The mud flats are often exposed during extreme low tides and strong north winds (northers). They are best suited for either burrowing organisms or very mobile ones. Since the bottom varies, the organisms also vary from one area to another. The bottom is sandier near the passes and in channels cut by currents.

The stout razor clam, a deposit feeder, lives in the sandy mud. Its enemies include the drill, the blue crab, the hermit crab and various shorebirds. The common rangia is a true estuarine species since it is found well into the mouths of rivers and bayous. There also are the jackknife clam, fragile angel wing, dwarf surf clam (which is eaten by bottom-feeding fish), mud shrimp, ribbon worms, two types of clams, the constricted macoma and southern quahog.

The mud crab, flat mud crab and large stone crabs are at home in the mud flats. The bur-

rows of the large stone crabs have an important role in the mud flat ecology. During low tides, these burrows provide shelter for the mud crabs, hermit crabs, grass shrimp, snapping shrimp, worms and several species of fish from the drying sun and foraging shorebirds.

In the sandier mud flats near the passes there are the bright red nemertean, moon snail, baby's ear, common mud snail, common Atlantic auger and oyster drill. There also are three species of hermit crabs. Many polychaete worms as well as the parchment worm and lugworm are at home in the mud flats.

There also are submerged beds of widgeon grass on the mud flats that help stabilize the sediments and provide food and shelter for organisms, particularly the grass, arrow and snapping shrimp. Another grass community in the mud flats is the turtle grass that provides a home for the pink and grass shrimp, mud crabs, thick lucine, cross-barred venus and bay scallop. The sea cucumber, virgin nerite, whelks, tusks and bubble shells also are found in the mud flats.

3. Use a stream table or similar container to construct a model of the mud flat and investigate how the grasses stabilize the sediments. Describe how you set up your model. Critique your model.

4. To summarize and communicate what you have learned about the mud flats, prepare an interview or skit with some of the organisms from the flat to present to the class or to students in an elementary class. Include in the interview or skit information about the:
   a. abiotic factors
   b. biotic components
   c. interaction between the biotic community and the abiotic factors.

5. Compare the life on the sandy beach, salt marsh and mud flat. What are the similarities and how do they differ?

Part III: What is life like in the Oyster Reef Community?

1. The oyster reef community is an important biotic community in the bays. The commercial oyster is found in almost every Texas bay. While there are some scattered reefs in South Bay near Port Isabel there are no oysters in the primary portion of Laguna Madre. Use the Texas highway map and determine where oyster reefs are found. In which bays are they found?

2. The oyster reef is more than a collection of oysters. It is a community of many plants and animals. Some animals use the reef as a hiding place, some as a source of food or for both. The plants and animals of the reef attract small fish, the small fish attract larger fish

and these in turn, attract fishermen. What is the attraction for each of the organisms?

3. Construct a table similar to the one below. Read the section on the oyster reef community and examine Figure 6.3, Profile of an Oyster Reef. Use this information to complete the table on the oyster reef community.

Fig. 6.3. Profile of Oyster Reef Community. (Source: Lien. 1979. Investigating the Marine Environment and Its Resources)

Table 3: Abiotic and Biotic Components of the Oyster Reef

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and Biotic Components

Oyster Reefs

Oyster reefs are groups of living organisms growing on the graveyard of their ancestors. They form very slowly over a long period of time. The life of the reef is related to the organisms forming it. When they die, the reef dies and becomes buried in the mud. A reef may be formed whenever conditions favor the growth of oysters. A firm bottom of sticky mud, clay, sand or gravel is needed. At first a few oysters attach to the bottom. The next generation of oysters attach themselves to these oysters. The formation of the reef depends on the direction of water currents. The oysters depend on these currents to bring in plankton for food. The oysters nearest the current are the closest to the food so they grow faster and are the first to be reached by young larvae. The young larvae attach themselves; as a result, the reef grows towards the current.

Since oysters grow well where the fresh waters of streams mix with salt water of the Gulf, they are found in the bays of tidal rivers. They can survive a wide range of salinity, from fresh water for brief periods of time to waters saltier than the Gulf. Freezing temperatures and temperatures over 90° F for a long period of time weaken the oysters if they are exposed. The greatest hazard to the oyster reef is the settling of clay or mud. A small amount may interfere with feeding and large amounts will smother and bury the reef.

Some members of the oyster reef community compete with the oysters for food or for a place to attach. These are mussels, anemones, barnacles, slipper shells and serpulid worm.

Many of the reef inhabitants are actually oyster predators. These are the drills, stone, blue, oyster, mud crabs, flatworms and snails. The porcelain and oyster crabs, sea squirts and pen shells use the reef as a shelter. The blennies and gobies are small fish found in the reef. The oystercatchers feed on the oysters. When the tide recedes and the oyster beds are exposed, the oystercatchers drive their strong beaks into the slightly open shells. Using their beak as a knife, they open the oyster shell and scoop out the flesh inside.

4. Select some organisms and use the library and Internet to gain more information about life and the interactions in the oyster reef community.

5. To summarize and communicate what you have learned about the oyster reef community, prepare an interview or skit with some of the organisms in each zone to present to the class or to students in an elementary class. Include in the interview or skit information about the:
   a. abiotic factors
   b. biotic components
   c. interaction between the biotic community and the abiotic factors.

Part IV: What are the threats to the estuarine ecosystems?

1. Use the information from Part I, II and III to evaluate the value of the estuarine environments or wetlands. These wetlands are important to commercial and recreational fishing, hunting and bird watching industries. Why are these such important areas to these industries?

2. Use the Texas highway map to identify some of the coastal cities and towns located by the estuarine ecosystems. Use a Texas Almanac to determine the economic impact of sport or recreational fishing and commercial fisheries. What is the economic importance of this area to sport and commercial fishing and to the coastal communities?

3. The estuarine environments perform many chemical and physical functions. They temporarily hold suspended sediments, excess nutrients, toxic chemicals and disease-causing microorganisms. The wetlands filter nitrates and phosphates from rivers and streams that receive wastewater from water treatment plants. They can convert other pollutants trapped in the wetland sediments to less harmful forms that can be used by plants. However, there are threats to the estuarine ecosystems. One is land subsidence or sinking and relative sea level rise. How will sinking of the land and/or a rise in sea level affect the salt marshes, mud flats and oyster reefs? How will this impact the organisms living there?

4. How might the destruction of the wetlands increase the toxic chemicals in the bays and in the Gulf of Mexico?

5. The estuarine environment also reduces erosion by absorbing and dissipating wave energy. They also bind and stabilize sediments and increase sediment deposition. Use a stream table or other container to create a model to test this. Explain the procedure used to set up your model and test the idea. Summarize your results.

6. The position of the coastal wetlands means that they slow the run-off during periods of flooding. They also slow and store the surface water so that it can infiltrate and percolate into the aquifer. Explain why the wetlands are considered to be a "recharge zone" for the Gulf coastal aquifer.

7. New housing and commercial development to accommodate the rapid increase in population is also a threat. Channels and canals are dredged to build residential areas. See Figure 6.4. What happens to the marsh when this occurs?

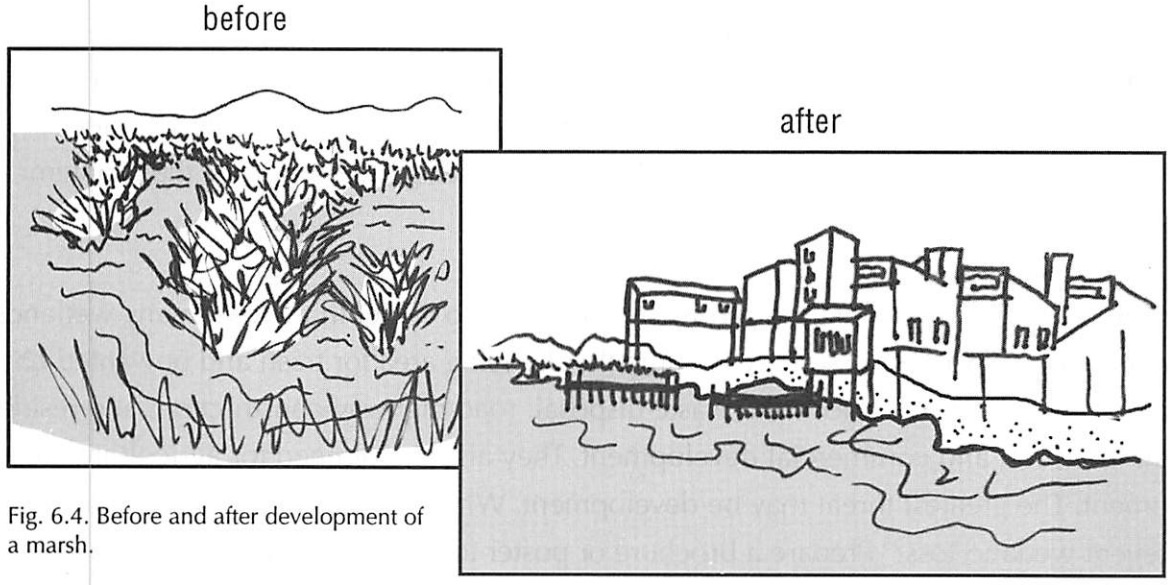


Fig. 6.4. Before and after development of a marsh.

8. Dredging increases the sediments in the water, how would this affect the oyster reef community? The salt marsh grasses? Animals that are filter feeders?

9. Dams have been built on many of the rivers that empty into the bays. How will *this affect* the salinity, sediments, nutrients and organisms living in the salt marshes, mud flats and oyster reefs?

10. Use the Texas highway map; select a river that empties into the Gulf of Mexico. Find the origin of the river. Note the number of cities and towns that the rivers flow past. What happens to all the chemicals (fertilizers, pesticides, herbicides, fertilizers, oil and gas spills and trash) that are washed into the streams and rivers by rain? How will this affect the marshes, mud flats and oyster reefs in the bays?

11. From 1955 to 1992, the coastal wetlands have lost 210,590 acres or about 5,700 acres a year. The Galveston bay area alone has lost 33,400 acres and wetlands lost in the river deltas amounts to 21,000 acres. How has this affected the estuarine life? How is this affecting humans?

12. Use the Texas highway map and locate the Intercoastal waterway. Along the entire coast, the mud and sand flats have decreased by more than 13 percent since the mid-1950s; a net loss of more than 30,000 acres. Much of the loss is due to the construction of dredge-spoil places along the Intercoastal waterway and other ship channels. Dredging and constructing channels for navigation, flood protection and residential development also lead to loss of wetlands.

13. To address the problem of wetland losses, a National Wetland Policy has been adopted with the recommendation of "no net loss" wetlands. Losses to sea grasses may be slowed or even reversed through properly planned and executed sea grass planting projects. However, this is not a simple solution. Will planting sea grass beds solve the problem? Explain.

14. Many people see the wetlands as a waste area with no value. In the past many wetlands were consider wasteland so they became the dumping area for trash and unwanted chemicals. Wetlands are filled for solid waste disposal, road/highway construction, and residential, industrial and commercial development. They also are drained for agricultural development. The greatest threat may be development. What do you think should be done to prevent wetland loss? Prepare a brochure or poster to inform the public of the importance of the estuarine ecosystem, the factors that cause its destruction and things that could be done to reduce the problem.

15. If you live in a coastal community, find out about your local wetlands and prepare a program informing the public about their importance and value; the problems they are facing and what should be done so that your community's wetlands will not be destroyed.

7. What Is Life Like in the Lagoon Ecosystems?

Marine Ecologist _____ **Team** _____

Lagoons are isolated or semi-isolated bodies of shallow coastal water that do not receive a large amount of freshwater. A lagoon that is cut off from the ocean is basically a body of standing water. If it is connected to the sea, tidal water flows in and out of the lagoon through an inlet. The amount and intensity of the flow depends largely on the range of the local tide. The larger the tidal range the greater the exchange of water between the lagoon and the ocean. You are going to investigate this marine environment to learn about its life and communities.

Materials: Texas Highway map, plastic shoe box or other container with soft mud sediments and water, pipe cleaners, string, wire, paper, recycled plastic bottles, Clear plastic cups (8 oz.) or plastic soda bottles cut to form a cup, 2 or 3 liter bottle, rocks, salt, food coloring, elodea, muddy water, test tubes, beakers, light source

Procedure:

Part I: What is life like in the lagoon?

1. Use the Texas highway map to locate Laguna Madre, which is a lagoon. Examine the lagoon on the Rio Grande Valley area map. How does it differ from the bays along the Texas coast?

2. Construct a table like the one below. Read the sections on the lagoon, the mangrove and the sea grass bed communities and fill in the information for each on the table.

Table 1: Abiotic and Biotic Components of Lagoon, Mangrove and Sea grass Bed Communities

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and Biotic Components

3. Lagoons have calm, shallow water. The salinity may range between brackish and hypersaline depending on the local climate. Laguna Madre is a lagoon with a salinity ranging from 2 -86 ppt. In a few isolated parts there have been salinities more than 100 ppt for short periods of time. During normal years, the salinities in the Redfish Bay area range between 40 and 60 ppt. The area is a highly productive fishing area. More than 50 percent of the finfish landings along the Texas coast come from Laguna Madre. During dry years, the

salinity may rise above 70 ppt and bring about large fish kills within the Redfish Bay area. Rains or hurricanes bring fresh water into the lagoon and may lower the salinity to 2 ppt. This can also result in fish kills. Why do these changes in the environment kill fish?

4. The vegetation of the lagoon may vary from sea grasses, mangroves or salt-marsh plants or have edges and bottoms that are barren. The water temperature will not vary with depth. Why is the water temperature the same through the lagoon?

5. Lagoons tend to have a sand or mud bottom that eroded from the nearby shoreline or was carried in through the tidal inlets from offshore. Subtropical lagoons have an interesting circulation pattern that results from high evaporation rates and little rainfall. As a result the water in the lagoon becomes saltier than the open water of the shelf. This dense salty water sinks to the bottom of the lagoon and flows out to the ocean through the inlet as a bottom current. This causes the shelf water to flow into the lagoon on the surface. This current flow pattern of inflow at the surface and outflow along the bottom is opposite of what happens in the estuaries. This type of current is referred to as inverse flow. Laguna Madre is a large, shallow and hypersaline lagoon that is located behind Padre Island and displays this inverse flow. High salinity water of Laguna Madre flows along the bottom to the Gulf. The less salty and less dense water of the Gulf of Mexico enters the lagoon at the surface. Draw a cross section of a lagoon and the Gulf. Use colored markers or pens to diagram the movement of the water circulation.

6. Construct a model to investigate this type of inverse flow. Add some weight, a small rock or two, to the plastic cup that will represent the lagoon. Cut a 2 cm notch in one side of the cup to represent a pass. Make hypersaline water by adding excessive salt to the water in the cup, add several drops of blue food color and mix the solution. Fill the cup so that it is filled to overflowing. Cut the top half off a 2 or 3 liter bottle. Fill it with slightly salty water to a height that is the same as the cup. Slowly lower the cup of hypersaline into the cut-off liter bottle. Observe what happens. Sketch what happens next to your sketch of the inverse flow of the lagoon. Evaluate your model. Did it represent the circulation of the lagoon and Gulf water? How could you improve on your model?

7. Along the edge of Laguna Madre are broad, nearly unvegetated sandy flats. They are only occasionally flooded so salt builds up on the dry surface. Vascular plants cannot live on these flats, but they are often covered with mats of blue-green algae. This community of algae supports rich invertebrate populations that attract large numbers of shore and wading birds. The lagoon life includes: copepods, amphipods, dove shells, Egg cockles, Pointed Venus and a variety of crabs (dwarf surf, fiddler, mud, portunid, hermit) and fish

such as the spotted seatrout, Atlantic croaker and sand drum. There are also transitory residents of the hypersaline systems. These include blue and hermit crabs, as well as the commercial shrimp. The brown shrimp can tolerate salinities over 70 ppt, the pink shrimp can occur in waters up to 60 ppt and white shrimp rarely occurs in waters above 45 ppt. Each species moves into the lagoon as far as its salinity tolerance will allow and will migrate to new areas as conditions change. The fishes are even more transient. Within the lagoon ecosystem of Laguna Madre there are mangrove and sea grass communities.

8. To summarize and communicate what you have learned about the lagoon ecosystem, prepare an interview or skit with some of the organisms in each area to present to the class or to students in an elementary class. Include in the interview or skit information about the:
   a. abiotic factors
   b. biotic components
   c. interaction between the biotic community and the abiotic factors.

9. How does the lagoon ecosystem differ from the salt marsh ecosystem (lesson 6) of the bays? How are they similar?

Part II: What is life like in the mangrove community.

1. The mangrove community consists of a number of trees or tree-like shrubs that are tolerant to both saltwater and brackish water conditions. The mangroves need warm waters protected from wave action. They are only found along portions of the Gulf of Mexico and the Atlantic Coast of Florida. Only one mangrove, the black mangrove is able to survive mild Texas winters. It barely reaches tree size. In most cases, it is shrub like. Mangroves can be seen along the causeway between Port Isabel and South Padre Island, and along South Bay, just south of the Brownsville Ship Channel. Mangroves also occur near Harbor Island in Aransas Bay near Aransas Pass. Locate these two areas on the Texas highway map (Rio Grande Valley Area and Corpus Christi Areas).

2. The mangroves have extensive root systems that anchor them firmly in the soft bottom. Long underground cable roots radiate out from the base of the trunk and anchor the plant in the mud. Construct a model of a mangrove and its roots system using the materials provided. Which root system design worked best for holding the plant in the soft mud? Make a sketch of the root system model that worked the best. Summarize what you learned about the structure of an effective design to anchor a tree or shrub in soft *mud.*

3. The mangroves have a specially adapted root system to take in oxygen in order to live in

the oxygen less substrate. The black mangrove produces pencil roots that grow up and out of the mud to surround the tree like a forest of spikes. They form a link between the cable roots buried in the anaerobic sediments and the atmosphere. These roots take in oxygen when they are uncovered during low tide. These roots also have salt -secreting glands that remove excessive salts from the root sap. As a result, the black mangrove has the highest salt tolerance of the mangroves. The seeds of mangrove trees germinate on the tree; the young plants then fall into the water, drift away and take root elsewhere. Use recycled materials and construct a model of a mangrove seed. Which designed worked best? Explain.

4. The intertidal mangroves provide a number of different habitats which include the muddy sediments, the surface of the mud, the surface of the trunks and roots of the trees. See Figure 7.1: Profile of the mangrove community.

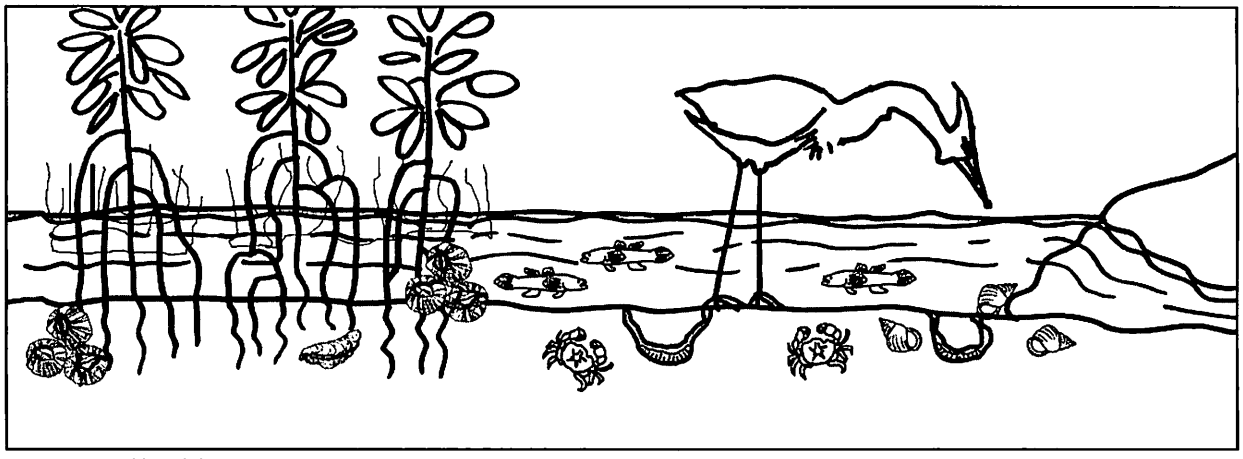


Fig. 7.1. Profile of the Mangrove Community.

The habitats above the waterline include the trunk and leaves. Barnacles, tunicates, oysters and sponges attach themselves to the tree roots that are free of clogging mud. Periwinkle snails are found crawling among the roots, grazing on algae. The different periwinkle species are located on the tree trunks in zones similar to that on rocky shores. Nearer to land, several species of crabs (Wharf, Fiddlers) are common. The bottom includes burrowing polychaete worms, shrimp, and amphipods. During high tides, shrimp and fish enter the area to feed. These animals attract wading birds like the reddish egret, other egrets, herons, ibises, night herons, roseate spoonbills and wood storks. Gulls and terns also use the mangroves. Why are wading birds more common than shorebirds in this community?

5. Add information about the mangrove community to Table 1.

6. To summarize and communicate what you have learned about the mangrove community,

prepare an interview or skit with some of the organisms in each area to present to the class or to students in an elementary class. Include in the interview or skit information about the:

a. abiotic factors
b. biotic components
c. interaction between the biotic community and the abiotic factors.

Part III: What is life like in the Sea grass Bed Community?

1. Sea grasses are the only marine vascular plants. They grow in enclosed and sheltered bays and lagoons. Why are sea grasses not found growing on the sandy beach or the jetties?

2. The sea grass meadows are very productive areas with quick growth and a fast turnover of dead organic matter. Why would these plants in water grow faster than land plants? Why are the grasses in the estuarine environments more productive?

3. The sea grasses do not belong to the family of true grasses, but are called grasses because they have grass-like leaves and rhizomatous stems. They are limited to depths within the bays between about 0.3 m to 2 m. Why are sea grasses not found in deeper water? What physical factors would limit the depth at which they can grow?

4. The sea grass beds are more abundant in the upper and lower Laguna Madre than in other Texas bays. Laguna Madre is shallow and clear, allowing good light penetration to the sea grasses. The waters are clear because the bottom is sandy. Use the Rio Grande Valley area of the Texas highway map. Locate Laguna Madre. Are there any rivers bringing water and sediments into the lagoon? How would this affect the environment in the lagoon? Would this explain why the lagoon has a sandy bottom and not a mud bottom? Explain.

5. Note the path of the intercoastal waterway. What affect does it have on the sea grass community when it is dredged?

6 How would the turbidity of the water affect the rate of photosynthesis of the plants? What is your hypothesis? Use a freshwater aquatic plant (elodea or anacharis) to represent the plants. Place the sprig of elodea in each test tube. Fill one test tube with muddy water and invert in a beaker of muddy water. Fill the other test tube with clear water and invert it in a beaker of clear water. Place both under a light source. Which produced the greater gas bubbles or had the greater productivity? Summarize the results of your investigation. *What* makes the lagoon ideal for sea grass beds?

7. In recent years the Laguna Madre has experienced a brown tide. Extensive growth of a microorganism resulted in the water being brown instead of clear. How would this affect the growth of the sea grasses?

8. The sea grasses provide refuge, substrate or food for a variety of plants and animals. Therefore, the diversity and total productivity of the sea grass meadows is very high. See figure 2: Profile of the Sea grass Bed Community.

   The common one is widgeon grass along with shoal grass, manatee grass and turtle grass. Attached to the leaves of the sea grasses are serpulid worms, diatoms, bryozoans and hydroids. Crabs (hermit, spider, blue) frequent the sea grass beds. Also small grass shrimp live there along with the broken-back shrimp and arrow shrimp. In addition to the smaller grass shrimp, the young of all the commercially harvested shrimp (white, brown, pink) use the grass beds and marshes as nursery areas. Gastropods graze on the sea grasses. These include the cerithiid, assiminea, bubble shell, dove shell and virgin nerities. A variety of mussels (bivalves) and bay scallops that feed on the phytoplankton, benthic diatoms, bacteria and detritus suspended in the water. A variety of soft-bodied invertebrates live in the grass beds. These include the polychaete worms and one species of sea cucumber. A small burrowing anemone lives in the grass beds as well as *Phoronis*, a suspension feeder that lives in a tube on the floor of the grass bed. One of the predators of the grass bed is the ribbon worm that feeds on the polychaetes, crustaceans and other invertebrates. If the sea grasses die, what will happened to this community?

9. Add the information on the sea grass bed community to Table 1.

10. To summarize and communicate what you have learned about the sea grass bed community, prepare an interview or skit with some of the organisms in each area to present to the class or to students in an elementary class. Include in the interview or skit information about the:
    a. biotic factors
    b. biotic components
    c. interaction between the biotic community and the abiotic factors.

11. Both the mangrove and sea grass community are found in the same lagoon. How are the communities alike and how do they differ? Why aren't they found in the same location?

8. What Is Life Like in the Open Waters?

Marine Ecologist _____ **Team** _____

The water itself creates an additional community for swimming and floating organisms in the bays, passes and the water over the shelf. The organisms are both plankton and nekton. You are going to investigate these organisms in the open waters of the bays and Gulf.

Materials: recycled materials (plastic bottles, paper, string, etc.), glue, small pieces of wood and a large container of water.

Procedure:

1. The organisms of the open water include plankton, which cannot move against a current, and the nekton, which can move against a current. The plankton change with the season since they are very sensitive to minor changes in temperature, salinity, oxygen level or toxin in the water. The larvae of most marine animals are plankton and so they are usually seasonal in their appearance. What are some possible explanations or hypotheses as to why the plankton is seasonal?

2. Copepods, ctenophores, arrow-worms and sergestid shrimp are some of the permanent plankton. Cabbage heads, sea nettles, moon jellyfish, Lion's mane jellyfish, lobed comb jelly, sea wasp, sea walnut and bay squid are among the larger plankton. Other animals such as spider crabs and blue crabs may hitch rides in the jellyfishes' bells. What do the permanent plankton have in common?

3. Select a type of permanent plankton and use the library and/or Internet to learn more about it. Construct a model of the plankton selected using the materials supplied. Test the model; does it float in the water? If it does not float, reconstruct the model so that it will float. Summarize what you have learned about the structure of permanent plankton and floating.

4. Prepare an information sheet to place next to your permanent plankton model. The information should include its name, where it lives, what it eats, how it eats, who eats it and other information. Include a sketch that identifies its body parts.

5. The most obvious invertebrate nekton are squid, shrimp and swimming crabs. See Figure 8.1. However, the majority of the nekton are the fishes. Some of the common *fish in the* bays are the striped mullet, bay anchovy, herring, sand trout or white trout, spotted sea trout, blue runner, tarpon, ladyfish, pinfish, needlefish, killifishes, cownose ray and ribbon-

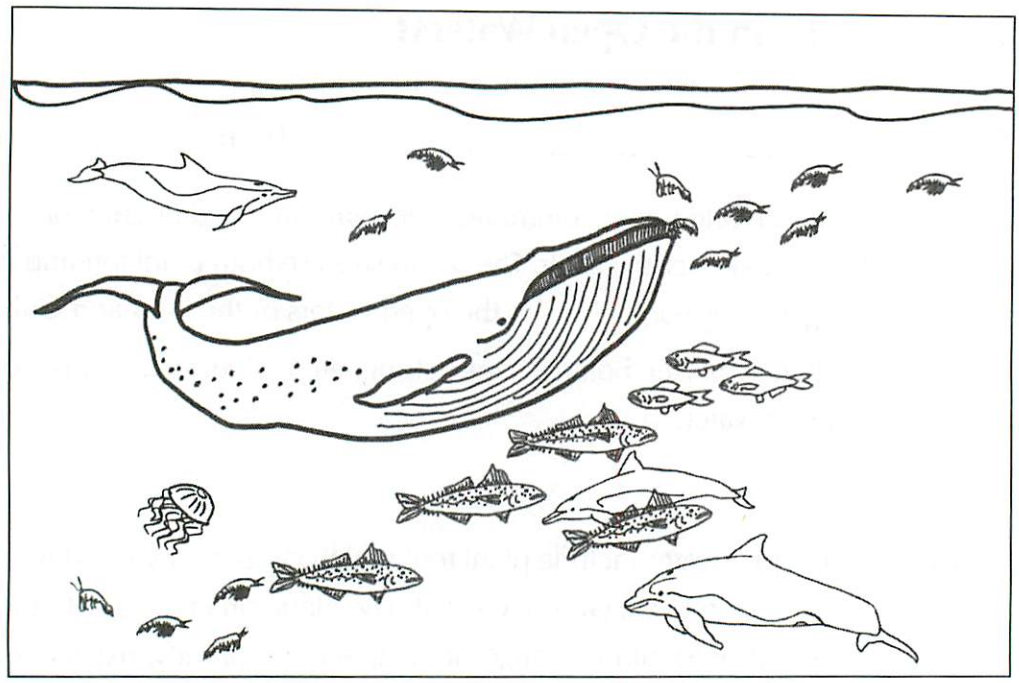


Fig. 8.1. Profile of Open Water. (Source: Lien. 1979. Investigating the Marine Environment and Its Resources)

fish. In the water offshore, the families of fish include the jacks, grunts and others. There are also 20 marine mammals in the open water of the Gulf. The marine mammals are only whales and dolphins; there are no porpoises in the Gulf. Select one of these to learn more about its habitat and niche in the open water. Determine what it eats, where it lives, who eats it and how it is adapted to the niche in the open water.

6. The waves washing up on the beach often carry organisms that normally live or drift in deeper water out in the Gulf. Portuguese-Man-of-War and two close relatives, the by-the-wind sailor and *Porpita porpita are* the common ones. Most are usually dead or battered when they reach the beach. The purple storm snails are predators of the Portuguese man-of-war. They have very thin shells and construct bubble rafts by covering trapped bubbles with mucous. This enables them to stay afloat. The blue nudibranch also feeds on Portuguese man-of-war and its kin. Why are they dead or dying when they reach the shore?

7. The flotsam (driftwood or nonliving objects afloat) carries several species, such as the stalked barnacles, which includes the gooseneck barnacle. Inside pieces of driftwood are boring clams and boring isopods. See Figure 8.2.When the driftwood lands on the beach, the marine animals are usually dead. Why would they die when they reach the beach?

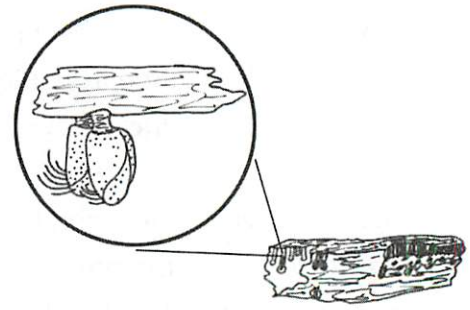


Fig. 8.2. Gooseneck barnacles and boring worms on flotsam. (Source: Beachcomber's Guide to Gulf Coast Marine Life)

8. Obtain a small piece of wood or plastic. Construct a model of a barnacle using the materials provided. Glue the barnacle to the piece of wood. Hold the piece of wood and put it in the water so that the barnacle model is underwater. Move it around. How well did the model work? How would the barnacle get food? What would it eat?

9. Barnacles permanently attach themselves to floating materials in the water including ships. What does this tell you about the glue-like material it uses to attach itself?

10. The floating *Sargassum* community is a fascinating community of specialized organisms. Sargassum is a pelagic brown algae. It normally lives in shallow warm seas. Storm waves break it from its attachment and the currents transport it. Most seaweeds die but not two species of *Sargassum,* it not only survives but actually grows and reproduces as it floats. The seaweed has tiny air bladders that help it float. It clumps together to form large mats. These mats attract an unusual group of animals. Hydroids, bryozoans, gooseneck barnacles and polychaetes attach to its surface. At least one very small anemone lives on it. Living in the *Sargassum* is the sargassum fish. Its body is misshapen in the pattern of the branching *Sargassum*. The sargassum pipefish mimics a blade of the *Sargassum*. It eats copepods, ostracods and shrimp swimming in the seaweed. The brown sargassum snail lives only in this seaweed. The sargassum nudibranch, which looks like the *Sargassum,* feeds upon the hydroids. The sargassum crab, Gulfweed crab, sargassum shrimp and sargassum seahorse are orange-brown like the seaweed. The sea spider also lives in the *Sargassum* along with polychaete worms. These animals have all found a niche for themselves in the floating mat of seaweed. Examine Figure 8.3, The Sargassum Community. Can you locate the organisms described? Which ones were you able to find?

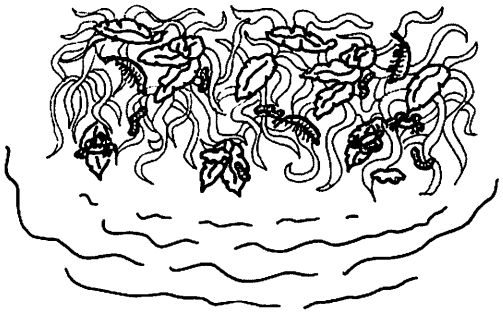


Fig. 8.3. Floating Sargassum Community.

11. Use the library and Internet to learn more about organisms found in the open water or in the sargassum community.

12. Construct a table similar to the one on page 650. Add the information for the open bay and Gulf water and the sargassum community.

Table 1: Abiotic and Biotic Components of the Open Bay and Gulf Waters and the Sargassum Community

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and Biotic Components

13. How would flooding in the bays affect these organisms?

14. How does the open bay and gulf water ecosystem differ from the sandy beach, jetties and salt marshes?

15. To summarize and communicate what you have learned about the open bay and Gulf water, prepare an interview or skit with some of the organisms in each zone to present to the class or to students in an elementary class. Include in the interview or skit information about the:
    a. abiotic factors
    b. biotic components
    c. interaction between the biotic community and the abiotic factors.

9. What Is Life Like in the Offshore Bottom Ecosystem?

Marine Ecologist _____ **Team** _____

The continental shelf extends from just beyond the waves breaking on the beaches to a depth of more than 200 meters. This is the area where shrimp boats trawl and recreational fishermen use rods and reels. The organisms that live in this area respond to different changes in this environment. You and your team are going to investigate life in this area.

Materials: plastic cups, sand, silt, mud or sand of different size particles, shell fragments, paper, glue, plastic shoe boxes or larger containers

Procedure:

1. The shrimp, crabs and other animals living on the sediment surface are sensitive to differences in temperature, salinity and water depth. What is a possible explanation as to why animals living on the surface of the bottom are sensitive to changes in these factors?

2. The burrowing animals are sensitive to the texture of the sediments. They use the shell fragments and sand grains to make their burrows. The particle size also affects how easy it is to burrow and how well the burrows will last. Conduct a test to determine which type of sediments (large grain sand, medium grain, fine grain sand, silt or mud) would be the easiest to burrow into. Fill each cup to a depth of 6 cm with sediment. Add water to each cup of sediment so that it is wet. Pretend that your finger is a burrowing clam and push your finger into each sample of sediment. Which was the easiest to burrow into and which was the most difficult?

3. Use sand particles or shell fragments, paper and glue to make a model of a tube for a worm that is 4 cm in length. Fill a plastic shoebox or container with sand or another sediment to a depth of 8 cm. Place your model tube in the sediment. Cover the sediment with 3 cm of water. Move the water around to simulate currents and waves. How well did your burrow or tube last? In which sediments did it last the longest? What type of tube lasted the longest? Summarize what you learned about sediments, burrows and tubes of worms.

4. The currents move food along the bottom for the burrowing animals. The burrowing animals include the polychaete worms, bamboo worms and other worm-like animals that feed on algae, copepods and barnacle larvae. The bloodworm preys on other *polychaetes* and amphipods. A gastropod, the sharp-knobbed nassa, and Atlantic clam also feed in the bottom. The cartilaginous fish that live upon or near the bottom include the guitarfish, the

electric rays and torpedo fishes, the skates, the stingrays, the butterfly rays and eagle rays. They feed on clams, crabs and a variety of invertebrates found on the bottom. The bony fishes that live on the bottom are the flatfishes, which include flounders, soles, and tonguefishes. All are carnivores. The sea catfish (Hardhead catfish and Gafftop catfish) are the most likely to be caught by anglers. Closer to the shore the bottom dwelling organisms must be more tolerant of variable temperature, salinity and high turbidity than those that live further offshore. Why would these factors be more important to animals living near the shore than those living farther offshore?

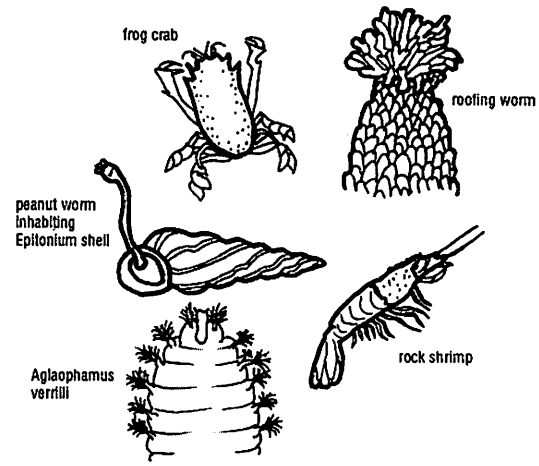


Fig. 9.1. Organisms found in the bottom ecosystem.

5. The bottom is dominated by a variety of polychaete worms. These include the roofing worm, paddleworm, scaleworm, parchment worm and others. The polychaetes inhabit the sand with other borrowing animals like the onion anemone, dwarf tellin and the fine-ribbed auger. During the spring these are joined by the surf clam hermit crab, amphipods, cumacean, lancet, commensal clam and several moon snails. The fragile paranoid worm is found in the silty sand and the reddish echiuroid worm is found near passes and in dredged areas. Many species of shrimp inhabit this area. Three are large enough and abundant for fishing. These are the brown, pink and white shrimp. Other shrimp include the sugar, seabob, rock, mantis, caridean and sergestid.

   Not all inhabitants of the offshore area are worms, burrowing crabs or shrimp. There are also large bivalves like the quahog, giant cockle, false angel wing and gastopods like the moon snail, dwarf olive and horse conch. Hermit crabs use their empty shells. Other crabs are the frog crab, mole crab and longheaded porcelain crab. In the coarse sediments are a variety of amphipods. Several brittle stars and the Spanish lobster live in this area along with the common octopus that inhabits crevices, large shells or empty cans found on the bottom. Use the library and Internet to research specific organisms found in this area or to gain more information about life on and in the bottom. What does the animal eat? How does it get its food? What animal eats it? How does it avoid getting eaten? Etc.

6. Locate pictures of the various animals and create a mural to show where they live.

7. Construct a table similar to the following. Add the information for each zone (on the bottom and below the surface) in the offshore bottom ecosystem.

Table 1: Abiotic and Biotic Components of the Offshore Bottom Ecosystem

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and Biotic Components

8. To summarize and communicate what you have learned about the sandy beach, prepare an interview or skit with some of the organisms in each zone to present to the class or to students in an elementary class. Include in the interview or skit information about the:
   a. abiotic factors
   b. biotic components
   c. interaction between the biotic community and the abiotic factors.

9. As a shrimp boat crosses the bottom, it catches not only the shrimp but also many other organisms that live in the same area as the shrimp. What are some of the animals (the bycatch) that they would catch in their nets?

10. These animals would then need to be separated from the shrimp in the nets. How is this done? What happens to these animals?

11. How does shrimping impact this ecosystem?

12. Why is shrimping regulated, meaning that shrimpers can only go out in the Gulf and trawl for shrimp at certain times?

10. What Is Life Like in the Coral Reef Ecosystem?

Marine Ecologist _____ **Team** _____

A coral reef is an organically constructed wave-resistant structure created by plants and animals. Most of a coral reef is made of fragments of shells and skeletons that are composed of calcium carbonate. In rock form it is referred to as limestone. The living part of the reef is mainly a thin layer of "skin" growing on the surface of the limestone deposits from ancient reef communities. When coral and other carbonate-secreting organisms in this "skin" die, their hard parts are added to the reef structure, helping the reef grow in size over time. You and your team are going to investigate life in a coral reef.

Procedure:

1. Not all corals produce reefs. The reef forming corals are those that secrete calcium carbonate and grow in tropical waters, where the conditions favor their growth. Water temperature, salinity, nutrient levels and light intensity (which is affected by water motion, depth, turbidity and sedimentation) are the primary factors that affect coral reef development. The Flower Gardens, the northernmost coral reefs on the continental shelf of North America, are located more than 100 miles off the Texas coast from Galveston. The East and West Flower Gardens is a pair of underwater coral reefs that are 12 miles apart. The other coral reefs in the Gulf of Mexico are south of Tampico, Mexico to the Yucatan continental shelf and in the Florida Keys. See Figure 10.1. For each factor that affects coral reef growth, cite your hypothesis about how it affects coral reef growth.
   a. water temperature
   b. salinity
   c. nutrient levels
   d. light intensity
   e. turbidity
   f. depth
   g. water motion

2. The Flower Garden Banks have formed above two bulges in the sea floor caused by salt domes and has probably been forming since the Ice Age. The

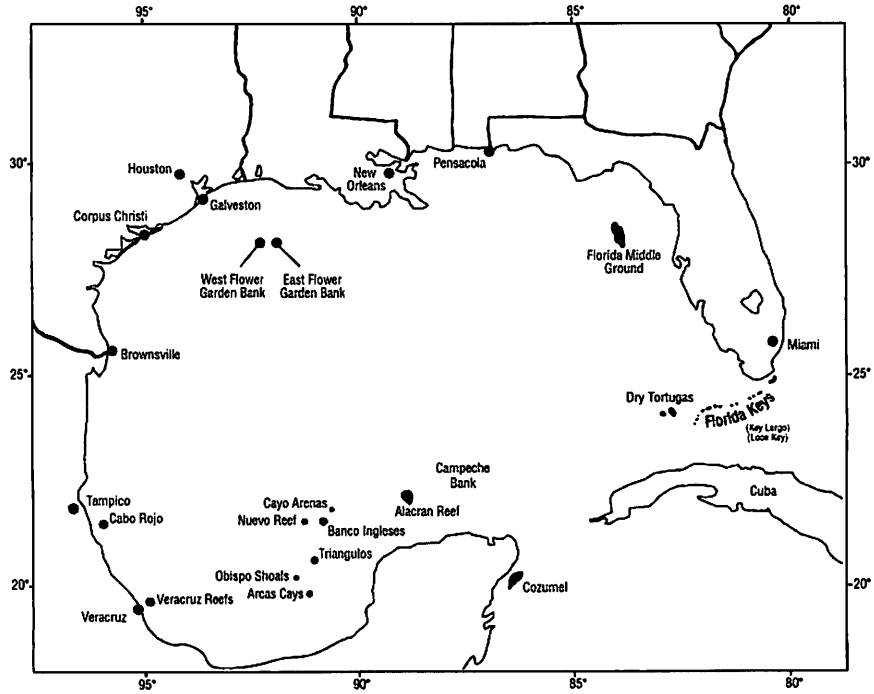


Fig. 10.1. Flower Garden Banks in the Gulf of Mexico.

East Flower Garden Bank is a pear-shaped dome approximately 6.1 by 4.8 miles and rises to about 50 feet below the water's surface. The West Flower Garden Bank is oblong shaped and is about 6.1 miles by 4.3 miles and rises to within 66 feet of the surface of the water. These reefs are home to at least 80 species of algae, 253 known macroinvertebrate species, and more than 175 reef fish species. Lobsters, snappers, groupers and Manta rays are found in the reef with loggerhead turtles and spotted dolphins visiting the area. Life in the reefs is divided into definite zones. See Figure 10.2.

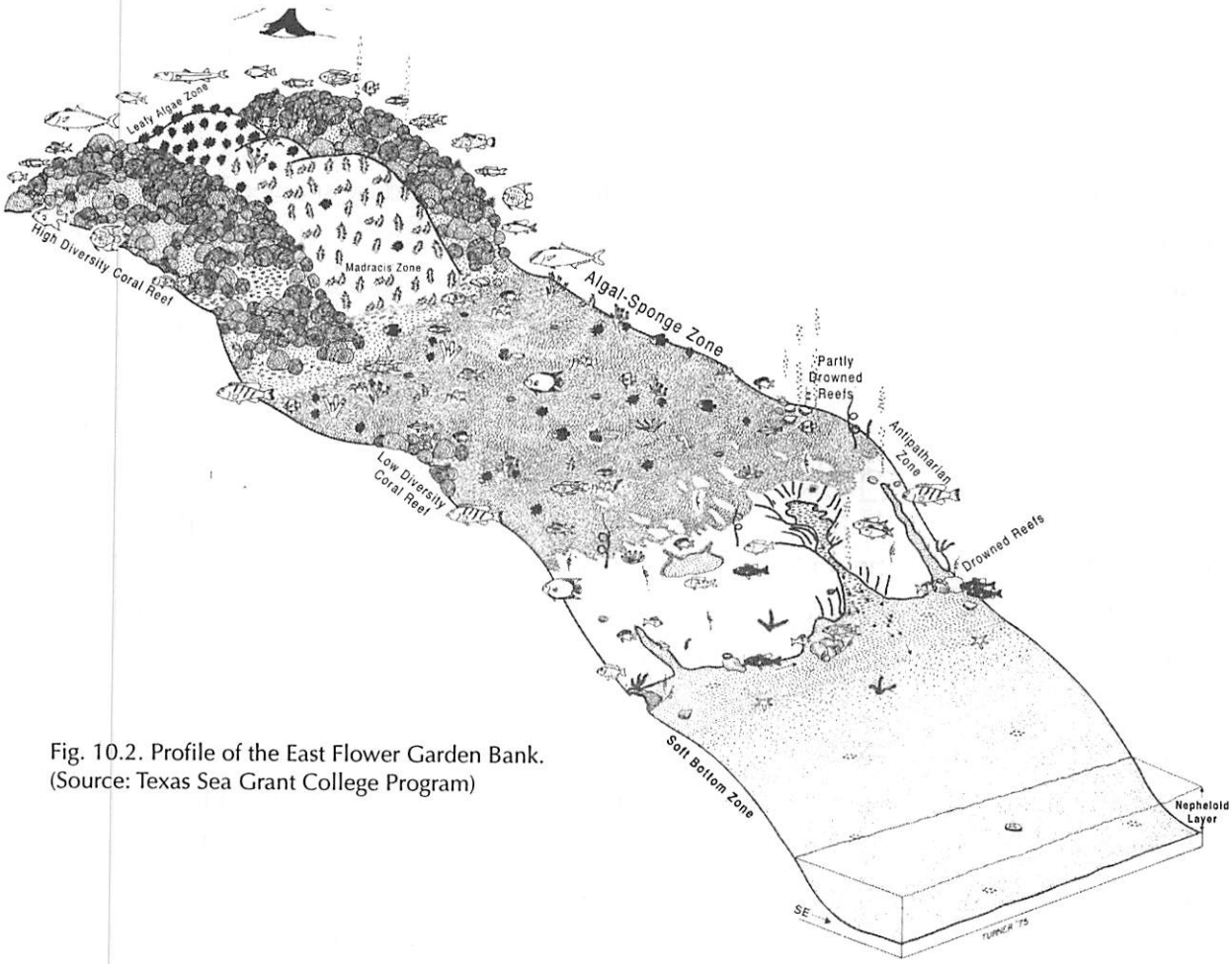


Fig. 10.2. Profile of the East Flower Garden Bank.
(Source: Texas Sea Grant College Program)

3. Construct a table like the one below. Add the information for each zone of the Flower Gardens Coral Reef as you read about the reef.

Table 1: Abiotic and Biotic Components of the Flower Gardens Coral Reef.

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and Biotic Components

4. The zone closest to the surface is the *Diploria-Monstastraea-Porites* Zone or High-Diversity Coral zone. This zone only reaches to about 118 feet. It is the zone where the most coral is found. This is the area most often visited by divers. Why is this area visited more often by divers than the other areas?

5. The types of coral include *Montastrea,* the mountainous star coral; *Diploria,* large-grooved brain coral and *Porites* species. This is the area where most of the reef invertebrates and fish are found. However, there are no large shallow water branching corals, sea fans or sea whips, which are found in similar depths on other Gulf and Caribbean coral reefs. Why are so many invertebrates and fish found in this zone?

6. In some areas next to the high diversity reef are areas covered by seaweeds. This is the Leafy Algal Zone. See Figure 10.2. The next zone is from 118 to 170 below the surface. This is a low-diversity coral reef, the *Stephanocoenia-Millepora* Zone. The conspicuous corals are the blushing star coral, *Stephanocoenia;* fire coral, *Millepora* species; cavernous star coral, *Montastraea;* large-grooved brain coral, *Diploria* species; lettuce coral, *Agaricia* species; large flower coral, *Mussa angulosa;* and the large fungus coral, *Scolymia* species. Coralline algae cover the dead coral reef rock. The American thorny oyster has been seen in this zone. The fish populations are less diverse in this zone. Both zones have populations of black urchins that erode the rock. Large groups of the small branching coral, *Madracis* are found at the edge of the main reefs. They are found between 125 and 144 feet below the surface. Why is the coral less dense in this zone compared to the one above it?

7. Below 151 feet is the Algal-Sponge Zone. Algal nodules cover 50 to 80 percent of the bottom in places. The Coralline algae are the most dominant organisms in this zone. The algae cover a much greater area of the reef than does the coral. A variety of sponges are found in this zone. These include the stinging-touch-me sponge. Less is known about this zone, but its diversity may be as great as that of the coral zone. Fish and mobile invertebrates are attracted to the sponges and are seen moving among them. The small yellowtail reef fish is the most abundant species. Other organisms are the asteroid starfish, sea urchins and sea hare. A transition zone occurs below 171 feet. It is the transition between organisms that exhibit shallow water traits and those adapted for deeper water. Why is less known about this area of the reef?

8. The bottom changes at the edge of the bank from algal nodules and crusts to soft, level bottom of mixed, coarse sand. Some places there are remains of drowned reefs. When the sea level was lower during the last ice age, these dead reefs may have been filled with living organisms. Now this area is in deeper water that is more turbid with less light pen-

etration. This area attracts several species of fish such as the yellowtail reef fish, snowy grouper, bank butterfly fish, scorpionfish and the rough tongue bass. Crinoids, sea whips, sea fans, sponges and non-reef building coral are the most dominant organisms. Why don't the reef building coral live in this area?

9. Another factor making the Flower Gardens different from other reefs is an unusual underwater salt lake. The lake is at the edge of the East Flower Garden bank and is fed by a brine seep. The lake's water is very salty and has high levels of hydrogen sulfide and dissolved hydrocarbon gases (methane, ethane and propane) and no oxygen. The lake is only 80 feet in diameter and about 10 inches deep. The main organisms in the lake are sulfide-oxidizing bacteria. A canyon begins at the end of the lake. The floor of the canyon is covered by a whitish mat, made of bacteria and algae. A specialized community of organisms, called thiobios are able to live here. They feed directly on the algae and bacteria. Fish and other animals cannot live in the stream leaving the lake. However, some fish such as angelfish, butterflyfish and cottonwick are able to swim in and out of the brine stream to feed. Large red snappers and groupers often swim very close to the lake. Why is this area of great interest to the scientists?

10. After you have completed Table one. Use table one to explain how the abiotic factors (temperature, salinity, sunlight, etc.) affect the life found in each zone. Summarize the relationship between abiotic and biotic factors.

11. Use the Internet to research specific organisms found in this area or to gain more information about life in the Flower Gardens. What do the different animals eat? How do they get their food? What animal eats it? How does it avoid getting eaten? Etc.

12. To summarize and communicate what you have learned about the Flower Gardens, prepare an interview or skit with some of the organisms in each zone to present to the class or to students in an elementary class. Include in the interview or skit information about the:
    a. abiotic factors
    b. biotic components
    c. interaction between the biotic community and the abiotic factors.

13. Global warming and associated climate changes are threatening coral reefs by:
    a. increasing the average ocean temperature, corals lives in waters between 77° and 84°F
    b. causing a rise in sea level
    c. changing the carbon dioxide levels in the ocean
    d. changing the patterns of the ocean currents

Why might each of these changes threaten the coral reefs?

13. The Flower Garden Banks are on the path of international shipping lines and were frequented by large vessels. The tops of the reefs have been damaged by anchors, cables and chains, which destroy the coral. The mechanical damage is like a deep cut and can cause the death of the coral and other organisms when their tissue becomes infected from the cut. Another concern was the offshore oil and gas operations close to the boundaries of the reef. Commercial fisherman, recreational fisherman and divers all visited the reef. How would this human activity impact the reef?

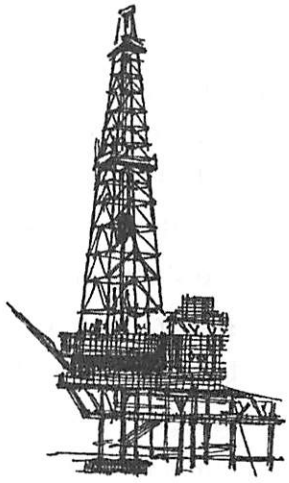
14. The National Marine Sanctuary Program was established in 1972 to designate and manage nationally significant marine areas for their ecological and historical value. The highest priority of all national sanctuaries is the long-term protection of the resources. The impact of human activity began to affect the reef in the mid-1970's. Eventually Flower Garden Banks were designated as a marine sanctuary. The activities of anchoring vessels; oil and gas exploration; fishing in the area; removing materials or animals from the reef; and discharging or depositing materials in the area are all regulated. Why was it important that the Flower Garden Banks became a designated marine sanctuary?

15. Many, but not all, of the plants and animals of the reef have been identified to species. Major groups still need to be identified. Much research is needed to understand how this important and unique ecosystem functions. What are some questions that need to be answered to help determine how to manage it?

11. What Is Life Like in the Artificial Reefs?

Marine Ecologist _____ **Team** _____

In 1938, the oil well was completed in the Gulf of Mexico. Since that time, there are now close to around 1000 major oil platforms, thousands of support structures and sunken ships. These all provide a habitat for marine organisms that need a hard surface for attachment. You are going to investigate the life of an artificial reef.



Procedure:

1. Review the natural ecosystems and communities in the Gulf that were covered in the previous lessons. List the organisms that need a hard surface for attachment.

2. Populations of bacteria and diatoms may cover the new surface within 24 hours of the surface being placed in the water. From where did these come?

3. Once the bacteria are established, protists, algae, barnacles and numerous other organisms appear. Depending on the time of the year and how close the structure is to shipping lanes, they may appear overnight. Why is the time of year and proximity to shipping lanes a factor in determining how quickly the artificial reef forms?

4. The organisms that attach to the artificial reef are very similar to those on the hulls of ships. What is a possible explanation for the similarity?

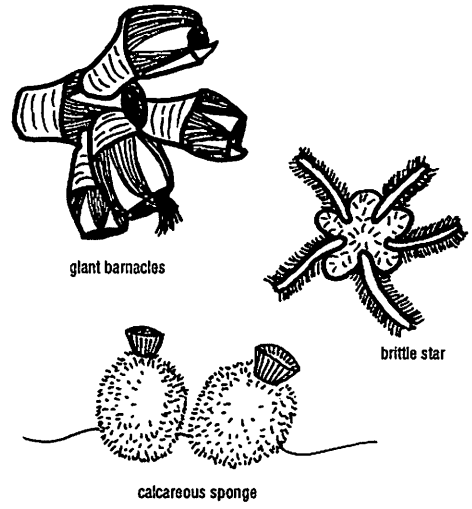
5. The arrival and attachment of the barnacles is the most important event. The barnacles increase the area for other organisms to attach. They also provide places for other coinhabitants of the reef. The shell of a dead barnacle may become the home of various crabs, shrimp or the crested blenny fish. The blenny grazes on the algae, hydroids and amphipods found on the shell surface. The giant barnacle, *Balanus tintinnabulum* is the most prevalent species. Why is the attachment of the barnacles critical to the formation of the reef?

6. Barnacles, attached near the surface or those growing on top of other barnacles may get knocked off by storm waves or grazing fish. These fall to the bottom of the reef structure. Here snail and hermit crabs wait to eat any food that falls down. The empty shells then serve as shelter for mud crabs and young octopus. Large barnacles that are broken off will

have tunnels of the boring clams like the mahogany date mussel and the scissor date mussel. What would happen to these organisms if the barnacles died out?

7. Several layers of sponges may grow on the barnacles. These will hide the barnacles. The sponges provide a substrate for other species and a shelter for mobile organisms. Polychaete worms and clamworms are found in between the barnacles and sponges. Nearer the surface, algae, hydroids and bryozoàns may grow over the sponges. Why would the algal masses be just below the water's surface?

8. The mobile organisms associated with the sponge-barnacle community are the brittle stars. Brittle stars will share crevices with a variety of amphipods. In the algal masses just below the water's surface, are the skeleton shrimp, the squat isopod and sea spider. The shore crab is also a resident of the barnacle zone. The small mud crabs take up residence in the shells of dead barnacles. The arrow crab crawls over the reef. The decorator crab carries sponges and a coat of hydroids, algae and bryozoans as a disguise. The red crab is found in the large crevices in the reef. A number of bivalves cement themselves to the artificial reef. These are the horse oyster, leafy jewel box, Atlantic wing oyster, mossy ark and pygmy venus clam. The two-toned tree oyster attaches itself to barnacle shells or between barnacles. The purple sea urchin is a predator grazing on the algae, hydroids and bryozoans. Polychaetes such as the serpulid worm and the feather duster worm are found in the substrate. Around the reefs are a variety of fish. Why would a variety of fish be found around the reef?



Reef life

9. Use the library and Internet to research specific organisms found in this area to gain more information about life on the artificial reefs.

10. Construct a table like the one below. Add the information for each zone (near water surface, barnacle zone, bottom of reef) of the artificial reef.

Table One: Abiotic and Biotic Components of the Artificial Reef

Location/ Zone	Abiotic (nonliving) Factors	Biotic Components (plants and animals)	Benthic, Plankton, Nekton	Interaction of Abiotic and Biotic Components

11. To summarize and communicate what you have learned about the artificial reef, prepare an interview or skit with some of the organisms in each zone to present to the class or to students in an elementary class. Include in the interview or skit information about the:
    a. formation of the reef by organisms
    b. abiotic factors
    c. biotic components
    d. interaction between the biotic community and the abiotic factors.

12. Prepare a chart comparing a coral reef (lesson 10) to an artificial reef. Summarize how they are similar and how they differ.

12. Why Are the Dives Different?

Diver Reporting _____ **Team** _____

Divers are often asked: Why do you do it? The response is because it's there. Diving became a boom sport of the 1950's when many would dive to spearfish. Soon the fish become scarce, divers then realized that undersea hunting was seriously harming the coastal fish populations. They turned to other areas of interest. Now resorts in tropical areas or near coral reefs are attracting divers who want to observe curious forms of life in colorful settings and comfortable waters. Today coral reefs are being designated as underwater parks. You are a diver who has been diving in the Gulf of Mexico for years and you have recorded you observations in a journal.

Materials: Descriptions of dives, paper and pencils

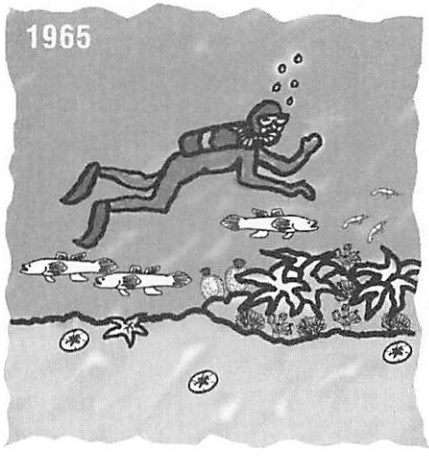
Procedure:

1. As you read the description of the first dive, picture it in your mind.

Dive One

It is 1965. Having just finished a dive in the Gulf of Mexico, I found a sea filled with life. The water is as clear as glass — I was surrounded by sea nettles, jellyfish, shrimp and many types of fish gently swimming around. The rays butterfly by with slow motion grace. A sargassum community floated by with its fascinating array of specialized creatures. Many of these animals have shapes and colors that blend in with the sargassum. As I watched, a Portuguese man-of-war falls prey to a sea turtle. Groupers, snappers, jacks and barracudas are among the many fish that swam by in search of food.

On the bottom, amid the crabs, I saw a flounder or two moving. Occasionally, I saw some chunks of wood, bottles or a shoe. Barnacles are attached to large pieces of wood with snails and crabs nearby. The empty shells seem to be occupied by fish or crabs. I even found a young octopus hiding underneath. I saw a piece of rotting net. There are also the fragile white shells that have been cast away with mud crabs hiding underneath them. Fish moved around appearing to be as curious as I was. Moving to sea grass meadows, I saw a circular opening at the base of the grass. The shape of the opening gave away its identity; it was a glass jar. Looking inside, I saw a little toadfish. The jar was snuggled down in the blades of Gulf of Mexico sea grass. This jar looked more like a submarine forest. Every exposed surface had been used as a place to live.



Fronds of pale hydroids, small animals that look like flowing baby's breath, circled the rim of the jar. The shaded sides were covered with clusters of a tiny plant that looked like a string of pink crystal beads. Tube-dwelling polychaete worms shared space with bryozoans and orange sponge. A flat brown crab along with several crustaceans and a sea urchin were clinging to a patch of green algae. A forest covered the jar. I decided to leave the jar and its community of life. It appears that all human debris in the sea, like the jar, experiences a change into a miniature forest. As I paused to listen, I noticed that there are plenty of sounds ranging from subtle snaps and sizzles of small crustaceans to grunts, pops and hundreds of other variations produced by fish and marine mammals.

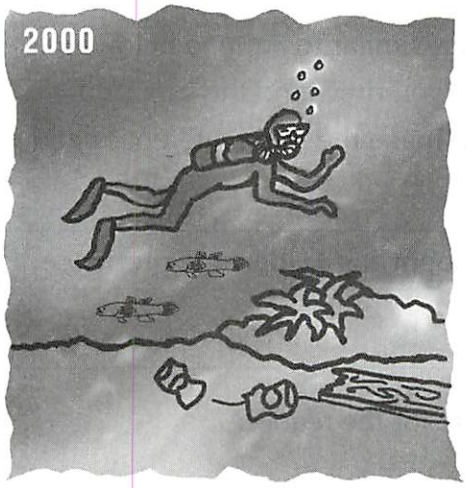
It was time to end the dive. I knew that I would be back to visit this beautiful and fascinating undersea environment again and again. As I surfaced, I noticed the pelicans silently gliding above the waves. Glancing toward shore I heard and saw a variety of birds as they searched for food from the sea.

2. Picture in your mind what you saw in the first dive and how you feel about what you saw. What are your feelings?

3. Now read your description of Dive Two.

Dive Two

It is 1997. You are returning to dive in the area where you picked up your first piece of flotsam, the glass jar. You had put it back when you saw that it was fine in its role as a toadfish house and a miniature reef. You are half hoping that you might find the jar again. However, storms and shoreline changes for marinas and human housing projects would make the chances of finding the jar very slim. As you dive, you notice that the water is a soup of saltwater, sediment and organic debris. An even greater problem is the challenge of identifying which of the many lumps on the soft bottom might be the jar. Visibility is limited. It makes it difficult to see the cabbage heads and Portuguese man-of-war as they float by. Periodically, fish swim into view. The fish are smaller and fewer in number than you remember. You wonder when you might see some of the larger groupers, snappers and barracudas among the fish swimming by.



The sea grass meadows are absent. You reach down to remove a barren polystyrene cup from the folds of the soft gray-brown mud. It occurs to you that *five centuries* from now another diver might find this same cup. As you slowly swim on, you notice more ocean debris:

cups, lids, straws, spoons, toys, rope, bags, fishing gear and more sharing the bottom with crabs. Periodically, you notice greenish-gold globules of oil and some black tar balls.

You pause to listen and notice that there are sounds, some quiet snaps, occasionally some grunts, pops and other variations. You notice that these sounds seem to disappear and the throb of engines or a low rumble of mechanical or electronic subsea thunder takes over.

It is time to end the dive. As you surface, you notice a lone pelican quietly flying above you. Toward the shore there are people and a few more birds. You wonder if you really want to return to dive here again.

4. What are your feelings after Dive Two? Why?

5. On a separate sheet of paper, create a box chart to compare and contrast information in the descriptions of the two dives.

Dive One – 1965	Dive Two - 1997

6. Use the information from the box chart to make inferences and draw conclusions. Support your conclusions with text evidence and experience. Prepare a table similar to the one below. Remember that each item in the table makes a connection between its row heading and the column heading.

Inferences	Conclusions	Supporting Evidence/Experience

7. Think about the future. What will it be like to dive into this area in the future, perhaps in 2015? Write your description of Dive Three.

8. Analyze your description of Dive Three. Create a box chart similar to the one below to list the inferences you made about the future, the conclusion you drew and the supporting evidence you provided in your description for a reader to make the same inferences and conclusions.

Inferences	Conclusions	Supporting Evidence/Experience

9. What feelings will your description of Dive Three generate for the reader?

13. What Are the Major Living Components of Marine Ecosystems?

Ecologist(s) _____ **Team** _____

The land and marine environment is composed of many ecosystems. An **ecosystem** is the interaction between: (1) **biotic** (living) components, which are the plants, animals and microorganisms; and (2) **abiotic** (nonliving) components—water, air, nutrients, minerals and solar energy.

Based on how they obtain food, living organisms in ecosystems are classified as producers, consumers or decomposers. Only producers make their own food. All other organisms are consumers that depend directly or indirectly on food made by the producers. **Producers** make their own food from compounds found in their environment using energy from the sun or chemicals. On land, most producers are green plants. In aquatic ecosystems, algae and plants are the major producers near the shorelines. The main producers in the open water are phytoplankton.

There are several classifications of consumers depending on their primary food source. **Herbivores** are primary consumers because they feed directly on plants. Meat eaters or **carnivores** are secondary consumers that feed on primary consumers (herbivores). Most secondary consumers are animals. Tertiary consumers feed only on other carnivores. Omnivores are consumers that eat both plants and animals.

Other consumers include detritivores, decomposers or scavengers that feed on dead organisms or their remains, which were either killed by other organisms or died naturally. Detritivores or detritus feeders feed on the parts of dead organisms, cast-off parts and wastes of living animals. Decomposers, mostly types of bacteria and fungi, are consumers that complete the final breakdown and recycling of organic matter. They breakdown dead organic matter to simple compounds and nutrients. The nutrients are released into the soil and water. Producers use them to make their food. You and your team are going to classify the marine organisms.

Materials: one marine organism card deck per group

Procedure:

1. Divide the marine organism card deck into two groups: producers and consumers. Which organisms are producers?

2. Construct a table similar to Table 1.

Table 1: Classes of Consumers

Primary Consumer	Secondary Consumer	Tertiary Consumer	Omnivore	Scavenger	Detritivore	Decomposer

3. Use the cards in the consumer group and divide them into the different classes of consumers: primary, secondary, tertiary, omnivores, scavengers, detritivores and decomposers. After you have grouped the consumers, list examples of each class in the appropriate column in Table1.

4. Select one of the primary consumers and explain why it is a primary consumer. Explain why primary consumers are herbivores.

5. Select a secondary consumer and use it to explain why they are secondary consumers and which level of consumers they eat. Explain why most secondary consumers are animals.

6. Can you think of any secondary consumers that are not animals?

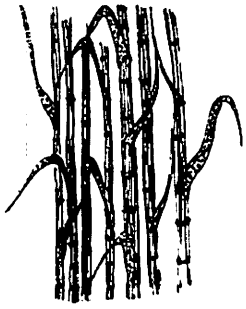
7. Select a tertiary consumer and use it to explain the characteristics of tertiary consumers, including the group that it eats.

8. Use an example of omnivore to explain the characteristics of this group.

9. Are some organisms members of more than one group? Explain.

10. Which level of consumers will have the greater chance of finding food? Explain.

11. Select one of the ecosystems from lessons 3-10 and identify the producers, the different levels of consumers, detritivores, decomposers, herbivores, carnivores and omnivores in the selected ecosystem.



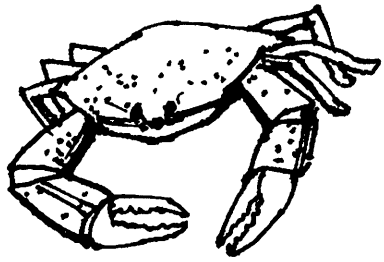
grass (cordgrass)

EATS:

plants make their own food

EATEN BY:

plant eating insects; crabs mice, rabbits



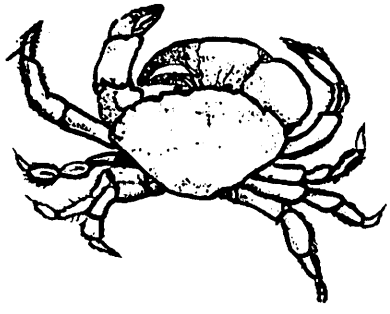
crabs filter feeders (porcelain)

EATS:

phytoplankton
zooplankton
detritus

EATEN BY:

shorebirds, swimming and diving birds, wading birds, crabs, turtle, flounder, fish-drums, trout, ray, otter



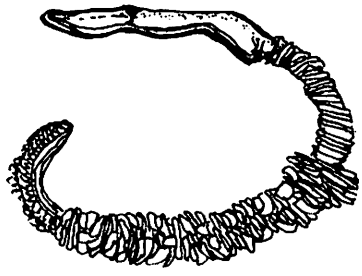
crabs (stone, calappa)

EATS:

oysters
barnacles
other crabs
clams
gastropods

EATEN BY:

crabs, ray
fish-drums, red-fish, otter, croaker, trout, flounder, turtle
wading birds, shorebirds, swimming and diving birds



marine worms (tubebuilding worms, parchment, scale worms)

EATS:

detritus
zooplankton
algae
detritus
phytoplankton

EATEN BY:

shorebirds
mollusk-murex
turtle
shrimp

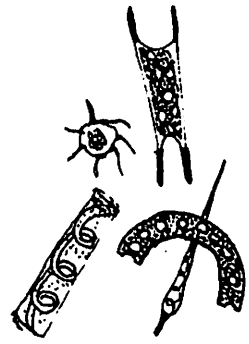
algae

EATS:

plants make their own food

EATEN BY:

marine worms, gastropods, fish, mollusks, waterfowl, filter feeders, deposit feeders



phytoplankton (diatoms)

EATS:

plants make their own food

EATEN BY:

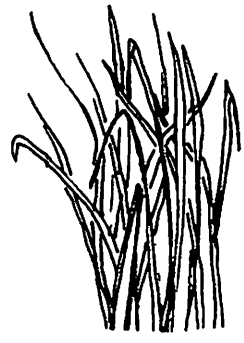
permanent zooplankton, temporary zooplankton, barnacles, marine worms, mollusks, crabs

whale (pilot)

EATS:

fish-mullet, drum, croakers, trout squid

EATEN BY:



grass (widgeon grass) (turtle grass)

EATS:

plants make their own food

EATEN BY:

plant eating insects; crabs, mice, rabbits

wading birds (heron, egret, ibis, cranes, spoonbill)

EATS:

shrimp
crabs
fish

EATEN BY:

alligator

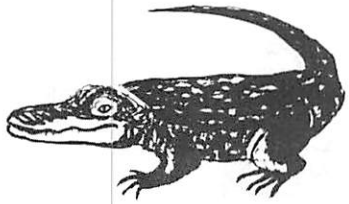
shorebirds (gulls, terns, sandpipers, plovers, turn-stones, surfbirds plalaropes)

EATS:

marine worms
pelecypods
shrimp
crabs
insects
fish

EATEN BY:

hawks, alligator, mink

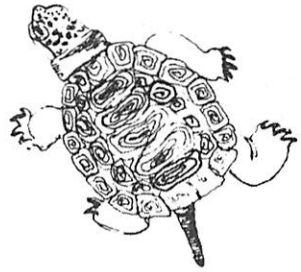


alligator

EATS:

fish
blue crabs
raccoon
muskrat
birds
turtle

EATEN BY:



turtle

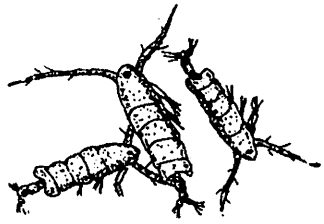
diamond back)

EATS:

grasses
mollusks
insects
crabs
worms

EATEN BY:

alligator



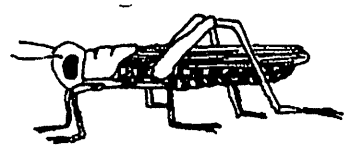
permanent zooplankton small crustaceans

EATS:

phytoplankton

EATEN BY:

temporary zooplankton, barnacles, mollusks fish-mullet oyster, sea perch



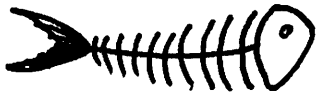
plant-eating insects (grasshoppers)

EATS:

grasses

EATEN BY:

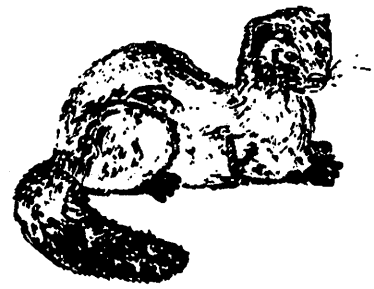
turtle, flying birds, seaside sparrow, shorebirds



death & decay

EATEN BY:

fiddler crabs, plant-eating insects, turtles mice, tiger beetles



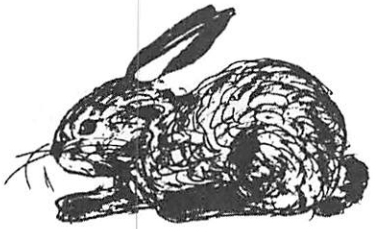
mink

EATS:

fish
clams
mussels
mice
muskrats
birds

EATEN BY:

alligator
hawk



swamp rabbits

EATS:

grasses

EATEN BY:

alligator
hawk

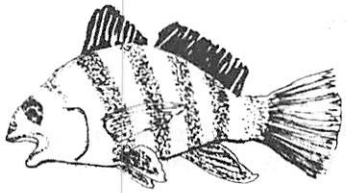
river otter

EATS:

fish
crabs

EATEN BY:

alligator



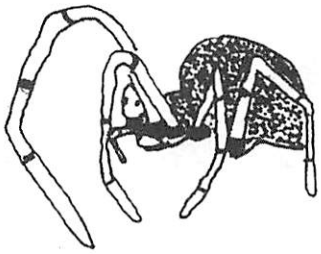
fish—
(drums, redfish, croakers, trout)

EATS:

shrimp
crabs
mullet
perch
mollusks

EATEN BY:

fish, dolphin, whale, otter



EATS:

plant-eating insects

EATEN BY:

flying birds, mice, seaside sparrow, shore-birds

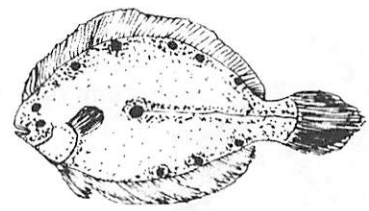
muskrat

EATS:

plants

EATEN BY:

hawk, mink, alligator



fish—flounder

EATS:

squid
shrimp
crabs
small fish

EATEN BY:

fish, shorebirds
dolphin, whale,
wading birds

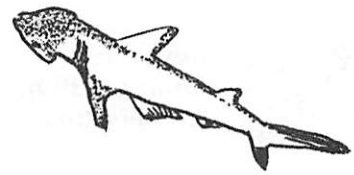
fish—redfish, snappers, jackfish

EATS:

shrimp
squid
crabs
mullet
perch
small fish

EATEN BY:

fish, dolphin, whale, otter, wading birds, shorebirds, swimming and diving birds



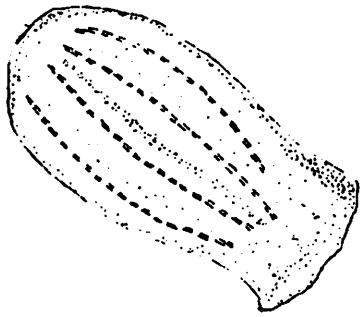
shark (shovel-nosed sand shark)

EATS:

crabs
shrimp
fish

EATEN BY:

other sharks



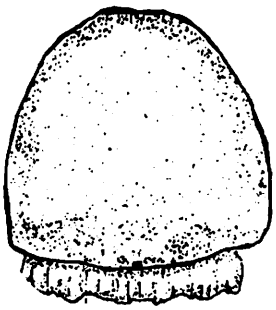
ctenophores (phosphorous jelly, sea walnut)

EATS:

temporary zooplankton

EATEN BY:

jellyfish
fish



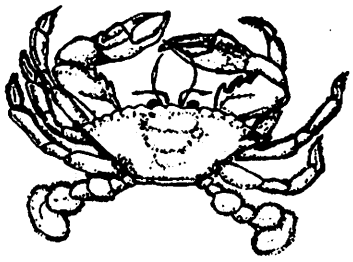
jellyfish

EATS:

filter feeders, temporary zooplankton, ctenophores

EATEN BY:

crabs



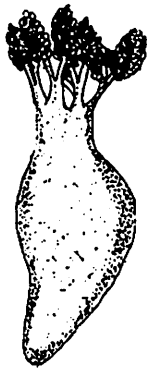
crabs—(blue, fiddler)

EATS:

detritus
grass shrimp
fish
crab

EATEN BY:

turtles, seaside sparrow, fish-drum, red snapper trout, redfish, otter, ray, sharks, flounder, wading birds, other crabs, shorebirds



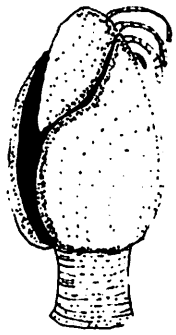
sea cucumbers

EATS:

detritus
plankton
algae

EATEN BY:

sea snails
melanella



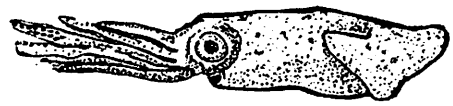
barnacles

EATS:

permanent
& temporary
plankton,
phytoplankton

EATEN BY:

mollusk
drill, whelk,
stone crab



squid

EATS:

small fish
shrimp

EATEN BY:

flounder
whale

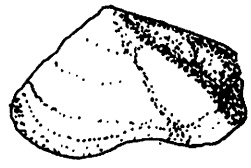
permanent zooplankton (protozoans)

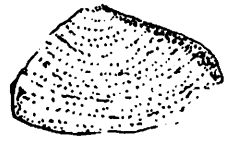
EATS:

phytoplankton

EATEN BY:

temporary zooplankton
phytoplankton
sea anemone
sea cucumber
marine worm
barnacle
mollusk
crab
oyster
certain fish





mollusk—pelecypod deposit feeders (macomas, clams, tellins)

EATS:

detritus
algae

EATEN BY:

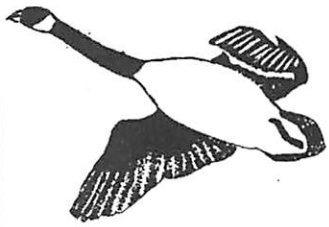
shorebirds, fish,
swimming and
diving birds,

bird (seaside sparrow)

EATS:

insects
crabs

EATEN BY:



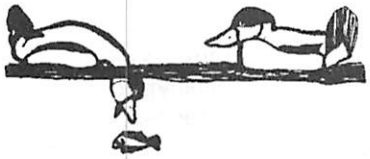
waterfowl (surface feeding ducks, teal, geese, swans)

EATS:

plants
detritus

EATEN BY:

hawks, mink, alligator



swimming and diving birds (sea ducks, stifftails, grebe, comorants)

EATS:

shrimp
crabs
mollusks
fish

EATEN BY:

hawks, mink, alligator

flying birds hawks

EATS:

plant-eating insects
birds
rabbits
mice
mink
muskrat

EATEN BY:

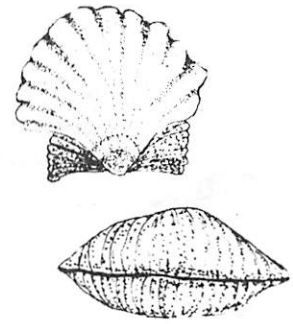
mollusks—gastropods (sea snails melanella)

EATS:

Portuguese-man-of-war,
jellyfish
sea cucumbers
sea anemones

EATEN BY:

fish, swimming and diving birds



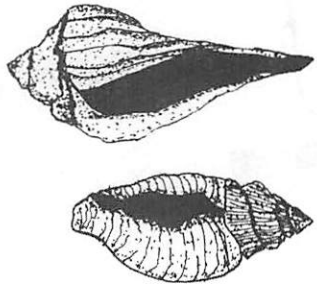
mollusk-gastropods, filter feeders (limpets, periwinkles, tegula slipper shell)

EATS:

algae
grass
phytoplankton
zooplankton

EATEN BY:

ray, turtle, salt-water perch, drum, red-fish, trout



mollusks—gastropods (moon shell bonnet, drill, conch, whelk, murex)

EATS:

oysters
clams
mussels
other bivalves
worms
barnacles

EATEN BY:

ray fish, turtles
stone crabs,
shorebirds,
swimming and diving birds

mollusks—pelecypods filter feeders (bivalves, clams mussels, scallops cockles, donax)

EATS:

algae
plankton
detritus

EATEN BY:

moon shell, mink, turtle, drill, whelk, crabs, drum-fish, shore-birds, s & d birds

mice

EATS:

grasses
plant-eating insects,
spiders
detritus

EATEN BY:

hawks, minks, muskrats

insects (tiger beetles)

EATS:

detritus

EATEN BY:

birds
mice

shrimp

EATS:

algae
small clams
marine worms
temporary zooplankton
small fish
other shrimp

EATEN BY:

squid, wading birds, shore-birds, diving and swimming birds, seaside sparrow, ray, saltwater perch, shark
fish-drum, red-fish, trout

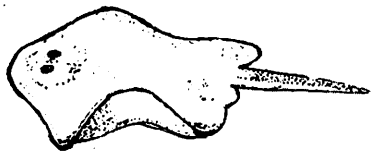
sea anemones

EATS:

small fish
zooplankton (permanent & temporary)

EATEN BY:

sea snails
melanella

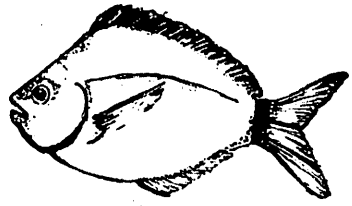


ray (stingaree)

EATS:

marine worms
mollusks
shrimp
crabs
plant material
detritus

EATEN BY:



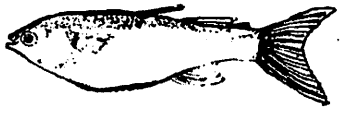
fish—saltwater perch or pinfish

EATS:

algae
plankton
small shrimp
crabs
mollusks

EATEN BY:

otter, redfish, dolphin, whale, redfish, snappers alligator, jack-fish, wading birds, swimming and diving birds, shorebirds



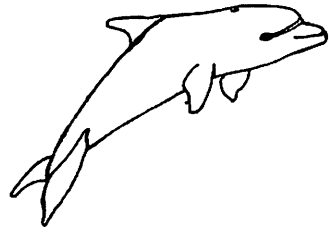
fish-mullet

EATS:

detritus
plankton

EATEN BY:

dolphin, otter, wading birds, shorebirds, swimming and diving birds, whale, fish-jack fish, drum, croakers, trout redfish, snapper

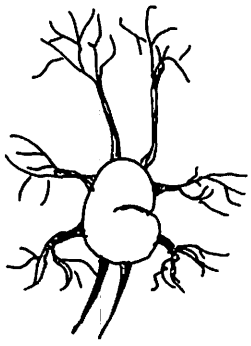


dolphin (bottle-nosed dolphin)

EATS:

fish-mullet
drum, croaker,
trout
flounder

EATEN BY:



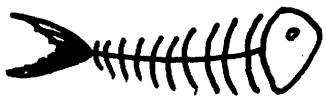
temporary zooplankton (larva of shrimp, oysters, mollusks, crab)

EATS:

phytoplankton
permanent zooplankton

EATEN BY:

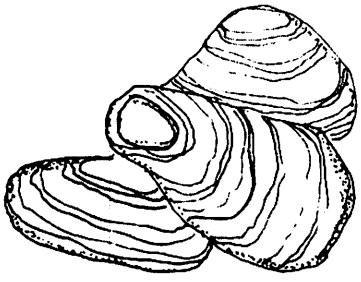
ctenophores
jelly fish
filter feeders
barnacle
mollusk
sea anemone
sea cucumber
marine worm
crab
certain fish



death & decay

EATEN BY:

fiddler crabs, plant-eating insects, turtles mice, tiger beetles



mollusk—pelecypod (oyster)

EATS:

detritus
diatoms
phytoplankton
zooplankton

EATEN BY:

drill, conch, crabs-stone blue fish-drum shorebirds swimming and diving birds

detritus (disintegrated plant and animal material)

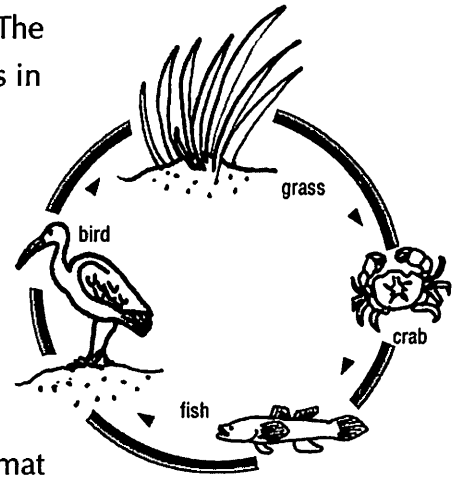
EATEN BY:

crab-filter feeders, waterfowl, mice, mollusk, fiddler crab, blue crab, tiger beetle, marine worms

14. How Does Energy Flow In Marine Ecosystems? Or Who's for Dinner?

Name _____ **Team:** _____

Energy or food is described as the money in ecosystems. The amount of energy or food controls the size of the populations in any ecosystem. All organisms, whether dead or alive, are potential sources of food for other organisms. The sequence of organisms, each of which is a source of food for the next, is called a food chain.



Materials: One set of marine organism cards per group

Procedure:

1. The cards can be used to build food chains in a game format or in a non-game format. If a game format is used, the number of players can be from 2 to 6.

2. How to play if a game format is used.
   - One person will be the dealer.
   - The cards are dealt to the players until each player has seven cards.
   - The cards are dealt face down.
   - The players may pick up and look at their cards as they are dealt.
   - The remaining cards are placed in a stack face down on the table.
   - A circle representing the sun is placed in the center of the table. It will serve as a base for the food chain that will be built.
   - The player to the right of the dealer plays first. The first player must place a card that uses the sun's energy to make its own food next to the sun. If the player does not have an organism that uses the sun's energy, then he or she must draw from the deck on the table until a card that can be played is drawn. If there are no cards left in the deck the player must pass.
   - If the player has a card of an organism that uses the sun's energy, it is placed next to the sun. (For example, grass or phytoplankton).
   - Play continues to the right. The second player can only play a card (for example, mice, plant-eating insect, etc.) that represents an organism that eats the organism (grass) on the first card played.
   - The third player can only play a card (for example, insect eating bird) that represents an

organism that eats the organism on the second card (insect). Play continues until no cards can be added to the food chain.

- When no more cards (organisms) can be added to the food chain. A second food chain can be formed. Play continues until no more food chains can be formed or all the cards are used.

3. Ecologists assign each of the organisms in a food chain to a feeding or trophic level depending on what it eats or breaks down. The first level is organisms that use the sun as a source of energy to make their own food. Look at your food chains. List the organisms that are in the first trophic level of your food chains?

4. Are they producers? Consumers? Or both? Explain.

5. Which consumers (primary, secondary, tertiary) make up the second trophic level in food chains?

6. Which class of consumers makes up the third trophic level in food chains?

7. Which trophic level are decomposers found?

6. What is the role of the decomposers?

7. Build the following food chains:
   a. Three links in the chain — a producer, consumer and decomposer
   b. Four links in the chain
   c. Five links in the chain
   d. Build three different chains using the same start and finish.

8. Select a food chain as an example and write a paragraph to summarize the pattern or sequence of energy flow in a food chain.

9. The energy flow in an ecosystem has been called the currency or money of the ecosystem. List how energy is like money.

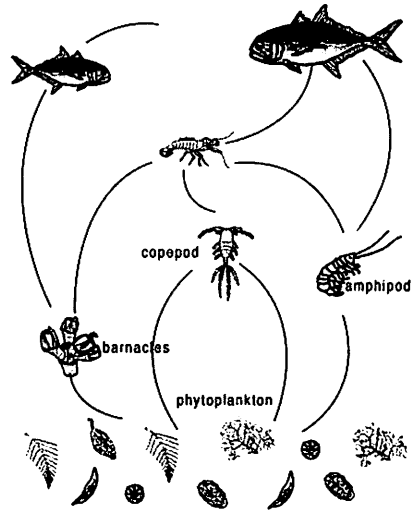
10. How is energy different from money?

11. Select an ecosystem from lessons 3 -10 and diagram three food chains found in the ecosystem.

15. How Does Energy Flow in the Ecosystem Food Web? Or Who Eats Whom?

Marine Ecologist(s) _____ **Team** _____

Energy flow in most ecosystems is a complex network. Most consumers feed on more than one type of organism and most organisms are eaten by more than one type of consumer. Because most organisms participate in several different food chains, the organisms in ecosystems form a complex network of interconnected food chains called a food web. You and your team members are going to investigate this interaction through a card game.



Materials: One set of marine organism cards for each group

Procedure:

Part I: What is the interaction of organisms in an ecosystem?

1. Your team will participate in a game using the marine organism cards to learn more about the energy flow in the ecosystem. Your teacher will set a time limit for the game because, like the food chain, the game could go on and on. Allow at least 20 minutes for the first game since it will take a few minutes to become acquainted with the rules. Three to six players per group.

2. How to play:
   - Deal all the cards face down. (Some players may end up with more cards than others.) Each player picks up his/her cards and looks at them. The first to play is the player to the right of the dealer. Do not show your cards to other players.
   - Player number 1 asks another player for a **showdown**. Both players place a card face down on the table, then turn the cards over at the same time.
   - Three actions are now possible:
     a. If player number 1's card represents an organism that eats the one on the other player's card, then player number 1 picks up both cards.
     b. If player number 1 plays a card representing an organism that is eaten by the organism on the other player's card, the other player picks up both cards.
     c. If neither organism eats the other, each card is taken back by the player who played it. This is a standoff. A standoff also occurs when both organisms eat each other.

- Now it is the turn of the player 2, who is to the right of player 1. Player 2 asks another player for a showdown.
- As the game progresses, the players will discover who holds certain cards. Then, rather than ask for a showdown, a player may **challenge**. In a **challenge**, the player asks another player for a card by naming the organism that his/her organism will eat. For example, "I want your oyster; my crab eats your oyster." The player challenging must show the card with which he is challenging.
- In a **challenge** the following actions can occur:
  a. If the player has the requested card he/she must give it to the challenger. The player challenging gets another turn for a showdown or challenge. As long as a player wins by challenge, that player continues to play. However, the challenger cannot use the same card consecutively.
  b. If the player did not have the card the player challenging asked for then the challenger must give his/her card to the player. Then it is the next person's turn.
- When a player is not sure who has certain cards, it is better to ask for a showdown.
- The **Death and Decay** card is very powerful. However its use is restricted.
- Death and Decay can be used as a challenging card only once during a player's turn.
- In a **showdown**, decay-consuming organisms provide a standoff with Death and Decay.
- In a **challenge,** the player challenging with a decay-consuming card wins the Death and Decay card.
- A player may capture only one Death and Decay card by challenging during his/her turn.
- When the time set for the length of the game expires; the player with the greatest number of cards is the winner.

3. Analyze the results of the game. Which organisms were more likely to be eaten? Why?

4. Which organisms were less likely to be eaten? Explain.

5. Which organisms eat dead and decaying materials?

Part II: How does a marine ecosystem food web work?

1. Your team can use the marine organism cards to build a food web.
   a. One person will be the dealer. The cards are dealt to the players until each player has seven cards. The cards are dealt face down.
   b. The players may pick up and look at their cards as they are dealt.
   c. The remaining cards are placed in a stack face down on the table.
   d. A circle representing the sun is placed in the center of the table. It will serve as a base for the food web that will be built.

e. The player to the right of the dealer plays first. The first player must place a card that uses the sun's energy to make its own food next to the sun. If the player does not have an organism that uses the sun's energy then he or she must draw from the deck on the table until a card that can be played is drawn. If there are no cards left in the deck, the player must pass.
f. If the player has a card of an organism that uses the sun's energy, it is placed next to the sun (for example, grass or phytoplankton).
g. Play continues to the right. The second player can play a card that uses the sun's energy or a card that (for example, mice or plant-eating insect, etc.) that represents an organism that eats the organism (grass) on the first card played.
h. The third player can play a card that is a producer, a primary consumer or a secondary consumer.
i. The web can be built by connecting cards up or down from the sun or branch off from the sides of cards. The organism that eats another is placed on the left of the card it eats or to the right of the card it is eaten by.
j. Play continues until no cards can be added to the food web.

2. Try to develop a web using all the cards. Use yarn or string to connect the cards to demonstrate that one is eaten by another.

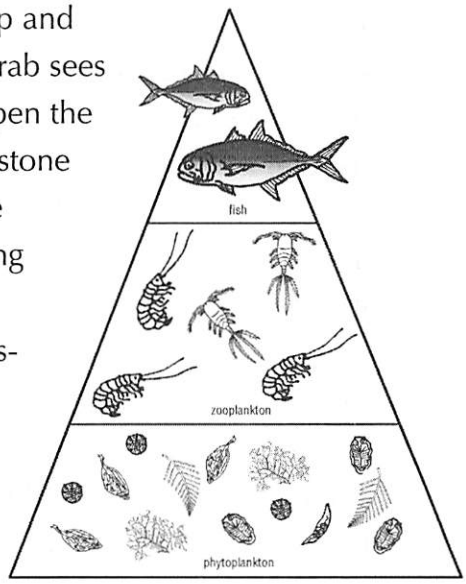
3. After your team has created a food web on the table with the cards, you can use this web to investigate the impact of various actions or "What would happen if . . .." to determine the impact of an action on the food web, remove the card of each organism affected. Some actions to investigate are:
   a. A herbicide (plant killing substance) is sprayed at the edges of the marsh or bay and runs into the water. What happens?
   b. Fertilizers wash from fields and lawns and build up in the marsh and bay. Organisms increase and die which lead to an increase of decomposers who use up the oxygen. What happens?
   c. Pesticide is used to kill insects. What happens?
   d. The crab population explodes. What is the impact?
   e. Humans are added to the food web. What is the effect?

4. Create your own situation to illustrate. What is the situation? What is the impact?

5. Use one of the ecosystems from lessons 3-10, create its food web.

16. How Much Energy Is Needed to Make a Dolphin?

Biologist _____ **Team** _____



In a salt marsh community, the marsh perwinkle moves up and down the cordgrass as it grazes on plant matter. The stone crab sees the perwinkle, it grabs the mollusk in its claws and cracks open the shell. The perwinkle becomes lunch for the stone crab. The stone crab is suddenly grabbed by a fish. The fish does not see the heron. The heron strikes. The fish becomes a meal. The young heron becomes careless. Suddenly it is in the grasp of an alligator. Eventually the alligator dies and decays. Decomposers use the alligator for their meal. The chain of events described can be described in a food chain. A **food chain** shows how energy is passed from one organism to another. The energy first comes from the sun and is trapped by the plants.

In the marsh community, you find only a few alligators. In order for the alligators to survive, they need to eat a large number of other animals. A **food pyramid** shows the amount of energy that is passed from one organism to another in a community. The base of the pyramid is made of the producers. Each feeding level or trophic level in a food chain or food web is made of a certain amount of organic matter or organisms. There are fewer organisms in each level of the pyramid. This is because not all the energy is passed from one level to the next. In nature, the losses vary from 80 percent to 95 percent. You are going to use a simulation to investigate this in a food chain.

Materials: Each group will need a set of the cards and a die

Procedure:

1. The purpose of this simulation is to create a dolphin using the following food chain: diatoms, copepods, oyster, crab, fish and dolphin. Each feeding level (trophic level) of the chain represents a different amount of food materials or energy. Since only 10 percent of the energy at each level is used to build the organism at the next higher level, it will take 4,000,000 pounds of diatoms, 400,000 pounds of copepods, 40,000 pounds of oysters, 4,000 pounds of crabs and 400 pounds of fish for one 40-pound adult dolphin. The rules for the simulation are:
   a. Two or more can play.
   b. One player is chosen to keep score and to hand out the food chain cards.

c. Each player will roll the die. The player with the highest number starts. The next player is the one to the left.
d. Each player begins with a diatom card.
e. Players move through each link of the food chain by collecting the amount of weight written on the cards.
f. Each card gives the value of the units on the die. A two on the die equals 2 units' times the value of a unit on the food chain card. For example, a diatom card would be 2 (on the die) x 100,000 (unit on the card) or 200,000 pounds. The player would have to wait another turn to roll again before receiving the copepods card. He will need 400,000 or more to get the copepod card.
g. If a player rolls a six on the die, their organism dies before being eaten. They will have to go back to the beginning of the food chain. They will begin with the diatom card.
h. As each player reaches or passes the amount written on the food chain card, he/she trades the card with the scorekeeper for the next card in the chain.
i. The first player to move through the entire food pyramid to the dolphin wins.
j. Each player is allowed only one roll of the die at a time.

2. Complete the simulation game at least twice. Use what you observed in the simulation to analyze what happens.

3. Which organisms in the pyramid have the largest numbers? Are they consumers or producers?

4. Organisms at which level require the most energy? The least energy?

5. Why are so many pounds of organisms needed to produce one adult dolphin? Explain.

6. In what ways is the energy lost in the transfer from one level to another?

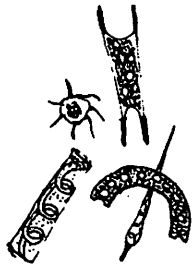
7. If you wanted to feed fish efficiently in your mariculture ponds would you feed them a first order or second order consumer? Explain.

8. With more and more people being born all the time, what must happen to the bottom of the food pyramid? Explain.

9. Which is more efficient for people to eat, plants or animals? Explain.

DIATOMS

This card represents tiny sea plants (phytoplankton). It takes four million pounds of phytoplankton to make a dolphin.



Each equals 100,000 pounds.

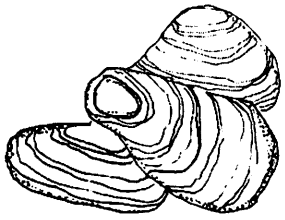
COPEPODS

This card represents tiny sea animals (zooplankton). Ity will take four hundred thousand pounds of zooplankton to make a dolphin.

Each equals 10,000 pounds.

OYSTER

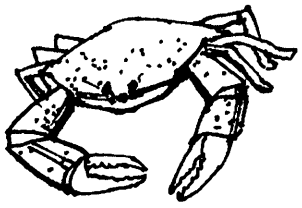
This card represents the oyster. It will take forty thousand pounds of oysters to make a dolphin.



Each equals 1,000 pounds.

CRABS

This card represents crabs. It will take four thousand pounds of crabs to make a dolphin.



Each equals 100 pounds.

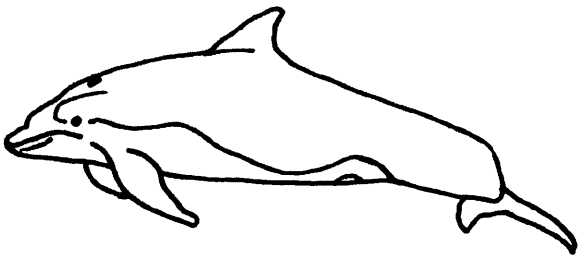
FISH

This card represents free-swimming fish. It will take four hundred pounds of fish to make a dolphin.

Each equals 100 pounds.

DOLPHIN

This card represents one 40-pound dolphin.



10. When people eat fish, the food chain is algae, zooplankton, a small fish, a larger fish and people. What would be the impact of people feeding algae and plankton to cattle and then eating the beef?

11. With our continually increasing population should we consider using seaweeds and algae (algae flour, seaweed salads, casseroles, soups, cookies, etc.) as food for people? How would this affect the food pyramid? Explain.

12. Use one of the ecosystems from lessons 3-10 and diagram its food pyramid.

Topic 13 — Marine Organisms and Resources

Topic 13 — Marine Organisms and Resources

The ocean covers more than 71 percent of the earth's surface and forms the largest habitat on Earth. It is home to a tremendous variety of living organisms that are adapted to the special conditions of the sea. However, it is thought there are about one million different species of animals on the planet but only 16 percent of these live in the marine environment. With more exploration of the ocean habitats this estimate may change. Within the marine environment, only about two percent live in the open ocean. The rest of the animals live on or near the seabed with a large proportion living on coral reefs. The sealife living on or close to the bottom of the abyss is even more remarkable in its diversity. The estimates of undescribed species range from many thousands to millions.

All organisms exhibit adaptations for survival. The ecological stresses impact the structures of the organisms, communities and ecosystems. Ecological adaptations can be grouped as:

1. Adaptations to accommodate the physical and chemical environment.
2. Adaptations for obtaining food and avoid being food.
3. Adaptations to ensure successful reproduction.

An organism's survival depends on the success of its adaptations. Analysis of each organism's adaptations to its environment is important to understanding the ecosystem.

The activities in this unit may be integrated with the activities in Topic 11: The Interaction of Marine Organisms and the Physical Environment and Topic 12: Marine Environments of Texas and the Gulf of Mexico.

Activity 1. Why Are Phytoplankton So Small?

TEKS: Science: 6.2,7.2,8.2,6.3,7.3,8.3,6.4,7.4,8.4,6.8, 6.10,6.12,7.12,8.12

Math: 6.8,7.9,8.8

Language Arts: 6.9,7.9,8.9,6.10,7.10,8.10

Social Studies: 6.6

Learner Outcomes: After completing the activities, the student will be able to:

- compare and contrast the various phytoplankton
- infer why the size of phytoplankton is an advantage
- infer factors that might limit the growth of plants in the oceans
- conduct an investigation to determine if cell size is a factor
- conduct an investigation to determine if the ratio of cell surface area to volume is important
- evaluate the impact of a decrease in the phytoplankton population

Background:

1. The dense fluid environment of marine organisms enables the existence of very small phytoplankton. They, in turn, influence the general pattern of all other forms of marine life. These features differ greatly from the patterns of life in terrestrial communities. Much of the special nature of life in the sea is due to the smallness of the phytoplankton. They are found throughout the photic zone of the marine environment and account for the major share of primary productivity. Only in the last few years has it been possible to collect representative samples of the exceptionally small picoplankton and ultraplankton. They were too small to be collected in nets or observed under regular microscopes. With improvement in sampling and microscopic techniques, more small phytoplankton are being recognized as important critical contributors to many marine communities. Ask the students to discuss the implications if there were no cyanobacteria or phytoplankton.
2. The success of phytoplankton depends on their ability to obtain sufficient nutrients and light energy. One of the most important features of all phytoplankton is their size. Their size enables the exchange of nutrients and wastes by diffusion across the cell membrane. The ability of the phytoplankton to satisfy their material requirements is a function of the ratio of cell surface area to cell volume. The higher surface area to volume ratio enhances the exchange between the external and internal environment.
3. To determine if cell size is a factor, make a transparency of graph paper. Place the transparency on the paper towel to measure the area of the towel and the area of diffusion. A drop of food coloring may also be placed at the edge to determine the diffusion of nutrients from the outside environment reaching to all parts of the cell.
4. In using cotton balls to demonstrate the importance of ratio of cell surface area to volume, make sure that the cotton balls are 100% cotton. If they are not 100% cotton, the dye is not as easily absorbed.
5. Many phytoplankton cells have complex *shapes* that increase the surface area without increasing the volume. The cell shapes look like ribbons, leaves, bars, long strings, or they may have

bristles or spines to increase the surface area to volume. These help increase diffusion and provide frictional resistance to sinking. Ask the students to use drawings and measurements to demonstrate how these shapes increase the surface area to volume ratio. Some cells are larger but have vacuoles that are filled with seawater. Ask the students to use illustrations and graph paper to illustrate how this is also effective in increasing the surface area to volume ratio.

Activity 2. Why and How Do Marine Plants (Phytoplankton) Float?

TEKS: Science: 6.2,7.2,8.2,6.3,7.3,8.3,6.4,7.4,8.4,6.8, 6.10,8.5

Language Arts: 6.9,7.9,8.9,6.10,7.10,8.10

Social Studies: 6.6

Learner Outcomes: After completing the activities, the student will be able to:

- compare and contrast land and marine plants and their environment
- predict how the shape of marine plants is an adaptation to the water environment
- construct models of marine plants and test their floating ability of each design
- construct models to determine the effect of surface area to volume ratio on floatability

Background:

1. Phytoplankton are generally slightly denser than seawater because of dense cell walls. They have little or no ability to propel themselves and must depend on the ocean's surface currents for movement. Ask the students to predict how these organims might extend their time in the photic zone.
2. The phytoplankton have designs that enable them to slow their sinking rate and keep them moving through the photic zone. Their shapes increase the frictional resistance as they move through the water by increasing the surface area to volume ratio. Have the students use information from Activity 1 to design various shapes to test the floating and sinking of the various shapes.
3. Point out that some cells reduce their sinking rates with horns, wings or other cellular projections. Others have shapes that result in zigzag or long spiral paths down through the water column. Some have shapes like leaves that create a "falling leaf" pattern that keeps them in the photic zone for a longer period of time. Some cells produce fats and oils that help slow their rate of sinking. Others have gas-filled vacuoles to provide for floatation. Encourage the students to develop models to demonstrate the effectiveness of these adaptations.

Activity 3. What Are the Marine Plants and How Are They Adapted to a Marine Life?

TEKS: Science: 6.2,7.2,8.2,6.3,7.3,8.3,6.4,7.4,8.4,6.8,6.10,7.12, 7.14,

Language Arts: ,6.10,7.10,8.10,6.13,7.13,8.13,6.20, 7.20,8.20

Social Studies: 6.7

Learner Outcomes: After completing the activities, the student will be able to:

- compare and contrast land plants and marine algae and sea grasses
- construct a model of marine algae and sea grasses to illustrate their adaptation to the marine environment
- infer why marine plants (sea grasses) may have been land plants
- construct a model of sea grasses to demonstrate how sea grasses stabilize an area
- Analyze the factors that affect the type and abundance of algae in an area
- cite evidence to support the idea that sea grass beds are critical to the coastal zone and that human activities are impacting the sea grass beds

Background:

1. Algae or seaweeds are not as complex as flowering plants. They lack roots, flowers, seeds and true leaves. However, they still have a variety of sizes, shapes and complex structures. Many of the larger members of seaweeds develop into plants that have a blade that is usually a flattened broad leaflike structure. The blades often branch. The blades have the photosynthetic cells but photosynthesis can also occur in the stipes and holdfasts. Both sides of the blades are capable of absorbing light and are exposed equally to sunlight, nutrients and water. There is no top or bottom. The blades are flexible and droop in the water or float erect. Several species like kelp and sargassum have pneumtocysts or gas-filled floats. The Sargassum forms large patches of floating plants that serve as the basis for a community. The flexible, stemlike stipe serves as a shock absorber and bends with the waves without breaking. The holdfast often resembles root systems of land plants. However, the basic function of the holdfast is to attach the plant to the substrate. The holdfast is adapted to the substrate and holds the plant to the substrate in spite of the pull of wave surges

and tidal currents. Some small red algae are epiphytes and attach themselves to other marine plants.

2. Until the construction of the jetties and groins, macroscopic marine algae were not found on the Texas shores. The construction of the jetties and groins has provided a habitat for algae and greatly increased the algae of the Gulf. The algae have provided nutrients and support a group of herbivores and a community. Red algae are the most diverse group on the Texas jetties, but certain species of green may be seasonally dominant. The number of algae increases toward the southern shores and they change in composition. The temperate algae are found along the northern shores and the tropical in the southern shores. The algae vary with the latitude and the zone of the rocky shore. About 200 species of algae have been described from the Texas and adjacent Gulf states shores.
3. Marine flowering plants or seagrasses are abundant with at least 90 percent of the southeast United States seagrass beds existing in the Gulf of Mexico. Seagrass beds are among the most productive marine plant communities. They are important not only in the biomass that is produced but the vast majority of commercial and recreational fish that spend some part of their life in seagrass beds. The seagrasses also provide a habitat for other wildlife such as birds, green turtles and manatees.
4. Seagrasses produce roots and horizontal stems or rhizomes. From the buried rhizomes, the plant may produce leaves to develop masses of vegetation. This helps the plants bind shallow underwater sediments and slow waves and currents. This traps fine particles in the water column to provide a natural and highly effective water column cleansing system. Have the students create a model to demonstrate the impact of the seagrasses in creating a nutrient rich environment as they cleanse the water.
5. Seagrass losses in the Gulf can result from the life history of the grasses, physical disruption from storms, hurricanes and shifting channels or seasonal low tides. Disturbances from burrowing organisms or overgrazing by herbivores (urchins, manatees, turtles) can affect the beds. Human interaction can cause additional losses. This includes dredging, boating (propellers damage grasses), increased turbidity of water, excess suspended solids and nutrients in the water, thermal effluents and dredge and fill. Discuss how each impacts the seagrass beds. Ninety percent of the seagrass in Galveston Bay have been lost. Ask the students to discuss the impact of no sea grasses. Include in the discussion, the impact of the loss of seagrasses (increase in erosion, turbidity, loss of habitat of marine organisms, impact on wildlife and fisheries, water is no longer naturally cleaned before it enters the Gulf, etc.).
6. For additional information on plants and animals of sea grasses, visit: http://www.pcug.org.au/-dfry/amanda/sgorgnsm.htm Discuss ways to prevent the loss of seagrasses.
7. Discuss the planting of seagrass to stop and reverse habitat losses. This is a priority of the National Wetlands Policy Forum. For additional information obtain: A Guide to Planting Seagrasses in the Gulf of Mexico by Mark S. Fonseca, Texas A&M University Sea Grant College Program, TAMU-SG-94-601.

Activities 4, 5 and 6

Activities 4, 5 and 6 are designed to motivate and interest students in studying alga and to inform them about the value of seaweeds or algae as a resource. If time is a problem, introduce each activity to the class then divide the class into three groups. Assigned each group one of the surveys from activity 4, 5 or 6 to conduct. After the survey data is compiled, analyzed and discussed as a class, assign each group a topic for an information brochure or article for a newspaper to inform the public about seaweeds or algae as an important natural resource in their daily lives.

Activity 4. Have You Eaten Seaweeds (Algae) This Week?

TEKS: Science: 6.8, 7.12

Language Arts: 6.11,7.11,8.11

Learner Outcomes: After completing the activities, the student will be able to:

- gather and interpret data on the uses of seaweeds in foods and drinks
- evaluate the importance of algae in food products
- analyze reasons for not eating algae plants

Background:

1. To motivate and interest students in algae, ask the students if they would eat algae. Discuss why or why not? Provide each student with a copy of the checklist. Ask the students to complete the checklist. Discuss and analyze the results.
2. To help to understand the role of algal extracts, compare "homemade" ice cream with ice cream that is purchased in a store. Focusing on how they differ in melting rate, texture, etc. The difference is the result of the addition of algal extracts to the manufactured ice cream.

Activity 5. How Are Seaweeds (Marine Algae) Used?

TEKS: Science:6.9

Math: 6.8,7.9,8.8

Language Arts: 6.13,7.13,8.13,6.20,7.20,8.20

Social Studies:6.7,7.10

Learner Outcomes: After completing the activities, the student will be able to:

- compare the use of land plants and seaweeds
- conduct a survey to analyze the importance of alga in people's lives
- analyze data on the use of seaweed.
- prepare a brochure summarizing the importance of seaweeds in people's lives

Background:

1. This activity can serve as an introduction to study algae to motivate and interest the students. After the brainstorming, provide each student with a copy of the survey to use in interviewing their family and others. Analyze and evaluate their findings. Discuss how knowledgeable people were about their use of seaweeds in their lives.
2. Encourage the students to use the reading "Uses of Seaweeds" and the internet to prepare an informational brochure to educate the public about the importance of seaweeds or alga as a renewable resource.

Activity 6. Are They Seaweeds or Sea Vegetables?

TEKS: Science: 6.10

Language Arts:6.11,7.11,8.11,6.10,7.10,8.10,6.20, 7.20,8.20

Social Studies:6.1

Learner Outcomes: After completing the activities, the student will be able to:

- conduct a survey to analyze seaweeds/algae as a food source in people's lives
- analyze data on seaweeds as a food source
- prepare a brochure summarizing the importance of seaweeds as food

Background:

1. To introduce the lesson, obtain marine algae or foods made of algae. These are available in grocery stores serving Asian communities. Do not tell the students that the foods contain seaweeds. Provide bite-size pieces of the different food items for the students to sample. Label the samples with numbers. Ask the students to number their papers and rate each item as they taste it. Remind them to do this quietly so their reaction to the food item does not influence others. Then analyze which items they liked or did not like. Not all students will like the same items since each individual's taste buds differ. After the discussion, point out that all the items contained algae and their taste varies. To reinforce this idea, ask the students which vegetables they like or dislike — including, for example, spinach, broccoli, cucumber, onions, etc. Some will like each one and others will not.
2. Ask the students to infer as to why marine alga are referred to as seaweeds. Ask the students to define "vegetable" and to give examples of vegetables. Broadly it can mean any plant. More specifically, any plant that is eaten whole or in part, raw or cooked, generally with an entrée or in a salad but not as a dessert is considered a vegetable. Ask if they agree or disagree with the statement that seaweeds are sea vegetables and to provide evidence to support their response.
3. Discuss the reading "Algae as Food—Past and Present " and "Sea Vegetables and Nutrition" from Activity 7 before having the students prepare a brochure to inform the public about algae as a food.

Activity 7. Are Seaweeds Good for You?

TEKS: Science: 6.2,7.2,8.2,6.3,7.3,8.3,6.4,7.4,8.4 ,7.12

Math: 6.8,7.9,8.8

Language Arts: 6.10,7.10,8.10,6.11,7.11,8.11,6.13,7.13,8.13, 6.20,7.20,8.20

Learner Outcomes: After completing the activities, the student will be able to:

- conduct experiments to determine the nutrients found in marine algae
- analyze and summarize the results of testing algae for nutrients
- interpret data on the chemical composition of seaweeds.
- evaluate algae as a source of the minimum daily requirements of vitamins and minerals

Background:

1. Ask the class to bring in food labels and compare the nutritional value. Ask students to make inferences about the nutritional value of algae. Have them predict whether starch, glucose, fats and protein will be found in algae.
2. Conduct the tests on the algae samples to determine the presence of various nutrients. If the

algae used is dehydrated, rehydrate the algae. Discuss the results.

3. Analyze the data in the table: Chemical Composition of Seaweeds. Ask the student for explanations about why algae have a high nutritional value.
4. Discuss why marine algae are among the most nutritious plants on earth since they grow in seawater. Seawater has more than 50 elements dissolved in it. Elements available to algae from the seawater are much greater than those available to land plants. In addition land plants use up the elements in the soil. All soils differ in the availability of minerals, however, seawater contains the same elements that are always available to the plants.
5. Discuss why people are not willing to eat marine algae. Discuss ways to change this. What might be done to change the marine algae from seaweeds to being recognized as highly nutritious sea vegetables. Encourage students to plan ways to inform people about sea vegetables. This might include brochures, newspaper articles, radio and TV programs or ads.
6. Discuss the mariculture of marine algae as a source of food for people and animals. Have the students list the pros and cons of farming marine algae to feed the world.

Activity 8. Who Are the Zooplankton and How Do They Get Their Food?

TEKS: Science: 6.8,7.9,8.8

Math: 6.8,7.9,8.8

Language Arts: 6.10,7.10,8.10,6.11,7.11,8.11

Learner Outcomes: After completing the activities, the student will be able to:

- make inferences about the adaptations of zooplankton
- explain the variety of adaptations that zooplankton use to obtain food
- explain the mechanism for keeping the phytoplankton in balance
- interpret the data on the vertical migration if zooplankton

Background:

1. Stress that in the pelagic division of the marine environment, life exists in a three dimensional, nutritionally dilute medium. The distribution of animals in this zone reflects on their nutritional dependency on the primary producers of the sea. Like the primary producers (phytoplankton) of the sea, the pelagic animals are concentrated in regions of updwellings over continental shelves and other shallows, and anywhere in or near the photic zone. At greater depths, population densities decrease rapidly, but animal life never completely disappears. The animal counterpart of the phytoplankton are the zooplankton. The animals of the pelagic zone include the zooplankton and nekton. Most of the nektonic animals begin life as zooplankton. As the zooplankton grow and develop their swimming ability, they graduate to the status of nekton. The zooplankton consist of temporary zooplankton, the meroplankton which include the larval stages of shallow-water invertebrates and fishes and a variety of permanent planktonic forms, the holoplankton. There are more copepods than any other kind of zooplankton and they dominate nearly all the oceans.
2. Because of their small size, the permanent zooplankton have difficulty overcoming the forces between the water molecules by swimming. They use flotation and bouyancy devices like the phytoplankton. They increase their frictional resistance to the water by having high surface area to body volume ratios. They may have spines, hairs, wings and other surface extensions to increase their resistance to sinking. Some even secrete gases into a float.
3. Discuss how the feathery antennae of the copepods help detect food particles in the water and how the filtration appendages direct the phytoplankton to the mouth region. Stress the importance of the copepods feeding on the more abundant size of phytoplankton and shifting to another food source when concentration of one decreases in order to maintain a balance. In the open ocean the food chain may have six tropic levels. The nanoplankton (phytoplankton) are eaten by microplankton or protozoa. These, in turn, are eaten by macroplankton like the copepods. The copepods are eaten by megazooplankton, and these are eaten by planktivorous fishes or baleen whales. The zooplankton are the source of food for the baleen whales.
4. One of the most interesting aspects of marine zooplankton is their daily vertical migration. Depending on the size and type of zooplankton, these vertical movements can vary about 400-1000m over a 24-hour period. Many of these vertical migrations follow a similar pattern. During the daylight hours, the zooplankton are relatively deep in the water column. As darkness begins, they migrate to the surface waters. At night they will move horizontally to feed. Just before dawn they descend to a certain depth in the water column. It is believed that the migration occurs to enable more effective feeding on phytoplankton, to help escape from surface

predators during the day, to decrease metabolic activity in the cooler depth and to provide better dispersal through water movement. For a 1mm copepod to swim from 450 to 150 meters below the surface compares to a swimmer swimming around 625 miles a day. A 1 mm copepod is capable of swimming at 50m/b or 14 body lengths per second. Olympia class swimmers can swim at a speed of 1.6 body lengths per second. They are also swimming through water that seems like molasses to a copepod.

Activity 9. What Is So Unusual about Coral and the Coral Reef?

TEKS: Science: 6.12,7.11,7.12,7.14,8.14,6.8,6.10

Math: 638,7.9,8.8

Language Arts:6.9,7.9,8.9,6.10,7.10,8.10,6.13, 7.13,8.13, 6.20,7.20,8.20

Learner Outcomes: After completing the activities, the student will be able to:

- formulate hypotheses as to why coral reef ecosystems have few plants and large numbers of animals
- explain why coral reefs are in specific locations
- explain the sequence of coral reef formation
- explain the relationship of coral, zooxanthellae, and sea urchins in the coral reef community
- predict what will happen to a coral reef if the water temperature, turbidity, or nutrients in the water change

Background:

1. In studying the Phylum Cnidaria use the Class Anthozoa, corals and sea anemones as examples. Note that not all reefs are formed by corals. Some reefs are formed by oysters, annelid worm tubes, red algae, barnacles or even cyanbacteria. Not all corals form reefs. Coral reefs are formed by a particular species of coral that secretes calcium carbonate that forms the matrix of coral reefs.
2. Ask the students to list what they know about coral reefs. Ask each group to list what they would like to know about coral reefs. Then present the information in the introduction and in numbers 1-10 to the students. Ask each group to use the information in the lesson to develop a hypothesis to explain why the coral ecosystem appears to have very few plants and a great number of animals. Ask them to hypothesize why corals are located in tropical and subtropical latitudes in clear water within 25 to 70 meters of the surface. Have them search the internet for data to support or refute their hypotheses.
3. The growth of corals is affected by the light intensity (which is affected by water motion, depth, turbidity and sedimentation), day length, water temperature, plankton concentrations, predation and competition from other corals. Coral reefs are restricted to tropical and subtropical waters (usually below 30°). They thrive in normal salinity and in clear water within 25-70 meters of the surface. Reef forming coral may only thrive in warm waters because of the high rates of calcium carbonate deposition needed for reef building. Corals also face competition from macroalgae that grow in increased nutrient concentrations, decreased water temperatures and decreased grazing pressure. They cannot tolerate low salinity so do not grow where rivers and freshwater runoff also increase sedimentation.
4. Reef forming corals have masses of symbiotic, zooxanthellae, unicellular algae that require light for photosynthesis. The concentration of these algae may be a million cells per square centimeter of coral surface. They also give the coral their color. The differences in color are due to the concentrations of photosynthetic pigments. The zooxanthellae have a mutualistic relationship. The corals provide the zooxanthellae with a constant protected environment and nutrients (carbon dioxide, nitrogen and phosphate wastes from cellular respiration of the coral). The coral receives the photosynthetic products of oxygen and energy rich organic substances from the algae. The zooxanthellae produce 10-100 times more carbon than they need and this is transferred to the coral. Therefore the coral are able to construct large reefs in phytoplankton poor waters because they receive their food supply from the zooxanthellae. Coral polyps are still able to prey upon zooplankton. Coral with large polyps feed upon larger zooplankton (copepods, amphipods and worms) and small fish. Coral with smaller polyps feed on small plankton and detritus particles. It also appears that nitrogen fixation has been found to be associated with bacteria living in the skeleton of corals. Stress that the living richness of coral reefs is in direct contrast to the generally unproductive surrounding ocean water. The relationship of producers and consumers on the reef is largely unknown. The coral reef is a highly efficient ecosystem that is able to recycle the limited supply of nutrients.
5. Ask for predictions about the impact of the following on the coral reef: increase in nutrients, increase in algae growth, increase in coral reef grazers such as the sea urchin or a decrease in any of the above. An increase in nutrients can result in an increase in algae that dominates the coral. Grazers keep the algae growth down.
6. All the coral polyps that make up a colony are

interconnected and are covered by a thin sheet of tissue. Stress that touching a living coral colony in any way can easily crush the tissue against its own skeleton and leave the colony open to infections.

7. Many corals spawn synchronously just several nights after the full moon. It is unclear why the mass spawnings are multispecies events.
8. Discuss the variety of factors that can cause the death of the coral reefs. One common natural cause is storm waves from hurricanes and typhoons. Another is an outbreak of predators like the coral-eating sea stars. This outbreak is linked to the disappearance of the major predator of the sea stars, a large and beautiful snail that has been nearly exterminated by shell collectors. Sudden outbreaks of pathogens can result in high mortalities of corals, either directly or indirectly. A waterborne pathogen killed large numbers of black sea urchins, which are algal grazers, in the Caribbean Sea so the algal populations overgrew the corals. Also pathogens can invade the coral's tissue and kill the coral. Physiologically stressed corals expel their mutualistic zooxanthellae. This results in a whitening or bleaching of the coral colony and its death. The bleaching events have been correlated with increased sea temperatures. Increased sedimentation and nutrification of surrounding waters can also destroy coral colonies. In some areas, divers toss explosives or squirt illegal and deadly cyanide to stun and net fish to sell for aquariums. This kills coral and fish. The once high fish yields of American Samoa's reefs have declined by 70 percent in recent years primarily due to overfishing, pollution and sediment runoff. All animals in the ecosystem are affected, not just the coral.
9. There are indications that more than one-fourth of the world's coral reefs have been destroyed by pollution and global warming. If water temperatures continue to rise, some predict that all coral reefs will be destroyed. Coral reefs, some of which have been alive for up to 2.5 billion years, play a crucial role as an anchor for marine ecosystems. Discuss the impact of the loss of the coral reefs on fish species and other marine life. The loss of the reefs will also threaten the livelihood of a half billion people around the world. The reefs bring in an estimated $400 billion a year in fishing and tourism revenues around the world. Discuss why the coral community is an excellent indicator of the health of the entire reef ecosystem and why "Corals are like the carnary in a coal mine."
10. Resources: Doubilet, D."Coral Eden" and Chadwick, D. "Coral in Peril' National Geographic, Vol.195, No. 1 (January 1999) contains pictures, maps of coral reefs of the world, water temperatures and ocean currents, maps of potential threats to coral reefs, and pictures of the colorful reef animals. Cervino, James and Smith, Garriet. "Corals in Peril" Ocean Realm, Summer 1997 summarizes problems coral reefs are facing.

Activity 10. What Is the Anatomy and Life Cycle of the Oyster?

TEKS: Science: 6.12,7.11,7.12,7.14,8.14,6.8,6.10

Math: 6.8,7.9,8.8

Language Arts:6.9,7.9,8.9,6.10,7.10,8.10,6.13,7.13, 8.13,6.20,7.20,8.20

Social Studies: 7.9,6.6,6.1,7.7

Learner Outcomes: After completing the activities, the student will be able to:

- observe and identify the anatomy of the oyster
- relate the structure and function of the oyster
- describe the life cycle of oysters
- identify factors that affect the life cycle of oysters
- predict the impact of physical, chemical and biological elements in the environment on oysters
- devise a plan for farming oysters

Background:

1. Use oysters as representatives of the Mollusca. Obtain oyster shells and whole oysters to enable the students to observe the shells and locate the various features that are described in Part I. The shell of the oyster is made of calcium carbonate. The outside is rough which can injure an organism that bumps into it. The inside of the shell is very smooth to protect the soft body of the oyster.
2. Obtain whole oysters to locate and examine the internal anatomy. Stress the importance of the muscle in opening and closing the shell. Shuckers are individuals who insert a sharp tool between the valves to cut the muscle so that the oyster can be opened.
3. Fill five-quart containers with water and point out that an oyster will filter 5 to 30 quarts of water per hour through its gills to bring in oxygen and food particles and to remove wastes. Point out that since oysters are filter feeders, pollutants or pathogens in the water are taken in by the oysters. As a result oysters in several bays cannot be eaten because of the amount of mercury or other pollutants that they contain.
4. Discuss the inefficiency of oyster reproduction and explain why millions of eggs are discharged into the water and very few are fertilized. Oysters spawn at the same time which helps to increase

the chances of the eggs becoming fertilized. Oysters spawn when the water temperature is above 75 degrees. During spawning season the oysters do not feed but use the fat supply that they have stored. As a result the oysters are thin and watery so oysters are not taken during the spawning season.

5. Ask the students to design an investigation to determine what type of surface is the best for oyster attachment. Provide the students with oyster shells, glue and a variety of surfaces.
6. Discuss the importance of young oysters feeding on different organisms than the adults so that they do not compete for the same food source.
7. Oyster reefs are being destroyed. Discuss some possible ways to prevent the loss of the reefs and to ensure that the oysters are healthy. To demonstrate their understanding of the oyster, have each team design a plan to grow healthy oysters.

Activity 11.What Is the Life Cycle of Shrimp?

TEKS: Science: 6.12,7.11,7.12,7.14,8.14,6.8,6.10

Math: 6.8,7.9,8.8

Language Arts: 6.9,7.9,8.9,6.10,7.10,8.10,6.13,7.13, 8.13,6.20,7.20,8.20

Learner Outcomes: After completing the activities, the student will be able to:

- describe the life cycle of shrimp
- use the diagram of the life cycle of shrimp to explain factors that affect the shrimp in each stage of their life cycle
- predict the impact of physical, chemical and biological elements in the environment on shrimp
- devise a plan for maintaining shrimp populations or for farming shrimp

Background:

1. Shrimp may be studied as representatives of the Crustacea instead of crayfish. Provide students with shrimp to identify their external anatomy. Point out that the internal organs are encased in the head section, while the edible "tail" section contains much of the female's ovaries.
2. Have the students infer the reason that the different shrimp are found in different areas and depths. This enables the shrimp to avoid competing for the same food and habitat.
3. Ask each group to analyze the diagram of the life cycle of the shrimp. Stress that the areas that are the nurseries provide the young shrimp with a partially sheltered area where small shrimp can grow, feed and are protected from storms and predators. Water temperature and salinity levels play important roles in these areas and greatly affect the growth and mortality of shrimp. Shrimp grow very slowly, or not at all, when the water temperatures are below 68°F. When the water warms, they shed their outer shells frequently and grow rapidly. A combination of low salinities (from floods, runoff, rain, etc.) and low water temperature (less than 50°F) may result in death. Postlarval and larger shrimp are omnivorous bottom feeders that feed on algae, small mollusks, marine worms and small crustaceans. Large shrimp may attack and eat small fishes and other shrimp. Changing from the plankton feeding stage provides the shrimp with greater food resources.
4. Brown shrimp enter the bays on ebb tides that correspond to a full moon. The size and time that shrimp enter the Gulf may be determined by several factors: low temperatures that cause shrimp to seek warmer, deeper water; excessive fresh water inflow that reduces salinities below a suitable level; storms; and approaching sexual maturity. More information is needed to understand the factors in shrimp migration.
5. Shrimpers use trawls that are cone-shaped bags with two wings on each side of the net opening. The spread of the opening may vary from 10 to 120 feet. The net body tapers to a cod-end. As the net is towed through the water, it acts as a large scoop held on the sea floor by heavy wood doors that produce a kite-like effect. As the trawl is pulled along the bottom, the catch is scooped into the net's mouth and concentrated at the cod-end. When the trawl is filled, it is pulled on the boat. The "bycatch" is discarded. The shrimpers behead the shrimp and ice the shrimp tails. Before the 1940s the white shrimp supported the industry. About 1947, the catches declined and the shrimpers were forced to go further out into the Gulf where they found the brown shrimp. Since 1977 about 74 percent of the shrimp landed in Texas are brown shrimp. Shrimpers are searching for new ways to increase catches. In 1955 shrimpers developed a way for a single boat to pull two trawls and catches increased 15 to 30 percent. The trawl size has increased to pulling two, 75-foot trawls. More recently some have developed a way to pull four trawls. Most shrimp boats carry up-to-date navigational aides: radar, Loran, fish finders, fathometers and ship-to-shore radios. Bay shrimping has become part of the industry in recent years, particularly for the bait industry. Knowledge of shrimp populations and size are important in managing the shrimp industry. Shrimp are an annual crop, however, so more data on the year-to-year fluctations are needed.

6. Discuss the problem of the bycatch that shrimpers catch in their nets. Some agencies report that this can be 8-10 times greater than the pounds of shrimp caught in the net while other research indicates the amount is closer to two pounds of bycatch for each pound of shrimp. Discuss the impact of this on the fish and other organisms that are part of the marine community.
7. With the increased interest in marine sport fishing, selling live bait has become a profitable business. Shrimp are important items in the diet of many fishes. Bait shrimpers drag small trawls, 12 to 25 feet wide from small shrimp boats. About 10 to 20 drags are made each day. To reduce shrimp mortality, most trawling is done in the early morning just before dawn. When the catch is taken on the boat, the bycatch (non shrimp animals) is quickly removed and the live shrimp are held in the boat wells or tanks with running seawater. Shrimp that die are sold at much lower prices so keeping the shrimp alive is critical.
8. Biologists believe that the harvest of natural shrimp populations has peaked. There is a greater interest in shrimp mariculture or shrimp farming. Shrimp farming must duplicate in captivity what occurs in nature. Have each group use the diagram of the life cycle of shrimp to plan a shrimp farm. Discuss all the information that one would need to farm shrimp. Note that when farming organisms other factors become a greater problem than in nature. Some of these are disease, accumulation of wastes, etc.

Activity 12. What Can You Learn from Observing a Fish? Or Can You Read a Fish?

TEKS: Science: 6.12,7.11,7.12,7.14,8.14,6.8,6.10

Language Arts:6.9,7.9,8.9,6.10,7.10,8.10,6.13,7.13, 8.13,6.20,7.20,8.20,8.5,6.2,7.2,8.2,6.3,7.3,8.3,6.4,7.4,8.4

Learner Outcomes: After completing the activities, the student will be able to:

- observe fish and make inferences about its habitat and lifestyle by examining its coloration, body shape and mouth
- conduct investigations to determine the relationship of color and color patterns to the survival of fish
- explain the advantages of various adaptations of a fish
- design a fish for a selected habitat

Background:

1. Provide each student with a picture of a different fish or each group with pictures of several different fish. Texas Parks & Wildlife has a book of colored pictures of saltwater fish that could be used. Or ask the students to locate pictures of fish using the internet. Fishes are the most successful vertebrates. There are more than 24,000 species know at the present and they total almost 50 percent of all living vertebrates. Marine fishes (about 14,000 species) account for about 60 percent of all known fishes and they vary in size from less than 10 mm to more than 12 m in length. Fishes have evolved and diversified to occupy nearly all the known aquatic habitats including the deepest oceans. Fishes inhabit polar waters around Antarctica where the temperatures fall below freezing to -1.9°F. Use the information and questions in Part I, II and III to guide the students in determining the relationship of color, color patterns, body shape and mouth to the habitat and lifestyle of each fish and how this enables the fish to survive in the habitat.
2. Fish in the open ocean seldom have the bright colors so common in coral reef fishes. Instead countershading is a common pattern of coloration. Many have dark, often green or blue coloration on their dorsal surfaces and silvery or white coloration on their ventral surfaces. When viewed from above, the pigmented upper surfaces of countershaded fishes blend with the darker background below. From beneath, the silvery undersides are difficult to distinguish from the light coming from the sea surface. From either side, these fish tend to blend in, rather than stand out against their environment. In clear coastal waters of the tropic many fish have bright colors and distinct patterns. In the colder and often murky waters to temperate and polar regions, the fish colors are darker with shades of green, brown and yellow. These fish merge with the background in which they live. Tiny fishes and the larval stages of larger fishes have no pigment so the body appears glass-like and transparent. This makes the fish difficult to see during the early stages of the life cycle and increases its chance of survival. Coloration of fishes is useful for a variety of purposes including sex recognition, warning, threat, distress signals, concealment, disguise and display. Concealment colors are imparted in different ways: resemblance, obliteration shading, and disruptive coloration. Some fish use deflective markings and they function to draw the attention of a predator away from vulnerable body parts or the head region is hidden by a head strip. This is a common feature among reef fishes. Directive markings draw the attention of the prey towards the predator. The lures of the anglerfish is an example. Advertisement colors function to reveal the presence of the fish. The purpose may be for sexual recognition and display. For many it is a warning to indicate the fish may have poisonous

spines. Some non-toxic fish mimic toxic fish for protection from predators.

3. Diet and feeding habits vary widely. Heads, jaw shapes, teeth and digestive systems have evolved to take advantage of many food sources. Most fish are predatory and eat animals that are smaller or weaker than they are. Carnivorous fish that cruise have elongated snouts and sharp teeth for seizing and holding prey. The position of the mouth also differs. A superior mouth is typical of slow swimming fish. An inferior mouth is found on many bottom feeders. A terminal mouth or one at the tip of the snout is found on fish that probe and nibble food from surfaces. The mouths may be protractile, extended, engulfing, coral crushing, shell-crushing, soft mouth (plankton feeders), tweezer-like or sucking and others. Teeth are adapted for hard or soft prey. The tooth type indicates the eating habits such as phyarygneal teeth for sieving, grinding, holding or tearing food in the gullet; molars for crushing hard prey (shellfish); canines to seize, hold and piece prey; and incisors for cutting and slicing. The intestines also have modifications for the different diets (carnivorous, herbivorous, or omnivorous).
4. In fast swimming fishes, the body is streamlined and they have reduced and thin fins or they may be flattened against the body or folded in to grooves to reduce drag during swimming. In slow swimming fish, the pectoral fins are positioned high on the sides of the body and the pelvic fins are usually well forward. Unusual modifications of fins exist. Leg-like pectoral fins for walking; wing-like fins for gliding; fin spines for protection; or reduced fins to produce a "sculling" motion that allows the fish to move in any direction. The tail fins also vary. Broad, flattened tails are common in slow-swimming and bottom-dwelling fish where maneuverability is more important than cruising speed. Fast fishes will have narrow forked tails that are more efficient for speed. Body shape also varies greatly from the streamline body to globe-shaped, serpentine, thread-like, elongated or flattened from top to bottom or flatten from side to side or shortened from front to rear. The shapes vary with the habitat and lifestyle of the fish.
5. After each group has completed Parts I, II and III, provide each group with different pictures of fish to use what they have learned to make inferences about the lifestyle and habitats of the fish. Or have the students design a fish for a selected habitat. It may be a painting, a paper or plaster model or one made from recycled materials. Provide scenarios for students. For example design a fish that would be adept at maneuvering through holes and crevices of a coral reef while also relying on a darting motion to catch prey. Or design a fish that lives on the bottom in shallow offshore areas that feeds on crabs and clams in the bottom.

Activity13. What Factors Affect the Lives of Fish?

TEKS: Science: 6.2,7.2,8.2,6.3,7.3,8.3,6.4,7.4,8.4

Math: 6.8,7.9,8.8

Language Arts:6.9,7.9,8.9,6.10,7.10,8.10,6.13,7.13, 8.13,6.20,7.20,8.20

Social Studies: 6.1,7.7,6.6,7.9,6.7,7.10

Learner Outcomes: After completing the activities, the student will be able to:

- infer the effect of various factors(salinity, temperature, bottom composition, depth, currents, dissolved oxygen and fishing) on fish
- conduct an investigation to determine the effect of temperature changes on fish
- explain the variation in fish habitats and habitats during the life cycle

Background:

1. Stress that ecology deals with the interrelationships among organisms and their physical and chemical surroundings. Water temperature directly affects the fish in a variety of ways: nutrient and food uptake, growth rate, survival and reproductive success. Salinity also exerts controls on the activity and distribution of fish. If the salinity of a fish 's body fluid is different from that of the surrounding water, it must osmoregulate in order to maintain a proper water balance in its cells. However, fish are adapted to a variety of salinities. The temperature and salinity may affect the types of plants or animals available for the fish to feed on thus indirectly affecting the fish. Use the activity to guide a discussion of the factors affecting the fish.
2. After a discussion of the factors, ask each group to design an investigation to determine the effect of different temperatures of fish. Stress as scientists they need to determine the problem they are going to investigate, develop their hypotheses, identify the variables and procedure for their investigation. After you have reviewed and approved of their plans, they may conduct their investigation. You may have each group use different fish (goldfish, minnows, mollies, etc.) in its investigation.
3. Have the students develop explanations for the patterns in the life history of different fishes. Stress that much more data is needed about different

fish populations and factors that impact the fish. Ask the students to list factors (overfishing, distruction of habitats, changes in habitats, pollutants, global warming, etc.) that might cause changes in fish populations in the future and predict their possible impact. Discuss what might be done to prevent decreases in fish population. Encourage the students to use the internet to research the status and problems in various fish populations. In discussing possible regulations, discuss what data is needed to make wise decisions for the future.

Activities 14, 15, 16 and 17

These activities can be combined in one lesson that covers several class periods. These activities can be integrated after lessons on invertebrates and fish to help make a connection to the use of these marine organisms as a food resource.

You may want to introduce this lesson by having each student complete the checklist in Activity 15: Are you a seafood connoisseur? Then compile the class data to analyze and follow this with lesson 14 and discuss the class data from the questionnaire. Then conduct the seafood tasting of activity 16. Then divide the class into groups to gather data by conducting surveys using the checklist in Activity 15 to analyze seafood eating habits and attitudes in the community and to analyze the advertising of foods. Follow this with activity 17 to analyze the nutritional value of seafood.

Activity 14. A Diner's Delight?

TEKS: Science: 7.12

Math: 6.8,7.9,8.8

Language Arts:6.9,7.9,8.9,6.10,7.10,8.10,6.13,7.13, 8.13,6.20,7.20,8.20

Activity 15. Are You a Seafood Connoisseur?

TEKS: Science: 6.8, 7.12

Language Arts:6.11,7.11,8.11

Social Studies: 6.7, 6.10. 7.12

Activity 16 How Do Marine Organisms(Seafood) Taste?

TEKS: Math: 6.8,7.9,8.8

Language Arts:6.11,7.11,8.11,6.20,7.20,8.20

Activity 17. What's Special about Seafood?

TEKS: Math: 6.8,7.9,8.8

Language Arts:6.9,7.9,8.9,6.10,7.10,8.10,6.13,7.13, 8.13,6.20,7.20,8.20

Learner Outcomes: After completing the activities, the student will be able to:

- analyze menus from various countries to gather data to compare the eating habits of different nationalities
- explain why menus or eating habits differ among countries
- analyze ads including grocery store ads to make inferences about the role of advertising on eating habits
- gather data to determine which marine organisms they have eaten or would eat
- formulate and test hypotheses about sea food eating habits
- evaluate the taste of seafood items and make inferences about the identity of the seafood
- analyze the relationship of taste and texture of seafood which were liked and disliked
- evaluate the eaten foods and barriers to eating unknown food items
- interpret the data on food labels
- analyze the data on calories, protein, cholesterol and nutritional value of various foods
- evaluate the position that seafood is healthy and provide support for the selected position

Background

1. Students could use the checklist to survey the community to determine if the responses are different for different age groups or people of different ethnic background. Ask to develop hypotheses about seafood consumption and attitudes about eating seafood. For example, do people of different age groups respond differently? Other possibilities might be ethnic background, past eating experiences, availability of seafood, attitudes about seafoods, etc. The data, the students gather can be statistically analyzed in math classes to determine if their hypotheses were supported or refuted.
2. Obtain menus for a variety of local restaurants. Ask the students to analyze the menus and determine patterns in the foods that are served. What are the most common items, etc.? Ask them to identify items that they would not eat and make a graph of the data. Provide the students with a copy of the menu in this lesson. Ask them to compare this menu with the ones from local restaurants. Again identify the items they would not eat and make a graph of the data. Discuss the differences and focus on the factors that determine what foods they will eat and not eat. Use the questions in the activities to guide the discussion.
3. Ask the students to evaluate the location of the country and its terrain and the foods that are

eaten. What evidence is there to support their responses? Counties bordering the Mediterranean as well as Japan, Korea and others have a greater proportion of coastline to land areas. Frequently, the land area is not sufficient to maintain domestic animal populations or to grow enough crops so the sea becomes a major food source. Discuss how this differs from the United States.

4. Ask the students to list the foods that they have seen advertised on TV or in newspapers and magazines. Or bring magazines and newspapers to class, and gather data to determine what foods are advertised the most. Include the data on foods advertised in the grocery store ads separately. Ask each group of students to discuss the factors that determine eating habits and the role of advertising in what people eat. Have each group share the key points of its discussion with the class.
5. Prepare plates of small bite-size pieces of different seafoods. Major grocery stores will have a variety of canned seafoods. Any local Japanese, Chinese or Asian grocery stores are also a source. (Save the food labels for activity 17.) A local seafood restaurant might prepare these. The bite-size pieces can be fried, baked or broiled but seasonings are not required since the focus is on the taste of the seafood. Before beginning the tasting, make sure that no students have allergies to seafoods. Stress that tasting foods or drinks is a serious activity. Like wine tasters, they will need to follow the instructions and concentrate on the taste, texture and flavor. To avoid influencing others, there is to be no talking or non-verbal reactions that could influence others during the tasting. Analyze and discuss the taste test results. Discuss the results. Have each group summarize its findings and conclusions about the seafoods.
6. Ask the students bring in food labels and obtain labels from seafoods. Use the labels to practice reading and analyzing the data on the labels. Stress the importance of noting information on per serving, serving size and number of servings in the package. Compare the labels of seafoods to those of other animal products and vegetables. Discuss the findings.
7. Provide the students with copies of Tables 1, 2, 3 and 4 to analyze the data and write conclusions or generalizations that summarize the data in each table. Or provide each group with a table or sections of "Seafood is Healthy" to analyze and summarize for the class.
8. To close these seafood activities, have each group plan, design and prepare a brochure, poster, TV ad (video taped) or radio announcement (taped to play for the class) that provides information on seafoods and promotes the awareness and benefits of seafoods. They may use any data gathered during the activities or include additional information they have found. Language arts communication skills can be emphasized and included in the evaluation of their project.

Activities 18, 19, 20 and 21

These activities can be combined in one lesson that covers several class periods. This lesson can be integrated with lessons on reptiles. Activity 18 introduces the students to the characteristics (size, length, weight) of Gulf of Mexico sea turtles by comparing the turtles to themselves and to land turtles. In activity 19, the students are to read the descriptions of the turtles and use these to identify the sketches and to observe the mouths and jaws of the turtles to note their adaptations of eating, which determines their habitat. Activity 20 follows an inquiry investigation that follows the scientific investigations to determine how turtle hatchlings know where the water is and where to spend their life. Activity 21 investigates the actions that have resulted in endangerment of sea turtles and new threats to their survival.

Activity 18. What Are the Characteristics of Sea Turtles?

TEKS: Science:6.10,7.11,7.12

Math: 6.8,7.9,8.8

LA:6.13,7.13,8.13,6.24,7.24,8.24

Social Studies: 6.6,7.9

Activity 19. What Is the Relationship of Sea Turtle Characteristics, Diet and Habitat?

TEKS: Science:6.8,6.10,7.12

Math: 6.8,7.9,8.8

Language Arts: 6.13,7.13,8.13,6.24,7.24,8.25

Activity 20.How Do Sea Turtles Navigate through the Ocean?

TEKS: Science: 6.10, 6.12,7.5, 7.11, 7.12

Math: 6.8,7.9,8.8

Language Arts: 6.11,7.11,8.11,6.20,7.20,8.20

Social Studies:,6.6,7.9

Activity 21.How Is the Survival of Sea Turtles Threatened?

TEKS: Science: 6.1,6.12,7.8, 7.11,7.12

Math: 6.8,7.9,8.8

Language Arts:6.10,7.10,8.10,6.11,7.11,8.11,6.24, 7.24,8.24

Social Studies: 6.1,7.7, 8.14

Learner Outcomes: After completing the activities, the student will be able to:

- compare the size of sea turtles to their own size and to land turtles
- use descriptions of sea turtles to sketch the turtles
- use the data on sea turtles characteristics to identify the turtles
- observe the differences in the sea turtles' jaws and heads and relate it to the food eaten by the turtle
- evaluate sea turtles' structure, function and adaptation
- examine and explain the relationship of sea turtle characteristics and their lifestyle and habitat
- formulate hypotheses for describing the relationship between factors that guide sea turtles navigation
- identify and control variables in planning experiments to determine how sea turtles navigate through the ocean
- analyze the factors that have led to the decline of sea turtles so that they are endangered
- analyze how human actions are threatening the survival of sea turtles and propose solutions to the problems

Background

1. Turtles have lived on the Earth for more than two hundred million years and have changed little over time. Modern sea turtles, though less specialized and diverse than their ancestors, are the only living group of reptiles that spend their lives in the marine environment, with the exception of a few sea snakes. Ask the students to predict the size (length and weight) of sea turtles. Have the students compare their predictions to the data in Table 1. On the board or bulletin board measure the length of each turtle from the floor to a point on the board to create a chart of the actual turtle sizes. Students can stand next to the lengths to compare their height to the length of the turtles. Add the length of the land turtles to the chart. Ask for students to volunteer to determine their weight or to weigh themselves on a bathroom scale. Compare their weight to that of the various turtles.
2. Ask the students to formulate hypotheses as to why sea turtles are larger than land turtles with the exception of the tortoise. Compare the effort of walking on land to that of swimming in water. The sea turtles swim with grace and speed in the waters off every continent except Antarctica.
3. Each species of sea turtle is distinctive in appearance, behavior and the environment in which it lives, yet all sea turtle have some common characteristics. The shell consists of an upper part, the carapace, and the lower part, the plastron. These are joined together by cartilage to protect the vulnerable internal organs. Provide the students with the descriptions of each turtle and have them sketch the turtles. Use the characteristics to identify the sketches of the turtles in Figure 1. Discuss problems they had in sketching the turtles from the descriptions and the importance of sketches or pictures in identifying organisms. Biologists use observation to identify the turtles. Ask the students to examine the drawings of the turtles in Figure 1 and list the ways in which they differ from each other. Ask students to note key differences that can be used to classify the turtles. Biologists note the number and arrangement of the scutes to identify the species of sea turtles.
4. Point out that the leatherback turtle has a large, elongated, rubbery carapace that is blackish with pale spotting covered by a leathery skin with 7 longitudinal ridges. Its long front flippers lack scales and claws. It is the champion among the turtles. It grows larger, dives deeper, travels further and is found in colder water than any other turtle. The hawksbill's carapace is a rich flecked tortoise shell-brown. It has two claws, one each of its two front flippers. The beauty of the intricate black and yellow plates of the Hawksbill had made it sought after for tortoise shell jewelry and combs. This has led to its becoming endangered. Japan was the largest importer of hawksbill shells, importing around 31,000 a year from around the world at about $375 per shell. For centuries Japanese have had the tradition of carving the tortoiseshell into ceremonial bridal combs. More recently it has been earrings and tie clips. With pressure from biologists, Japan agreed to halt imports in 1992. The green turtle has an oval to rounded carapace and has one claw on each of its front flippers. The green turtle's meat is the most delicious of any sea turtle. This may be because it is a vegetarian, grazing on sea grasses and algae. Its common name comes from its heart-shaped, gray-brown carapace while its fat is green colored. The demand for its meat has led to its decline and becoming endangered. The loggerhead turtle has a red-brown carapace that is broad and shield-like. The Kemp's ridley has a grayish, heart shaped round carapace that is as wide as it is long. It has two claws on its flippers. The ridleys were killed for their leather, a practice banned in 1990. Once the greatest threat to their survival was the overharvesting of their eggs from their only natural nesting beach in Mexico. The eggs were prized as an aphrodisiac and energiz-

ing protein. The Mexican beach has been patrolled by federal officials since the late 1990s and a corresponding increase in nests has occurred.

5. Sea turtles do not have teeth, but their jaws have become modified into "beaks" to crush, tear or bite, depending on the food they eat. Have the students note the differences in the mouths and jaws of the turtles and how each is adapted to the food that it eats. The leatherneck is the only sea turtle that lacks head scales. Its diet ranges from crustaceans to seaweeds but it prefers jellyfish. The hawksbill lives in coral reefs where it uses its long, sharp beak to nip sponges out of crevices. It is easily identified by its narrow head and strongly hooked beak. The green turtle's beak is slightly hooked or not at all. The adults prefer to feed on seaweeds in sea grass meadows. The loggerhead has a robust beak and a thick neck with a broad head. The head seems enormous in portion to the rest of the turtle. Its diet includes echinoderms, mollusks and crustaceans (crabs), which are crushed by its enormous beak. It feeds mostly in the subtropics in estuaries and along the continental shelf. The Kemp's ridley has a large head and powerful jaws but the beak is not as robust as the loggerheads. Point out that even as juveniles, each species has its own niche in the marine environment. The Kemp's ridleys are found in the shallows of the Gulf of Mexico and North Atlantic. The leatherback adapts to both Arctic and tropical waters and makes the longest seasonal migration. The green turtle grazes on grasses in the tropics. The loggerhead lives in the subtropics while the hawksbill is found around coral reefs.
6. All sea turtles begin life as tiny hatchlings (about the size of half dollar) dashing to the surf. They undertake long migrations from the beach on which they hatched to their feeding grounds and back to the nesting beaches. The extraordinary navigational ability of sea turtles has contributed to their evolutionary success. However, sea turtles now face threats to their survival. Studying the orientation mechanisms of sea turtles not only provides insight to their navigation system but it may also help save them from extinction. No one is sure how sea turtles find their way. Activity 20 is a guide through a series of studies of sea turtle migration to determine how they find their way and provide students the opportunity to hypothesize, identify and control variables to plan investigations, just as biologists have done in studying the migration of sea turtles. Do not provide the students with the complete activity. Use the activity as a section-by-section inquiry. First provide each team with number 1 and ask team members to select possible hypotheses and plan the testing of one of the possible hypotheses. Then discuss their hypotheses and plans as a class. Repeat the process with number 2, number 3, etc.
7. The first few moments out of the nest are the most dangerous for baby sea turtles. Many hatchlings do not make it to the water. Ants, ghost crabs, raccoons, feral pigs, dogs and birds such as terns, gulls and frigate birds are just a few of the predators that eat the eggs or hatchlings. Human beings are the most dangerous enemy of sea turtles.

   Turtle eggs and meat are eaten. Some are killed for the skin of the neck, shoulders and flippers (which is tanned to make leather purses, shoes and boots while the shell is used for carved rings, hair clips, earrings, combs and other decorative items.
8. In activity 21, the various human activities and their impact on the sea turtles are analyzed. Have the students conduct further research to learn what is known about the life cycle and lifestyle of the sea turtles and factors affecting their survival. Each team could be assigned different human actions to investigate and propose ways to decrease or eliminate the human impact. Point out that although the U.S. Department of Interior and Commerce have implemented recovery plans for sea turtles, the turtles do not recognize national borders and their conservation is an international problem. Conservation requires bridging the gap between research and education about sea turtles. However, local people must be allowed to participate in and benefit from the protection and management of sea turtles. Alternatives must be developed when locals rely on the sea turtles for food and exporting parts of turtles for their income. One such alternative might be to design programs to help local people derive an income from ecotourism without jeopardizing the area's natural values.
9. The building of sea walls, groins, jetties, etc. can result in a permanent loss of nesting beaches due to erosion and the prevention of natural beach and sand accretion. It also leaves little suitable habitat for sea turtles to nest. Beach renourishment, or replacing sand that was eroded, generally results in imported sand that is different from the original sand. This can affect nest site selection, digging behavior, incubation, temperature, gas exchange characteristics in the nests and the moisture content of the nest. All these factors could affect the hatching success. Turtles tend to avoid beach areas with bright light so artificial beach lighting disorients hatchlings. Biologists have found that striking a match on a dark night in the vicinity of a green turtle emerging to lay her eggs was enough to cause her to go back to the

sea. Raking of the beach with heavy equipment can crush nests or hatchlings waiting to emerge and hand raking can disturb sealed nests. Increased human presence of nesting beaches can cause turtles to shift to other nesting beaches, delay egg-laying and cause the selection of poor nesting sites. People driving on the beaches at night can impact the turtles. Headlights of vehicles can disrupt the nesting process and disorient hatchlings. Hatchlings can be run over and nests destroyed. Exotic dune and beach vegetation can invade a beach area and displace native species. These non-native plants can cause dune destablization so erosion occurs or impacts adult turtles from properly digging nests. In some cases the exotic plants force the turtles to use the middle and lower beach, which increases the chances of flooding the nests. Plants shading the nesting area will lower the sand temperatures, which affect the hatching survival. Pollutants on the beaches or in the ocean also impact the survival of sea turtles. Discuss the possible impact of an oil or chemical spill on a beach where turtles are known to nest.

12.Sources of additional information include:

Carr, Archie. *The Sea Turtle: So Excellent a Fishe*. Austin, The University of Texas Press, 1964, 1984.

Ripple, Jeff. *Sea Turtles*. Stillwater, Minnesota. Voyageur Press, Inc. 1996.

Rudlow, Jack and Anne. "Sea Turtles: In a Race for Survival." National Geographic 185(2):94-121, February 1994.

Seifert, Douglas D. "Loggerhead Sea Turtles: The Solitary Life of the Great Ocean Traveler." Ocean Realm, 44-9, Summer 1997.

"Rebirth of a Nation" Texas Shores, 30 (2) Texas Sea Grant College Program, Summer 1997

Activity 22 How Are Birds Adapted to their Environment?

TEKS: Science:6.2,7.2,8.2,6.3,7.3,8.3,6.4,7.4,8.4, 7.12,6.12,7.11

Language Arts:6.13,7.13,8.13,6.20,7.20,8.20,6.24,7.24,8.25

Learner Outcomes: After completing the activities, the student will be able to:

- conduct investigations to investigate the vision, feathers and flight of birds
- plan and implement an investigation to determine the relationship of the type of beak to the habitats in which the birds live and the types of food available
- research and analyze a bird and its adaptations to its habitat
- research a bird and construct a life size model of the bird in its habitat
- research a bird and prepare a presentation of the findings
- if given a description of birds behavior and its food, design a bird that would live n the habitat described

Background

1. This activity can be integrated into lessons on birds; or form and function; diversity, or adaptations and patterns. According to the American Birding Association, Texas has more bird species-nearly 600-which is more than any other state or province in North America. Some birds are found nowhere else in the nation and birdwatchers from around the world come to see them. The Texas coast is so popular among birders that some communities have become world famous for the birds that are seen in the area. Bird diversity increases toward the tropics and the location and size of the state account for the numbers. Warm weather species nest in Texas, northern ones pass through on their long migration flights and many remain for the winter. The birds change with the seasons but are plentiful any time of the year. More than 75 percent of the species in Texas are found along the coast.
2. Begin by have the students draw an outline of a bird's head and/or body to evaluate their knowledge of birds. The drawings will also reflect the diversity of birds they have seen. Discuss the different birds and locations they have seen birds and what they know about birds. Use the drawing to focus on the head region and bird's eyes. Discuss the advantage and disadvantage of monocular vision in birds versus in humans. The vision of birds is adapted to their lifestyle. Eagles, for example, can spot a rodent from flying high above while another bird's vision is adapted to spotting seeds or insects that are close by on the ground. Discuss why the vision of a bird differs depending on its lifestyle.
3. Obtain feathers for analysis. Have the students investigate the role of the oil gland and feathers to discover its importance in making the feathers water repellent for all birds but especially wading, swimming and diving birds. Provide the students with feathers (available from craft stores). Encourage the students to design an investigation to determine the impact of oil spills on bird feathers and test various substances to remove the oil. Then investigate the effect of the cleaning substance on the water repellant ability of the feathers and smoothing the feathers.
4. Use Part II to guide the students in developing

their understanding of bird's and flight.

As a part of the Texas Essential Knowledge Skills, students are to plan and implement investigative procedures—ask questions, formulate hypotheses, collect data, analyze, evaluate and predict from evidence. Use Part III to enable the students to practice and develop these skills. Have each team develop its own question, hypotheses and procedures for the investigation and to conduct the investigation to gather data. Each group can share its experiment with the class. The class can discuss and evaluate each experiment and determine the relationship between the different niches of the birds in a habitat, their diversity (shape, beaks, etc.) and adaptations for feeding and survival. Have the class determine whether their data refutes or supports the principle that the greater diversity supports a greater number.

5. Assign each student, pair or group of students a bird or birds to enable the students to research, analyze, evaluate and make inferences from evidence about the bird's lifestyle and adaptations for survival in a habitat. The students are to assume the role of researchers gathering data. Provide the students with the questions in Part IV to guide their research. Each (student or group) is to prepare an oral presentation on his or her findings to the class or scientific meeting and a written report, which may be a poster session or illustrated paper as a part of the presentation. Also stress that bird populations change dramatically in response to habitat alterations and hypothesize about the factors that may impact the bird population in the report. Texas Parks & Wildlife magazine and its website are helpful. Other sources:

   Doughty, Robin. *Return of the Whooping Crane.* University of Texas Press, Austin. 1989.

   Oberholser, Harry. *The Bird Life of Texas.* University of Texas Press, Austin,

   Peterson, Roger Tory *Birds of Texas.* New York, Houghton Mifflin, 19963, 1966,1988.

   Tveten, John L.*The Birds of Texas.* Fredericksburg, Texas.Shearer Publishing, 1993. (excellent resource with information on each group of birds and color photographs).

   Jim Hiney. *Birding.* **Texas Shores** 33:4. Winter 2000. Texas Sea Grant College Program.

6. For closure to demonstrate their knowledge, use the descriptions in Part V and develop additional ones. Have the students design the bird (it could be the bird's beak and feet or the whole bird) that fits the description; or have each team develop a description so classmates can design the bird that fits the description.

Activity 23.What Caused the Brown Pelican Problems?

TEKS: Science:6.2,7.2,8.2,6.3,7.3,8.3,6.4,7.4,8.4, 8.14,7.8,7.12

Math:6.3,7.2,8.2

Language Arts:6.11,7.11,8.11,6.13,7.13,8.13,6.20, 7.20,8.20

Social Studies:6.1,7.7,6.22,7.21,8.30

Learner Outcomes: After completing the activities, the student will be able to:

- infer how the pelican gets its food and what it eats
- participate in a simulation to collect and interpret data to determine what happened to the brown pelican population in the 1950s and 1960s
- interpret data concerning the food chain and how toxic substances can accumulate in higher species in a food chain
- infer why brown and white pelicans were affected differently by the DDT
- analyze factors that are affecting the brown pelican's survival and propose solutions

Background

1. Show the students a picture of the brown pelican and discuss numbers 1 and 2. The pelican uses its pouch as a dip net in catching fish. After scooping up its catch, the pelican closes the beak and raises its bill, the pouch contracts to force out the water before swallowing the fish.
2. Present the information in number 3, and ask each group to list possible hypotheses. Discuss the hypotheses and what information will be needed to accept or refute them.
3. Tell the students that they are going to participate in a simulation to collect data to test their hypotheses. Do not give the student the activity but use the instructions in number 4 and 5 to conduct the simulation.
4. Discuss the data gathered from the simulation and numbers 6-10. Discuss the movement of chemicals through the food chain and the accumulation in organisms in the food chain.
5. Stress that other factors also are affecting the survival of the brown pelican (discuss numbers 11-13). Discuss what would be required to provide a habitat where the brown pelican could live and survive so that there will be brown pelican for their children to see.
6. Have the students reexamine the birds that they researched and reported on in Activity 23 and infer the impact of pesticides, herbicides, heavy

metals or other pollutants in the bird's habitat.

7. Reference:

   Casteel, Pamela. *Brown Pelicans*. **Texas Shores**, 27:3, Fall 1994. Texas Sea Grant College Program.

Activity 24. What Type of Swimmers Are Marine Animals?

TEKS:Science:6.2,7.2,8.2,6.3,7.3,8.3,6.4,7.4,8.4,6.10,7.11

Language Arts:6.13,7.13,8.13,6.20,7.20,8.20

Learner Outcomes: After completing the activities, the student will be able to:

- construct a model of secondary swimmers to study how they have adapted to swimming
- compare the tails and tail movement in the swimming of dolphins, whales and fish
- explain the adaptations that had to occur in secondary swimmers

Background

1. Different marine organisms swim in varying ways. These specialized approaches to swimming, with adaptations of body shape, fins and muscle, reflect the various ecological niches of the nekton. Review the body shape and role of fins and tail in the swimming of fish. The evolution of the cetaceans from land ancestors has resulted in a remarkable group of structural, physiological and behavioral adaptations to a totally marine existence. Although the embryo has limb buds, they disappear before birth leaving only vestigial internal remnants of pelvic appendages. They breathe through a single or pair of dorsal blowholes and are streamlined to propel themselves with broad, horizontal, fluke tails. The tail flukes have an efficient hydrofoil shape, reducing water drag and providing lift during the upstroke. It is swept up and down, not sideways, as in fishes. The movement involves the entire posterior part of the body. The dorsal fin, when present, is also fibrous and provides stability, as do the bony pectoral flippers.
2. Have the students observe fish in an aquarium to note how they swim and move. Observe the functions of the fins and tail. Encourage them to experiment and determine the best arrangement of fins and sketch the arrangement. Examine pictures of the secondary swimmers (whales, dolphins and porpoises) to compare their findings of fin arrangements on their model. Discuss how sea turtles differ from land turtles and how these adaptations benefit a marine life.
3. Discuss the other ways in which secondary swimmers must adapt to living in water. Cetaceans inhale and dive with their lungs full of air. Nasal plugs in the blowhole provide an airtight seal which is opened only by voluntary action. The lungs are very efficient in transferring oxygen from the air into the liquid blood. Their lungs collapse completely when diving below 100 m. This eliminates the need for respiratory structures capable of resisting the extreme water pressures experienced during deep dives. Oxygen is stored in the blood and muscle, where it is most needed. The blood is high in hemoglobin that carries the dissolved oxygen around the body and to the brain. Diving animals have more red blood cells so more hemoglobin to store oxygen. The muscles are rich in myoglobin, a protein that binds with oxygen from the blood and stores it for metabolism during the dive. They also have unusual networks of blood vessels (capillaries) around the dorsal side of the thoracic cavity and the major vein returning blood to the heart is more elastic. These features all contribute to the total reserve of stored oxygen for use during a dive. The swimming muscles of secondary swimmers are also highly tolerant to anaerobic conditions during a dive. Also, most of the circulating blood is restricted primarily to the heart and brain. The heart rate also slows (20 to 50 percent) during a dive.

Activities 25 and 26 can be combined into one lesson to enable the students to study whales, dolphins and porpoises to examine the difference among them.

Activity 25. Is It a Whale, Dolphin or a Porpoise?

TEKS: Science:6.10,7.12

Math:6.3,7.2,8.2

Language Arts:6.10,7.10,8.10,6.13,7.13,8.13 6.20, 7.20,8.20

Activty 26. Is It a Dolphin or Porpoise?

TEKS: Science:6.10,7.12

Math:6.3,7.2,8.2

Language Arts:6.10,7.10,8.10,6.13,7.13,8.13,6.20, 7.20,8.20

Social Studies:6.1,7.7

Learner Outcomes: After completing the activities, the student will be able to:

- interpret data to distinguish between whales, dolphins and porpoises
- analyze the characteristics of each group to determine their lifestyle and behavior
- observe the differences to classify whales, dolphins and porpoises

Background

1. Ask the students to list what they know about whales, dolphins and porpoises and describe how they differ. Whales, dolphins and porpoises belong to a single group of marine mammals known as cetaceans. There is something special and appealing about cetaceans. The mystery surrounding them may be part of their appeal. Many of our early assumptions about them were wrong or at least not entirely accurate. Yet the more we learn about these incredible creatures, the more intriguing they become.
2. Cetaceans share many features in common, however, they come in a impressive variety of shapes, sizes, colors and live in many different habitats. They have also developed a variety of adaptations for survival in their underwater world. They range in size from small dolphins and porpoises that are as little as 4 feet in length to the enormous blue whale that can grow to more than 98 feet in length.

   Over the centuries, cetaceans have been viewed as sea monsters, gods, guardians, reincarnations, sources of food and income, and even living islands. Personal encounters have shown that many are ready to accept humans as friends and show a striking level of trust. At least 10 dolphin species are known to have shown a liking for human company. Stories of dolphins helping human swimmers in distress or protecting them from sharks are common despite a history of humans hunting them, polluting their environment, drowning them in fishing nets and catching their fish.
3. Stress the importance of classifying the cetaceans by scientific observations instead of by the common names of whales, dolphins and porpoises. Ask the students to examine Figure 1 in Activity 26 and note how the baleen whales differ from the toothed whales. Discuss how dolphins and porpoises should be grouped.
4. In Activity 26, use Figures 1-4 to complete Table 2. Ask the students to infer which would feed on small crustaceans like krill and copepods? Fish? Squid? Other marine mammals? The baleen whales comprise only 11 species but they include many of the large and more popular whales such as the blue, gray humpback and bowhead. Instead of teeth, they have hundreds of furry, comb-like baleen plates that hang from their upper jaw. These are tightly packed in the whale's mouth, and have stiff hairs that form a sieve-like structure to filter food out of seawater. They feed mainly on small schooling fish or crustaceans, such as krill and copepods. Another difference is that toothed whales have a single blowhole while baleen whales have two side by side.
5. In Activity 27, use Figures 1-3 to describe how to distinguish between dolphins and porpoises.
6. Stress that the growing worldwide demand for seafood has affected cetaceans as well as the fish populations. The number of whales, dolphins and porpoises that drown in fishing nets is high, yet it has decreased in the last 10 years. The tuna fishing industry received a great deal of negative publicity about its catch methods and was once blamed for killing more dolphins than any other human activity. The U.S. industry adopted a "dolphin-free" standard in the 1990s and participating companies began printing this on their labels. The tuna fishing industry is governed by rules and regulations in this country but international enforcement, or compliance, is still slow to develop.
7. Marine pollution is another problem. It may result in immediate death or prolonged suffering, although exact figures are unknown. Very small amounts of toxins in the ocean are picked up by the plankton that are eaten by fish and squid. These fish and squid, in turn, are eaten by cetaceans. This creates a build up of toxins in the bodies of cetaceans over time. As they get older the toxins tend to accumulate in the blubber and in organs such as the liver. The toxins are also passed from mother to the young through her milk. Despite the warnings, many governments ignore the problem of marine pollution. There are also hidden dangers. These include habitat loss and noise pollution. There is relatively little research in this area so the harm caused to whales, dolphins and porpoises is largely unknown. Even without a great deal of research, logic suggest that cetaceans are likely to be highly susceptible to noise pollution since they rely on effective hearing for all their daily activities. There are no easy solutions to most of the problems facing cetaceans but solutions do exist. Education to create awareness is a beginning.
8. Resources:

   Carwardine, Mark. Whales Dolphins and Porpoises. New York, Dorling Kindersley Publishing, Co. 1995

   Carwardine, Mark and others. The Nature Company Guides, Whales, Dolphins & Porpoises. San Francisco, US Weldon Owen Inc. 1998

   Würsig, Bernd and others. The Marine Mammals of the Gulf of Mexico. College Station, Texas A&M University Press. 2000.

Activity 27. How Are Dolphins Trained?

TEKS: Language

Arts:6.10,7.10,8.10,6.11,7.11,8.11,6.24,7.24,8.24, 6.20,7.20,8.20

Learner Outcomes: After completing the activities, the student will be able to:

- conduct an investigation to investigate the training of animals
- evaluate the pros and cons of keeping and training animals in captivity

Background

1. Since the first bottlenose dolphins were taken into captivity more than a century ago, at least 25 species have suffered a similar fate. Divide the class into groups for the simulation activity. Send the '"dolphins" out of the room for 10 minutes to enable each group to construct the sentences that the trainer will use in the experiment. Provide the trainer and the remaining group members with the instructions. The "dolphins" should not see the instructions. Once the trainer in each group is ready, bring the "dolphins" back to the classroom.
2. After the training session, have each member of the group, including the "dolphins," discuss their reactions and feelings. Based on the simulation, ask each group to explain what is intelligence, learning, language, behavior, memory and conditioning. Use the simulation as a basis to discuss the pros and cons for taking cetaceans from the wild and keeping them in captivity. Have each team develop its plan for controlling and regulating the maintenace of cetaceans in captivity.

Activity 28. Can the Sea Be a Medicine Chest?

TEKS: Science:6.10,6.12,7.12

Math: 6.8,7.9,8.8

Language Arts:6.10,7.10,8.10,6.11,7.11,8.11,6.13, 7.13,8.13, 6.20,7.20,8.20

Social Studies: 6.1

Learner Outcomes: After completing the activities, the student will be able to:

- explain why the ocean sediments and organisms are sources for future medicines
- explain the processes that scientists use to select areas and organisms to evaluate for producing medicines
- analyze information and data concerning its feasibility for medicine

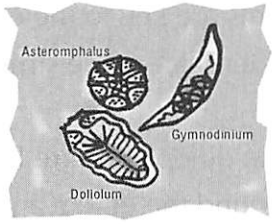
Background

1. New medicines are needed for diseases that are caused by organisms which have become disease resistant and also for a long list of diseases for which there is only limited or no treatment. Drugs derived from nature make up 75 percent of all medicines prescribed in hospitals; most of these compounds come from the land. Now new diving technologies are opening the sea to medical researchers. They are enthusiastic and hopeful about what they may find since the oceans cover three-fourths of the earth's surface. The sessile invertebrates are excellent candidates since they are attached and cannot run or hide. They have developed powerful chemicals for defense, reproduction and even communication. The chemicals need to be isolated and analyzed to determine if they can be used for fighting diseases and pain. Not all the organisms will provide medicines. Some like the stony skeletons of corals may be used for bone implants.
2. Use the activity as a guide to challenge the students to analyze organism like medical researchers to identify potential sources for medicines. The marine environment can also produce other substances. Currently there is no glue that bonds underwater; scientists are studying mussels. They secrete a glue that, in less than five minutes, hardens into a filament or thread that will attach the mussel for life to an intertidal rock that will withstand years of pounding surf. Surgeons and naval repairmen are a few of the people eager for such a bonding substance. Discuss the impact of this type of glue in medical or dental surgery or in repairing any object in the water. Other researchers are looking for a non-adhesive compound or anti-glue. This type of substance could keep barnacles and other fouling organisms from attaching to ships, a thin coating applied to teeth could prevent plaque, and could keep medically implanted devices from clotting or becoming coated.
3. Challenge the students to think about some of the characteristics of marine organisms and how these might be used in medicine. Encourage the students to use the internet to search for the latest information about drugs, medicines or medical help from the sea.
4. Discuss the importance of understanding the chemical ecology of the ocean and protecting the marine environment. Point out that organisms in the marine environment are more susceptible to environmental pollution than those on land. Chemicals can easily be dissolved in and move through the water.

1. Why Are Phytoplanktons So Small?

Marine Biologist _____ **Team**_____

The vast majority of the ocean's plant species are actually phytoplankton, not true plants. They do not have true roots, stems, leaves, flowers or seeds. The phytoplanktons are microscopic, unicellular plants that drift with the currents. The marine phytoplanktons include members of two of the five kingdoms. They include the Monera and Protista. You are going to investigate the characteristics of the marine environment and why drifting, minute single-celled organisms, rather than large rooted plants, dominate the community of plants.



Materials: plastic cups, food coloring, 100% cotton balls, scissor, forceps, droppers, paper towel, paper, empty 2 or 3 liter bottle

Procedure:

1. Phytoplankton is grouped into four size categories. The smallest are the picoplankton, which have cells smaller than 2 microns. The ultraplankton are 2 -5 microns in size. The nanoplanktons are 5-20 microns and microplankton are 20-200 microns. It is thought that the most important producers in all marine environments are the nanoplankton size or smaller. Our knowledge of this small phytoplankton is limited. Why is our knowledge of these important organisms limited?

2. Marine cyanobacteria that are less than 5 microns in size have been the object of recent studies. They are found in intertidal and estuarine areas and less in the open ocean. The red pigment of a cynanobacteria, *Oscillatoria*, is responsible for the name and color of the Red sea. Benthic cyanobacteria are found almost everywhere light and water is available. Some grow so well that they produce dense floating mats or tarlike patches on rocks in the intertidal zone. These bacteria are not newcomers to the Earth. They are descendents from some of the earliest life forms on Earth. Fossil evidence indicates that they are very similar to those living on the Earth over 3 billion years ago. Why have the cyanobacteria lived on Earth so long?

3. Cyanobacteria have a tendency to form a symbiotic association with other organisms. Some are found in diatoms. Along the Gulf coast, many of the cyanobacteria are *attached* to larger plants, the sea grasses. These cyanobacteria are nitrogen fixers. Why do they play an important role in the fertility and productivity of the sea grass beds?

4. The most obvious and abundant members of the phytoplankton are the diatoms of the phylum, Protista. They are between 50 and 500 microns in size. The benthic diatoms are very similar to the planktonic ones. However, they are found on almost any solid surface (rocks, larger marine plants, man-made structures and the hard shells of marine animals) in shallow water. One type makes it's home on the undersides of blue whales. Benthic diatoms are key to the ecological succession of organisms that grow on docks, boats and other man-made structures. Why are they so important to life on these structures?

5. The dinophytes are Protista that have two flagella. One broad, ribbon-like flagellum circles around the cell in a groove. The other long flagellum project forward and provides forward motion to move the cell. Their cell size ranges from 25 to 1,000 microns. Use the Internet to locate pictures of some of the dinoflagellates.

6. Dinophytes can reproduce very rapidly like the diatoms. If the conditions are right, dense concentrations of dinophytes are produced quickly. These blooms may have over a million cells per liter and color the water red, brown or green. Along the East and Gulf coasts, some dinophytes produce toxins in blooms known as red tides. Red tides can kill fish and other marine vertebrates and contaminate shellfish. The Red tides can kill fish in two ways. The toxin can be fatal to certain fish or by depleting the oxygen in the water. Two dinoflagellates cause red tides in the Gulf. One does not affect shrimp or crabs but accumulates in oysters, clams and mussels; this one doesn't kill shellfish but the other does. Why are mollusks more likely to have more red tide toxin in them?

7. One of the most characteristic features of all phytoplankton is their small size. They are all microscopic. Why would smallness be a strong advantage?

8. The most vital activity of all plants is photosynthesis. This is the process where food is synthesized chemically for inorganic (nonliving) matter. Plants require sunlight as an energy source and matter—nutrients, water and carbon dioxide. On land the availability of water and nutrients determines how lush the growth will be. Which of the factors limit the growth of plants in water?

9. The density of the air is much less than that of water so what did land plants develop to remain upright? Why do land plants need leaves, roots, stems or trunks? Are the same structures required for plants in water? Explain.

10. Phytoplankton is constantly bathed in ocean water that not only provides nutrients and water but also carries away the waste. The exchange of these materials is by diffusion across the cell membrane. Is cell size a factor?

11. Conduct an investigation to determine if cell size is a factor.
    a. Fold one paper towel so it is 4 cm by 4 cm.
    b. Fold the second paper towel so it is 8 cm by 8 cm.
    c. Which paper towel has the most layers after folding? Which paper towel has the greater surface area? Which paper towel takes up the least space or has the smaller surface area to volume ratio?
    d. Place one drop of food coloring (represents wastes) in the center of each paper towel. Observe what happens and summarize your findings.
    e. If the folded paper towel represented a cell, which cell size would be more effective in getting rid of its wastes? Explain.

12. Conduct an investigation to determine if the ratio of cell surface area to volume is important.
    a. Fill a plastic cup half full with water. Add several drops of food coloring. Stir the water so the color is uniform.
    b. Obtain two cotton balls that are made of 100 percent cotton. Cut one cotton ball in half. Cut one of the halves again so you will have a one-half, and two one-fourth cotton balls.
    c. Use the forceps and place the whole cotton ball into the plastic cup of colored water. Keep the cotton ball under water for 5 seconds. After 5 seconds immediately remove the cotton ball and use the scissors to cut it in half. Note how far the food coloring soaked into the cotton ball.
    d. Repeat this with the one-half and one-fourth size cotton balls.
    e. Summarize the results of the investigation.

13. Why are the ocean's plant species microscopic, single-celled phytoplankton instead of large plants with roots, stems, leaves, flowers and seeds?

14. Satellite surveys have indicated a sharp decline in plankton in several oceans. Scientists did find a close link between the decline in plankton and increasing ocean temperatures. Phytoplankton account for about half of the carbon dioxide that plants remove from the atmosphere each year. What would be the effect of reduced numbers of plankton on the marine ecosystem and on the planet?

2. Why and How Do Marine Plants (Phytoplankton) Float?

Marine Biologist_____**Team**_____

Look outside. See all the green plants? What if they all suddenly came uprooted and flew up into the air to grow there instead of on the ground? Then cows, horses, and all the animals that eat plants would have to chase the plants in the ocean of air to get anything to eat. This sounds crazy. But there is one place on Earth that is very much like this. Plants and animals float around and are not confined to the Earth's surface. This place is the ocean. The vast majority of the plants in the ocean are phytoplankton. These are microscopic, unicellular plants that drift with the currents. This free-floating, virtually invisible plant life of the oceans is very different from the large, rooted plants on land. Why is this so? You and your team are going to investigate this.

Materials: containers of water, glue, oil, scraps of paper, cloth, foil, plastic, etc

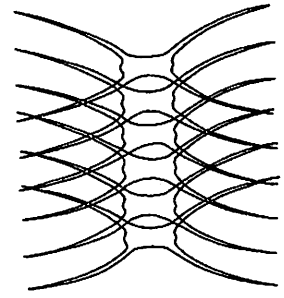
Procedure:

1. List ways that land plants differ from marine plants.

2. The striking contrast between the size of land and marine plants is the result of adapting to life in two very different kinds of fluid—air and water. How does the density of air and water compare? How would this affect plants?

3. How does the penetration of the sunlight differ in the ocean and in the atmosphere? Does sunlight reach the bottom of the ocean? Does sunlight reach the bottom of the atmosphere?

4. Marine plants must remain afloat near the water surface where sunlight is available. Look at the drawing of a marine plant (phytoplankton) in Figure 1. Use reference books and/or the internet to locate photographs or drawings of phytoplankton. Observe their shapes. Predict how might their shapes help them floats?



5. Design and sketch models of phytoplankton. Select one type of material (paper, foil, cloth, wax paper, plastic, etc.) to use in your experiment to create a model of phytoplankton.

6. Test the floating ability of each design. To avoid the model being held up by the water surface tension, wet it completely first. Measure the time it takes the different designs of the same material to sink to the bottom. Construct a table like the one below to record your data.

Table 1: Time Various Plankton Models Float

Plankton Model	Time placed in water	Time reached bottom	Total floating time

7. What shapes enabled your model to float the longest? What is the relationship between shape and floating ability?

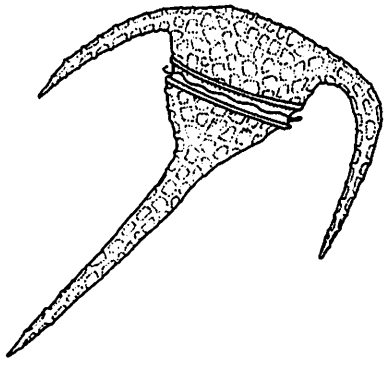
8. The ocean water is in constant motion. Repeat the experiment to determine the impact of the motion of moving water and the floating of the plankton. Construct a table like Table 2 to record the data.

Table 2: Time Various Plankton Models Float in Moving Water

Plankton Model	Time placed in water	Time reached bottom	Total Floating time

9. What is the impact of the movement of water on the plankton?

10. Why are waves and surface currents important in keeping plankton afloat?



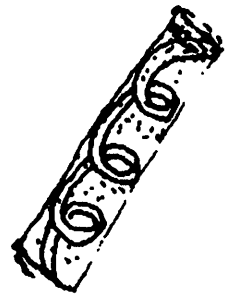
11. Some plankton produce oil and store it in their bodies. Try folding your materials so it will hold several drops of oil. How does this affect flotation?

12. Some other ways that marine plants use to improve floatation includes pores and spines on their shells and some form chains of attached plant cells. How would these help to keep the plants floating?

13. Plant cells are slightly denser than seawater so normally they would sink rather than float. The way the plant can reduce its rate of settling is to maximize its surface area, so that friction with the water retards sinking. In other words, the smaller object will have a greater surface area and more frictional drag per unit of volume than will a larger object. Construct two models of different sizes to test this.

14. Microscopic plants are very well suited to being suspended in seawater. Many phytoplankton have evolved complex shapes that increase the surface area. Cell shapes look like

ribbons, leaves or long bars. Some have bristles or spines. How does this compare to the floating ability of your designs? Test the different shapes.



15. Why is it important for phytoplankton to stay in the surface layer of the ocean?

16. The most common plant members of the ocean are the unicellular diatoms. The dinoflagellates are another important group. Research these plants to learn more about their designs and how they move.

3. What Are the Marine Plants and How Are They Adapted to a Marine Life?

Marine Biologist _____ **Team**_____

The abundant plant groups on land that are familiar on land— ferns, mosses and cone-bearing plants, are absent from the marine environment. The flowering plants are poorly represented. Most marine plants belong to the brown and red algae that are almost completely limited to the oceans. The green algae and flowering plants are most commonly found on land. However, they are found in shallow coastal marine environments where they play a major role. The majority of the attached marine plants are called seaweeds. This term is used to refer to the macroscopic algae that live in marine environments. There is no record of marine algae in the western Gulf of Mexico prior to the construction of the jetties. Humans have created a new habitat for the Gulf of Mexico and in doing so increased the marine alga in this region. About 200 species of macroscopic algae have been identified from Texas shores to Alabama. You are going to investigate the marine plants to determine how they are adapted to their environment.

Materials: aquarium or similar container, variety of materials (plastics, rubber, paper, wood, etc.), glue, scissors

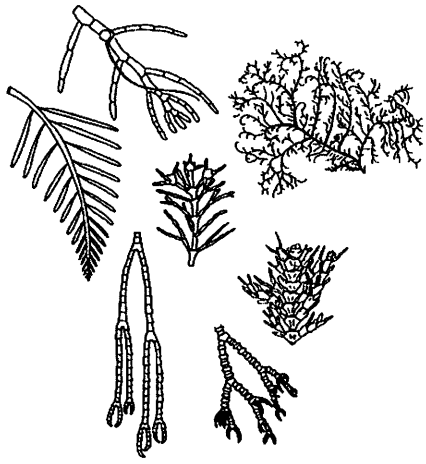
Procedure:

Part I: What are the marine algae and how are they adapted?

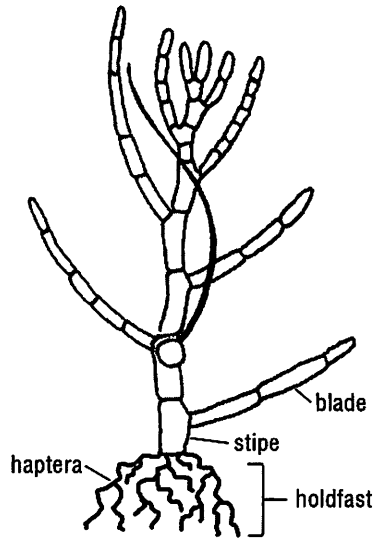
1. Seaweeds are not as complex as the flowering plants. On a separate sheet of paper, construct a table based on the following example and compare flowering land plants with marine algae. Fill in the function of each structure of the flowering plants.

Table 1: Comparison of Flowering Land Plants with Marine Algae

Flowering Land Plants- structure	Flowering Land Plants—function	Marine Algae-Structure	Marine Algae-Function
Roots		Holdfast	
Stems		Stipe	
Leaves		Blade	
Flowers		Spores and Gametes	
Seeds			



2. Use the information below to add the information on the function of the structures of the marine algae.



3. The holdfast in the larger seaweeds may look like a root system but it is not. The basic function is to attach the plant to the substrate. The holdfasts are well adapted for getting a tight grip on the substrate whether it is rock, sand or mud. The grip is so tight that the strong waves and tidal currents cannot detach it. The type of holdfast depends on the type of substrate. Why is the holdfast important to the survival of the plant?

4. A flexible, stem like stipe is the wave shock absorber between the holdfast and the wave-tossed upper parts of the seaweed. The flattened, leaf like structures of seaweeds are called the blades. Some blades blend into the holdfast without a stipe.
What would happen if the stipe was not flexible and more like the stem of land plants?

5. Using materials provided, construct and test models of the marine algae to determine which design and material is the best shock absorber of waves.

6. The blades often branch even though each begins as a young plant with a single un-branched blade. The photosynthetic cells are found in the blade but also occur in the stipes and holdfasts. Some of the algae have special conductive cells in the stipe. How does this help the algae?

7. Most algae have no conductive tissue. How do nutrients move to the different parts of the algae without conductive cells?

8. Some of the small red algae are epiphytes and attach to other marine plants like the seagrasses. How does this help the red algae?

9. Summarize and compare the flowering land plants with the marine algae.

10. The marine algae composition and diversity along the Texas coast varies with the area of the coast. The algae composition differs with the region of the coast, zones of the jetties, the side of the jetties and the seasons. There are a number of factors, including salinity, turbidity, light intensity, day length, tidal fluctuation, wave exposure, temperature and tolerance to drying, that may affect the abundance of the algae. Explain how each factor might affect the type, diversity and number of algae found in a location.

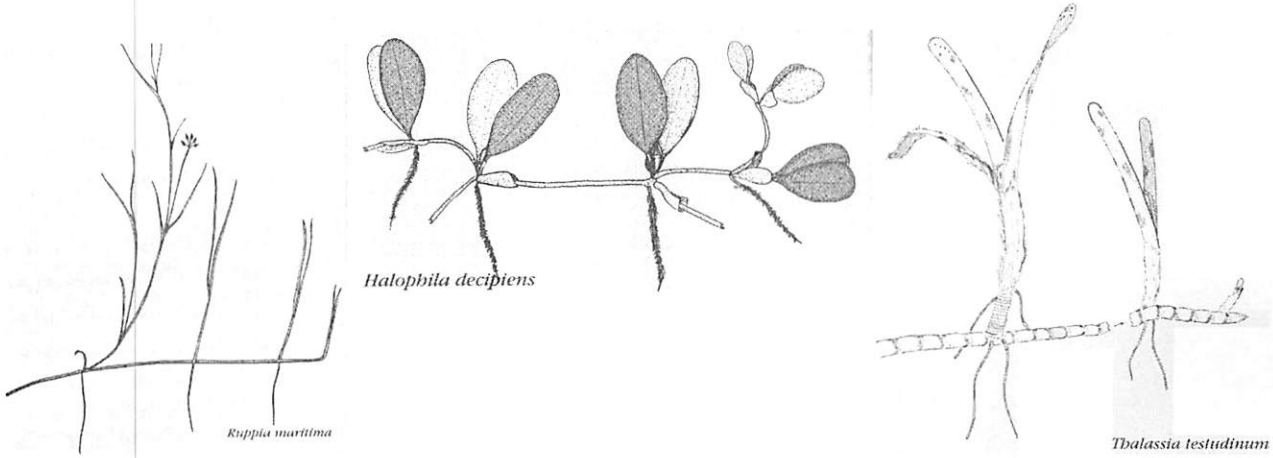
11. In addition to the physical factors that influence the distribution of the marine algae, they are also subjected to grazing by herbivores. How can the herbivores influence the distribution and diversity of marine algae?

12. Explain the impact of the jetties in creating a habitat for an entire community of marine organisms.

Part II: What are the marine flowering plants and how are they adapted?

1. Marine flowering plants are found in areas along the bays, lagoons and salt marshes. These sea grasses are exposed to the air during low tides and are seldom completely covered by seawater. They have leaves, stems and roots with water and nutrient conducting structures in their roots, stems and leaves. Eelgrass is the most common sea grass on the Texas coast. The eelgrass seeds drop in the mud and take root near the parent plant. Why are the sea grasses considered to be land plants that adapted to the marine environment?

2. The flattened, lance-shaped leaves of seagrasses slow the movement of water. As the water slows, sediments and particles are deposited. Seagrasses help to stabilize bottom sediments with root like rhizomes that grow horizontally. New plants grow up from these rhizomes to extend the bed into new areas. Collect some recycled materials or use grass to construct a model to demonstrate how sea grasses help to stabilize an area.



3. Create a series of sketches on how the model of seagrasses helps to stabilize an area and how they help to create a nutrient rich habitat for other organisms.

4. Seagrasses grow best in protected areas where the waves are not great. They can live in very salty water or in relatively fresh water. They cannot survive in turbid waters. In which habitat of the coastal zone would the seagrasses grow best? Explain.

5. Most animals are unable to eat seagrasses directly. Why is this an important factor in seagrass bed development?

6. Fungi and bacteria must break down dead seagrasses that may form a mat of material on the bottom. Here crabs and shrimp move about feeding on the seagrass particles. Burrowing worms, mollusks and mud shrimp also feed on the particles. Groups of sea urchins and sea cucumbers move through the seagrass beds feeding on the partially decomposed organic matter (detritus) in the mat of the leaves and stems. The sea grass beds are the nurseries for pink shrimp. The seagrass also provides a surface for anemones, bryozoans, algae and some larval stages to attach. Many species of fish including mullet and croaker feed on invertebrates in the seagrass beds. Large numbers of waterfowl feed in the area during the winter. Create a food chain or food web of the seagrass beds.

7. Use the food web to explain why the seagrasses and marine flowering plants are critical to the coastal zone?

8. Human activities are reducing the seagrass beds. How will this impact the coastal zone?

9. The Big Bend seagrass bed off northwestern Florida includes areas that provide grazing for the endangered manatees. Historically this area has also been a favorite feeding ground for endangered Kemp's ridley and the threatened green turtles. Conduct additional research on the seagrasses. Use this information to prepare a brochure or a poster describing the seagrasses and their importance to the marine environment and marine organisms.

4. Have You Eaten Seaweeds (Algae) This Week?

Name _____ **Team**_____

We are becoming more aware that our land resources for both food and energy are limited. Efforts are being made to conserve our nonrenewable resources. At the same time we are also developing and using more of our renewable resources. Marine algae or seaweeds fall into this category. Would you eat algae? What use have we made of algae? Few people realize that they have been eating seaweeds in one form or another for many years. Are you one of them?

Materials: Pen or pencil

Procedure:

1. Check (√) each item in the list on page 722 that you have eaten or drank in the last week.

2. How many of the items listed have you eaten in the past week?

3. Did you realize that you have been eating seaweeds in one form or another? Each of the items listed above contain extracts of seaweeds or marine algae. Actually extracts from marine algae are found in practically every type of prepared food item. We eat these completely unaware that they are in our prepared foods. The extracts are food additives and are mainly from red and brown algae. How do you feel about learning that you eat extracts from seaweed each day?

4. You cannot get through a day without coming in contact with something made from a seaweed colloid or gelling compound. Seaweed gels (algin, alginate, carrageenin, furcellaran, agar and gelatin) are found in our kitchens. Most of the extracts are used as gelling compounds that used to emulsify, stabilize and thicken food. What are colloids and gelling compounds?

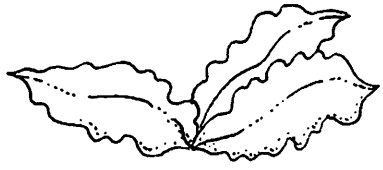
5. What effect do colloids or gelling compounds have on the food items? Select four food items from the list above and describe what the foods would be like without the algae extract.

6. Since you already eat extracts from marine algae or seaweeds, would you consider eating the whole plant? Why or why not?

Food Product Have Eaten			Food Product Have Eaten		
Dairy products	**Yes**	**No**	**Meat, fish products**	Yes	**No**
Ice cream			Canned meats		
Iced milk			Canned fish		
Milk shake			Sausages		
Sherbet					
Ice Pop or Ices			**Beverages**		
Chocolate milk			Soft drink		
Instant pudding			Fruit juice		
Cooked pudding			Beer		
Cottage cheese			Wine		
Cream cheese					
Cheese spread			**Dressings, Sauces**		
Yogurt			French dressing		
			Salad dressing		
Bakery products			Syrups, toppings		
Bread made from dough			Relish		
Cakes and icing			White sauces		
Doughnuts			Mustard		
Fruit pie			Catsup		
Jelly filled pastry			Cocktail sauce		
Meringue pie					
Cookies			**Dietetic foods**		
Frozen pie filling			Starch free dessert		
			Jelly, jam		
Confectionery Products			Syrups		
Caramels			Pudding		
Nougats			Sauce		
Marshmallows			Icing		
Candy, gels			Candies		
Miscellaneous Foods					
Jam, preserves					
Prepared cereals					
Processed baby food					
Soups					
Frozen food					
Synthetic potato chip					
Fountain topping					
Artificial cherries					

5. How Are Seaweeds (Marine Algae) Used?

Researcher(s) _____ **Team**_____



With the increase in the human population, there is a need to find more resources or new ways to use renewable resources. Seaweeds are a renewable resource. Most people think that seaweeds or marine algae are just weeds that grow in saltwater. However, you and your team are researchers for a company that specializes in finding new uses for renewable resources that others consider useless. Your group has been given the assignment of investigating seaweeds as a renewable resource that could be developed.

Materials: copies of "Survey of Use of Products Using Seaweeds" and "Uses of Seaweeds"

Procedure:

1. Individually, list on a sheet of paper all the ways that you can think that we use land plants. Spend two minutes making your list.

2. Now as a group use each person's list to make one list from your group. The recorder will combine the list to make a group list.

3. Brainstorm as a group for two more minutes to add additional ideas to your group's list. The recorder will add every additional use of plants to your group's list of all the ways that we use land plants.

Follow the Brainstorming Rules:

a. The group leader or chairperson is to make sure that everyone participates and stays on task.
b. The recorder writes down every idea that is suggested.
c. The timekeeper makes sure that the time limit is followed.
c. All ideas are welcomed. Nothing has to be explained.
e. Expand on each other's ideas.
f. Help each other. Listen. Others may trigger something in your mind or you may trigger an idea for them.
g. Work to get as many ideas as possible.

4. For five minutes, as a group, brainstorm all the possible ways that we could use seaweeds or marine algae. Follow the Brainstorming Rules in Number 3.

5. Compare your list of uses of land plants with the list of ideas for seaweeds. What do you notice? What generalization(s) can you make?
6. Seaweeds are not just a source of food for people and animals. Extracts from seaweeds are used in many nonfood products. Obtain a copy of "Survey of Use of Products using Seaweed Extracts." Place a check mark by each item that you and your family have used. Analyze the results of your survey. How many products that use seaweed extracts have you and your family used?

7. Can you go through a day without using a product that used seaweed colloids or gelling compounds? Explain.

8. Have four other people (non-family members) complete the survey. Analyze the responses of the individuals you surveyed. How many products did they use?

9. Write a two to three sentence summary about nonfood seaweed products.

10. Obtain a copy of "Uses of Seaweeds." Briefly summarize what you feel are the three most important ideas you learned about the uses of seaweeds.

11. Use "Uses of Seaweeds" as a resource to create an informational brochure on one of the following topics: Uses of Seaweeds, Seaweeds as Fertilizer, Medical Uses of Seaweed or Industrial Uses of Seaweed. After selecting your topic, decide what information you want to provide. Use the Internet and other resources to locate additional information and pictures. To make the brochure, use a sheet of 8 1/2 x 11 paper. Fold it horizontally into 3 equal sections. Plan what you will include on each side of the brochure. Be creative. Illustrate your brochure.

Survey of Use of Products Using Seaweed Extracts

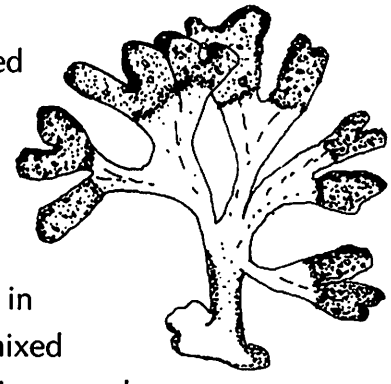
Products	Used by Family	Used by Others	Products	Used by Family	Used by Others
A. Pharmaceuticals			**C. Textiles**		
Aureomycin tablets			Size compound for cotton and rayon		
Terramycin suspensions					
Triple sulfa tablets			Textile print pastes		
Penicillin suspensions			Plastic laundry starch		
Anti-acid tablets			Fabrics stiffened or glazed		
Sulfa suspensions			**D. Adhesives**		
Aspirin compound tablets			Wall board		
Calamine lotion			Paper bags		
Hemostatic powders			Shipping containers		
Bulking laxatives			Gummed tape		
Dental impression compounds			Decals		
			E. Paper products		
Toothpaste			Food packages		
Orthopedic impression compounds			Pharmaceutical soap and detergent packages		
Surgical jellies			Milk containers		
Suppositories			Butter cartons		
Mineral oil emulsions			Frozen food packages		
Rubbing ointment			Insulation board		
Cough syrup			Food wrappers		
Hand lotions			Greaseproof paper		
Shaving cream or gel			Acoustical tile		
Hair crème			**F. Miscellaneous products**		
Cosmetics			Paints		
Shampoos			Ceramic glazes		
B. Rubber			Porcelain ware		
Natural/synthetic latex creaming and thickening			Leather finishes		
			Auto polishes		
Finished articles			Welding rod coatings		
Auto carpets			Boiler compounds		
Electrical insulation			Battery plate separators		
Babies' rubber pants			Wallboard joint cement		
Foam cushions			Beet sugar processing		
Rubber coating			Wax emulsions		
Tires			Shoe polish		
			Shoe dye		
			Linoleum		
			Artificial leather		

Uses of Seaweeds

Seaweeds are used in many coastal countries as a source of food, for industrial applications and as a fertilizer. The major use of seaweeds as food is in Asia, Pacific Island nations and Ireland. Seaweeds are harvested and cultivated in these countries. In most western countries, there has not been pressure to develop a seaweed industry.

Seaweed as Fertilizers

Seaweed has been used as a fertilizer since the time of Rome or even earlier. Since 1776, Americans have used many kinds of fertilizers and food-growing technologies. The first was the celebrated fish used by the Indians to grow corn in New England. The early settlers near Cape Cod used seaweed as a fertilizer for growing vegetables for the Boston market. It was also the favorite nutrient for growing tobacco in Connecticut. Today in the United States seaweed is not really used in agriculture.



In several European countries detached seaweeds or "drift" seaweeds have been used. The soil or sand is layered with seaweed for vegetable production, particularly potatoes. Using seaweeds has proven to be very useful in barren areas, particularly off the coasts of Ireland and Scotland. Seaweeds may also be useful in areas with soils of poor water-holding qualities. Recently in Britain, seaweeds have been used as fertilizers and soil stabilizers in the planting of the embankments along highways. Grass seed is mixed with an extract of brown algae to make a paste-like mixture. This is sprayed onto the disturbed areas. The paste keeps the seeds in place, retains moisture and holds the soil together.

Along the coasts of Spain, France, Britain and Ireland, crustose, calcareous red algae grow and collect to form large beds of stone-like algae. This is called "coral sand". The algae are made of layers of calcium and magnesium carbonates. It is dredged, dried, ground and sold as a soil additive. Over 700,000 tons are harvested yearly from live and dead deposits. The main advantage of using the algae over lime is the large amounts of trace elements present in the seaweed. Although using the algae may be more expensive, it's use is preferred by organic farmers and horticulturists. They believe that it provides trace elements that the plants they grow need. If they used lime, they would have to add "chemicals" to provide the trace elements. When this algae is ground to a powder it is also very good for water filtration.

Liquid Seaweed Extracts

Liquid extracts of marine brown algae are marketed for use in agriculture and horticulture. They are primarily used for gardens and greenhouse crops and are also exported to a wide range of countries. They have been used on citrus fruits in Guyana, on citrus and grapes in Greece, on orchids in Belgium, on garden crops in Thailand and on greenhouse crops in

Iceland. In New Zealand it is used on orchards and pastures.

Research on agricultural uses of seaweed is also limited. However, many different beneficial effects have been recorded for crops treated with liquid seaweed extracts. The results include: increased crop yield; improved seed germination; increased uptake and use of inorganic nutrient from the soil; increased resistance of plants to frost, fungal and insect attack, and plant diseases; and reductions in storage losses of fruits.

For 200 years, crop and livestock wastes and the nitrogen cycle was the main source of fertilizer in agriculture. Then with the discovery of petrochemicals, the United States in 30 years went "chemical". Agriculture's energy base moved from organic wastes and the nitrogen cycle to petrochemicals—oil and gas. Petrochemicals are used to produce pesticides and fertilizers and to run the machinery to harvest, process and transport the food. Fossil fuels are not an unlimited resource. In addition, the petrochemical industry generates toxic wastes and burning the fossil fuels has an impact on the environment.

Seaweed extracts definitely offer ingredients that could be used in fertilizers. The use of seaweeds in agriculture could provide a nontoxic, nonpolluting and non-petrochemical alternative to the present petrochemical based products that are used. In the search for alternatives to the use of fossil fuels, seaweeds could be an alternative. The uses of the seaweeds or marine algae may only be limited by our attitudes and knowledge. Even more important than all these uses, however, is still the fact that as much as 90 percent of all photosynthesis is accomplished by marine algae. Marine algae may also be used as energy-collectors.

Seaweed Industrial Gums

The term "industrial gums" is a generic term used for products from animals and plants that affect viscosity. The three groups of industrial gums extracted from seaweed are: alginates, agars and carrageenans. Alginates are extracted solely from brown seaweeds while the others are extracted from red seaweeds. Figure 1 provides the value of seaweed gum production. There are a number of artificial products that claim to be replacements for seaweed gums. However, none have the exact gelling properties of seaweeds.

International Seaweed Gums Market

Seaweed gum	Total(Tons)	Price($ Per kg)	Total Value($ Million)
Agar	10,161	20	203
Carrageenan	25,403	8	203
Alginates	>25,000	6	150
Total	>61,000	-	560

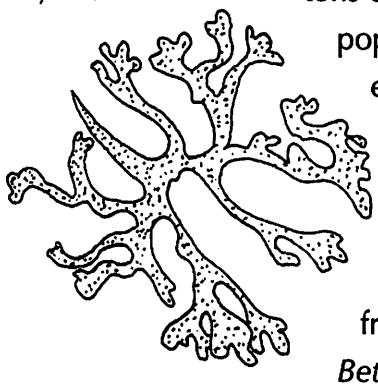
Production and value of international seaweed gums market, 1995
(Sources: Quest International, Cork and IMR International, San Diego)

Alginates are materials found in the cell walls of brown algae. They are used as emulsifiers, suspending agents, stabilizers, gelling agents and thickeners. Alginates are widely used in the

textile industry because they form excellent dressing and polishing material. They are also used as a thickening paste for colors in printing textiles. They serve as a hardener and thickener for joining threads in weaving that can be dissolved away to give special effects to the material. Other uses include glazing and sizing paper, special printers' inks, paints, cosmetics, insecticides and pharmaceutical preparations. Alginates take up atomically heavy metals. For example, lead and other heavy metals will be taken up in preference to sodium, potassium and other "lighter" metals. Therefore, alginates are useful in lead and strontium-90 poisoning.

About 25,000 tons of alginates per year are extracted worldwide from large brown seaweeds, *Laminaria, Ascophyllum and Macrocystis*. The main producers are Scotland, Norway, China and the United States, with smaller amounts being produced in Canada, Japan, Chile, France and Spain. In the US, the giant kelp, *Macrocystis pyrifera* is used. It is the largest seaweed in the world and is capable of growing up to 50 cm per day. It is harvested from large beds off the coasts of California and Mexico. Some 120,000 tons of wet weight are gathered each year using ships equipped with cutting machinery.

Agar is a general name for polysaccharides extracted from certain kinds of red algae, *Pterocladia, Gelidium* and *Gracilaria*. They are harvested by hand from natural populations. At present, there is no commercial mariculture of agar-producing seaweeds, although about 10,000 tons of agar is produced worldwide. There is a shortage of natural populations of agar-producing seaweeds, so a high quality agar is expensive. Its greatest use is as a substrate for culturing microorganisms and other laboratory applications. It is also used in the food industry in canned foods, bakery products and various ice creams.



Carrageenan is a general name for polysaccharides extracted from *Chondrus, Gymnogongrus, Eucheuma, Ahnfeltia, Gigartina, Betaphykus* and *Kappaphycus*. About 25,000 tons of carrageen is manufactured worldwide. Today it is a product that is a mixture of various types of carrageenan to make a gel with particular properties. Most is collected from natural populations using long-handled rakes and dredges from small boats. It is then dried and exported to the US and Denmark for processing. It is used as an emulsifier, stabilizer, gelling agent and thickener in primarily food products such as ice creams, milk, shakes and instant deserts. It is also used as a suspending agent in soft drinks.

Medicinal Uses

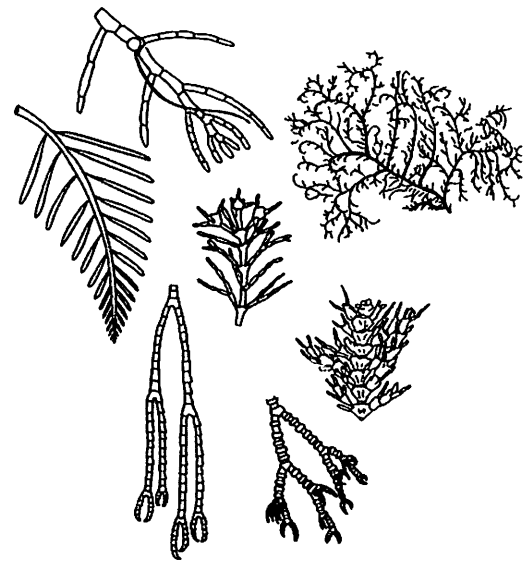
Many claims have been made that seaweeds are effective in treating arthritis, colds, flu, tumors, intestinal worms and lung diseases. However, research is needed to determine if any effect is, in fact, due to substances in the algae. Does it really work? There are some medical uses that are known to be effective. *Laminaria* and *Sargassum* species have been used in

China for the treatment of cancer. The polysaccharides in the algae seem to inhibit cancerous tumors in animals. Dry Laminaria stipes are used in obstetrics to dilate the cervix during childbirth. Extracts from two red algae (*Dumontiaceae)* have been found to inhibit the herpes simplex virus but no tests have been conducted on humans. Another red algae (*Ptilota)* produces a protein (a lectin), which causes human type B red blood cells to clump. Extracts from it are being marketed. Another discovery that may be important is an extract obtained only from the carragheen group found in *Chondrus;* even when greatly diluted, it acts as a blood anti-coagulant. However, many of the reported medicinal effects of marine algae have not been tested and verified.

Have you ever had a cut or burn which was bandaged, remember what it felt like to take the tape and bandage off. Imagine using a bandage that you could painlessly dissolve away by washing it in salt water. Calcium alginate is used to make dressings that are very suitable for burns and extensive wounds. The calcium alginate is made into a fiber that is then woven to make a gauze-like product. The gauze-like product is used to bandage a wound or burn. When it is put on the burn or wound, it provides a network around which a scab can form. This bandage can be removed by soaking it in saltwater solution. It is dissolved by the saltwater. Removing regular bandages causes a lot of pain and often removes the scab or disrupts the wound. Research on extracts from seaweeds for medicines have been limited so it is possible that there may be medicinal uses waiting to be discovered.

6. Are They Seaweeds or Sea Vegetables?

Scientist _____ **Team**_____



What do you think of when you see or hear the word "vegetable"? You hear someone talking about plants and they use the word "weed" to describe them, what words do you think of that would describe the plants? You hear someone talking about the marine algae along the coast, do you think of them as seaweeds or sea vegetables? You are going to evaluate marine algae to determine if they should be called seaweeds or sea vegetables.

Materials: Copy of "Algae as Food- Past and Present"

Procedure:

1. Read "Algae as Food – Past and Present". After reading the article, would you support calling marine algae sea vegetables?
   Reasons for supporting:
   Reasons for opposing:
   Your decision:

2. Conduct a survey to determine what people think of marine algae or seaweeds. You might use the following questions as a part of your survey. You may add additional questions to your survey.
   a. Would you eat seaweeds? Why or Why not?
   b. Do you think that seaweeds are eaten by people? Explain.
   c. Would you be willing to taste foods made from seaweeds? Why or why not?
   d. What flavor or taste do you think that seaweeds would have?
   e. Do you know that people in many countries including the United States use marine algae (seaweeds) as sea vegetables?

3. Summarize your survey results. What did you learn about people and their ideas about marine algae as a food?

4. Compare you survey results with that of your classmates. Were the results the same or different?

5. Were all the responses to your survey questions the same? Or were there differences? If there were differences, analyze the results. For example did the age, sex or ethnic background of a person affect their responses?

6. Use "Algae as Food- Past and Present" as a resource to create an informational brochure on "Sea Vegetables –The Healthy Choice" or "Seaweeds as Seafood" or create your own title. Use the Internet and other resources to locate additional information on using algae for food or recipes using algae and pictures. Decide what information you want to provide in your brochure. To make the brochure, use a sheet of 8 1/2 x 11 paper. Fold it horizontally into 3 equal sections. Plan what you will include on each side of the brochure. Be creative. Illustrate your brochure.

7. Conduct a survey of your neighborhood, town or city to determine the availability of marine algae. Check the grocery stores and health food stores. What did you learn?

Algae as Food–Past and Present

In our English language the suffix "weed" has been used to describe marine algae. Webster's dictionary defines weed as a plant of no value. This has defined the value and the way that many people look at marine algae. In many parts of the world, the edible seaweeds are appreciated for they truly are, sea vegetables. A vegetable is defined as a plant grown for an edible part that is usually eaten with a meal. For those who dislike the idea of eating weeds, they need to remember that our spices, like thyme, mint, sage and oregano, are in fact weeds. Certain algae might, based on their use, be considered herbs or spices. In general, the sea plants are more like land vegetables.

Another mistaken idea is that sea vegetables (marine algae) are only eaten in poor countries and in times of famine. Although people have depended on algae in times of hardship, to consider algae only as a food for survival is a mistake. This has colored the way in which many people view the idea of eating these plants. It is possible that a taste for some of the individual flavors in the algae might have to be acquired. The same can be said for land vegetables like broccoli, cabbage, Brussels sprouts or any other of the stronger tasting vegetables. In Asian countries sea vegetables are part of the daily diet. Actually the algae are used as vegetables wherever the local coast will support its growth and marine animals will allow it to grow. It is a part of basic cooking from the subarctic to the subtropics around the globe. Countries whose landmass is either too small or too poor to support farming or raising animals for food have in the past depended on algae as a source of food. Areas where the climatic conditions are harsh have relied on marine algae as a year-round source of fresh vegetables.

Since the beginning of time, people have appreciated the different tastes and textures and were fascinated by the beauty of the many forms of algae; in much the same way they appre-

ciate land vegetables. Seaweed has been used in Japan and China as a food for a very long time. The use of kelps ("kombu" in Japan; "haidai" in China) dates back at least to the 5th century in China. In 600 B.C., Sze Teu wrote in China, "Some algae are a delicacy fit for the most honored guests, even the King himself." A Chinese Book of Poetry documents the esteem that these plants were held from 800 to 600 B.C. So even at the time of Confucius, algae were thought of as something special. Japanese court poetry also reflected the appreciation of algae with expressions like "gemlike seaweed" and "seaweed glows like gems" were commonly used. Here is an example that shows this.

Love
Although no fisher
Reaping the gemlike seaweed,
I yearn for you
So deeply that the salt spray
Never dries upon my sleeves

In Iceland, the oldest law book (961 B. C.) makes reference to the rights and concessions involved before a person could collect and/or eat fresh sol (Palmaria palmata) on a neighbor's land. Ancient Hawaiian nobility kept limu gardens. It was important to have a fresh supply of plants that were instantly available for eating at all times. A limu garden was maintained in Honolulu at the residence once belonging to Queen Liluiokalani. After World War II, the eating of algae fell out of favor. Fast foods have resulted in the discarding of traditions. This is also true of other cultures.

In Japan algae was also considered to be a delicacy fine enough to serve as an offering to the gods. In Japan it is still possible to have a meal where several kinds of algal foods are served. The cooking of algae developed by the Japanese is still popular today. Some 21 species of algae are used in everyday cooking in Japan, six of them since the 8th century. Seaweed accounts for some 10% of the Japanese diet and seaweed consumption averaged 3.5 kilograms per household. Most important are Nori (Porphyra species), Kombu (Laminaria species) and Wakame (Undaria species). The plants are dried after harvesting and either cut into strips or powdered. In Japan, kombu is used in the preparation of fish, meat dishes, and soups and also as a vegetable with rice. Powdered kombu is used in sauces and soups or is added to rice in the same way as curry. Some kinds are used to make a drink like tea. The algae are collected from wild sources and are also cultivated. Laminaria is grown by planting blasted areas of rocky shores, ropes or nets. The Chinese imported it from Japan from the 5th century until the founding of the People's Republic. In the early 1950's they began to grow it.

Another kelp (Undaria pinnatifida) is widely used in Japan (where it is known as "wakame") and China ("qundai-cai") as food. In Japan, it is a more important crop than Laminaria. Natural production was increased by placing stones on the sea bottom and blasting reefs to provide more areas for the algae to attach and grow. Annual production from these

natural habitats was 40,000 to 60,000 tons. Growing the algae on ropes in the water has been part of algae farming since 1955. The harvested algae are dried after washing in freshwater. After resoaking, the plant material is used as an additive to soups. Wakame soup is served with almost every meal in Japan. Wakame is also toasted, used with boiled rice and coated in sugar and canned.

Nori (Porphyra species) is a red algae. Since the 17th century Japanese fishermen have planted either bamboo or brushwood in shallow waters to increase the area for nori to grow. It is also grown artificially on ropes in the water. Nori is sold in sheets that may be toasted, then flaked and added to sauces, soups and broth. Small dry nori sheets are used to wrap cold rice balls, which make a popular lunchtime snack for Japanese children.

Most primitive coastal societies from Siberian Indians to the Aborigines of Tasmania have used algae as a part of their daily diet. Dulse was gathered and eaten by the Vikings. Findings in the dwellings of Stone Age South Africans indicate that they regularly ate algae. Even the early American colonists imported large quantities of Irish Moss (Chondrus crispus) to make their favorite deserts. In the 1800's, the colonists in Massachusetts were farming large beds of Irish Moss. It was even a booming industry in Scituate, Massachusetts.

Not all use of algae as food has fallen out of use. Today, in the British Isles, laverbread is still made from red algae, Porphyra leucosticta. It is boiled until it is soft like cooked spinach. It is flatten into small cakes, rolled in oatmeal, then fried to make a breakfast food. In Canada, dulse (Palmaria palmata) is used to make chips, which are sold in pubs to eat while drinking beer. It is considered an improvement on potato chips. In Russia, a particular species of algae is prepared with beets and tomatoes and is canned and sold as sea cabbage. In Siberia, Palmaria palmata is fermented into an alcoholic beverage. In Southeast Asia, large amounts of sea vegetables are eaten daily. In the Philippines, China, Japan and Korea marine algae is cultivated in every bay and stretch of useable coast. They are harvested daily for the fresh vegetable market.

As people have migrated to new regions, they have experimented with the local algae. Species resembling or identical to those found in their native countries are soon used in their meals. On the West coast of the United States and Canada, wherein the Russian, Philippines, Japanese, Korean, Chinese and Hawaiian communities, local species of algae are used extensively in cooking. Also small groups of algae gathers and uses are found in the Boston area and parts of Maine. With the movement of people from Southeast Asia into the inland areas, algae is being imported inland. Grocery stores in these areas are beginning to import sea vegetables and ethnic grocery stores are being established to meet the need for sea vegetables. In recent years an important factor affecting the popularity and availability of sea vegetables has been the movement to natural foods. So now sun-dried sea vegetables can be bought in local health food stores.

The algal flavors are not salty or fishy as might be expected. Some might be described as

having a bean like, nut like or even celery or grape flavor. The flavors produced by algae are unique and are not like those of land plants, so they are difficult to describe. There are a lot of different flavors among the sea vegetables, just as there are among land vegetables. The flavor is affected by the available nutrients, light, water conditions and quality of the substrate of the sea floor in the area where it grows. Therefore the same species may be delicious from one area and have a poor taste from another area. Or it may be delicious in the winter and not in the summer. In the past, most of the algae were dried or salt was used to preserve it so that the natural taste wasn't lost. Today with refrigeration, the algae can be kept fresh longer or frozen so that it will still have its delicate fresh taste when it reaches stores in the United States.

Since the beginning of history hundreds of species of marine algae have been eaten by different people. They were liked for their different tastes and textures. People were fascinated by their beauty and diversity. They appreciated marine algae much like we appreciate land vegetables. In many parts of the world, the edible seaweeds are appreciated for what they really are, sea vegetables.

7. Are Seaweeds Good for You?

Nutritionist(s)_____ **Team**_____

Have your parents ever told you to eat something because it was good for you? You have probably heard commercials or seen ads for cereals or other foods that provide the minimum daily requirements of a number of vitamins and minerals. In science and health classes you learned that the most important thing about food is whether is provides the proper nutrients. You learned that your daily diet should include the proper amounts of carbohydrates, fats and oils, proteins, vitamins, minerals and water. You are going to evaluate seaweeds to determine if they are really "good for you". Can seaweeds provide the nutrients needed for your daily diet?

Materials: samples of algae, include agar; sectioned test trays or spot plates or 1 oz. plastic proportion cups; corn starch, 0.1% iodine solution (starch test); brown paper lunch bag cut into 5 cm (fat test) squares; Tes-Tape strips (glucose test); Coomassie blue paper (protein test); droppers; dropper bottle of water; toothpicks; forceps; teaspoon, starch, corn syrup, developing solution for protein test papers (.5 liter, 1 pint) of white vinegar with .5 liter of rubbing alcohol in a plastic quart mixing bottle

Procedure:

You are going to test algae for nutrients. Follow the instructions for each test.

1. Testing Algae for Starch (carbohydrate)
   a. Prepare a record sheet on a page of notebook paper as shown in Table 1. Record your predictions using the following codes: Present (+), Not present (-) or Don't Know (DK)

Table 1: Marine Algae Nutrient Tests

Sample	Prediction of: Starch	Results of Starch test	Prediction of Glucose	Results of Glucose test	Prediction of Fat	Results of Fat test	Prediction of Protein	Results of Protein test
#1								
#2								
#3								

   b. Obtain the test materials from the supply area.
   c. Label the sections of the test tray or cups: Control, Starch sample, Algae #1, Algae #2, Algae #3, etc.
   d. Put two drops of iodine in the control section. Observe the iodine and record your observations on the record sheet.
   e. Add a teaspoon of cornstarch to the section or cup labeled starch sample. Add two

drops of water to the starch sample. Stir the sample and water well with a toothpick. Observe. Record your observations on the record sheet. Foods with large amounts of starch turn purple-black when iodine is added. Those with lesser amounts turn a faint purple-black.

f. Remove the piece of algae from the sample bag. Use your forceps to tear the algae sample into small pieces. (Do not touch the algae with your fingers since your fingers may contaminate the sample). Place a teaspoonful of the sample into a test tray or cup. Make sure that the number of the sample matches the number of the test tray section or cup.
g. Add two drops of water to the algae sample. Stir the algae and water well with a toothpick.
h. Repeat steps (d) and (e) for each sample. Be sure to use a different toothpick for each sample.
i. Add two drops of iodine to the algae and water. Record your observations and test results on the record sheet.
j. Repeat step (g) with each sample.

2. Testing Algae for Glucose
   a. Obtain the test materials from the supply area.
   b. Label the sections of the test tray or cups: Control, Glucose sample, Algae #1, Algae #2, Algae #3, etc.
   c. Put two drops of water in the control section. Add a teaspoon of corn syrup to the section or cup labeled glucose sample. Add two drops of water to the corn syrup sample. Stir the sample and water well with a toothpick. Observe. Record your observations on the record sheet. Foods with large glucose turn the yellow test tape bright green.
   d. Remove the piece of algae from the sample bag. Use your forceps to tear the algae sample into small pieces. (Do not touch the algae with your fingers since your fingers may contaminate the sample). Place a teaspoonful of the sample into a test tray or cup. Make sure that the number of the sample matches the number of the test tray section or cup.
   e. Add two drops of water to the algae sample. Stir the algae and water well with a toothpick.
   f. Repeat steps (d) and (e) for each sample. Be sure to use a different toothpick for each sample.)
   g. Use the forceps to put one strip of glucose test paper in each section with the algae and water. Be sure at least half of every glucose test paper is wet. Wait a few seconds and then observe the color of the paper. Check the color table on the Tes-Tape dispenser to

see if glucose is present. Record your observations and test results on the record sheet. Tape the test paper on the record sheet.

h. Repeat step (g) with each sample.

3. Testing Algae for Fats
   a. Remove a brown paper square for each algae to be tested.
   b. Put a very small spoon of shortening on a piece of brown paper labeled fat sample. Wipe your fingers with a paper towel. Then with your fingers rub the sample against the brown paper. Let the paper dry. Note the grease spot on the paper. Food containing fat or oil produces a grease spot on brown paper. The more fat the more intense the grease spot.
   c. Put a small spoon of each algae sample on a piece of brown paper numbered to match the sample. Make sure the algae numbers, spoon numbers and paper numbers all match.
   d. Wipe your fingers with a paper towel. Then, with your fingers take the algae sample and rub it hard against the brown paper with the number that matches the sample. Record your observations on the record sheet.
   e. Repeat this process for each sample.

4. Testing Algae for Protein
   a. Hold the protein test papers with forceps to avoid contamination. Number the test papers to match the algae sample numbers. Write the number on the white end.
   b. Remove a peanut's papery skin. Put the peanut into the test tray section or cup labeled protein sample. Use the forceps to crumble or crush the peanut.
   c. Put a small spoonful of each of the algae samples into test tray sections or cups. Make sure the sample number, spoon number and section or cup number match.
   d. Put three drops of water on each food in the tray. Use different toothpicks for each sample to mix each until it is wet.
   e. Use the toothpick to mash a bit of the dampened algae sample onto the blue part of the appropriately numbered protein test paper.
   f. With toothpicks, brush off any extra algae sample from the test paper. Use a paper towel to blot it dry.
   g. Using forceps, place all the protein test papers in the developing solution so that the blue tip is in the solution. Leave the test papers in the developing solution for five minutes. Use a toothpick to keep stirring the papers around in the liquid.
   h. After five minutes, remove the protein test papers from the developing solution and place them on a paper towel.
   i. Compare your results with the control. (If the blue color remains on the test paper, the

sample contains protein). If the blue color fades, the sample contains a small amount of protein. If the blue color almost disappears, the sample does not contain protein.) Record the results in your record sheet.

j. Tape the protein test papers to your record sheet.

5. Clean up after each test.
   a. Return the iodine and unused test tapes to the materials area.
   b. Flush the developing solution for the protein test down the drain.
   c. Discard all the samples in the test trays or cups and used toothpicks into a plastic lined disposal box or can.
   d. Wash the test trays, cups and forceps in soapy water, rinse them in clean water and wipe them dry. Return them to the materials area.

6. Which nutrients did the algae samples contain?

7. Based on your results are seaweeds healthy? Why?

8. Compare your results with the data in the table on Chemical Composition of Seaweeds. The table gives the chemical composition of selected, representative seaweeds, some of which are currently used for food or have been used for food in the past.

Chemical Composition of Seaweeds

	Ascophyllum nodosum	***Laminaria digitata***	***Alaria esculenta***	***Palmaria palmata***	***Porphyra* sp.**	***Porphyra yezoensis***	***Ulva* species**
Type	Brown	Brown	Brown	Red	Red	Red	Green
Water (%)	70-85	73-90	73-86	79-88	86	Nd	78
Ash	15-25	73-90	73-86	15-30	8-16	7.8	13-22
Total Carbohydrates	-nd	-nd	-nd	-nd	40	44.4	42.46
Alginic acid	15-30	20-45	21-42	0	0	0	0
Other Carbohydrates	c. 10	1-2	1-2	nd	nd	nd	nd
Protein	5-10	8-15	9-18	8-25	33-47	43.6	15-25
Fat	2-7	1-2	1-2	0.3-0.8	0.7	2.1	0.6-0.7
Potassium	2-3	1.3-3.8	nd	7-9	3.3	2.4	0.7
Sodium	3-4	0.9-2.2	nd	2.0-2.5	nd	0.6	3.3
Magnesium	0.5-0.9	0.5-0.8	nd	0.4-0.5	2.0	nd	nd
Iodine	0.01-0.1	0.3-1.1	0.05	0.01-0.1	0.0005	nd	nd

NOTE: All figures, except for water (as percentage), are given as grams per 100 grams of dry matter. When no data are available "nd" is inserted.

9. Analyze the data in the table: Chemical Composition of Seaweeds. Write a paragraph summarizing the nutritional value of seaweeds.

10. Read "Sea Vegetables and Nutrition." Use the information from the readings, your testing algae for nutrients and the table on the Chemical Composition of Seaweeds to create a brochure that stresses the nutritional value of sea vegetables and encourages people to use sea vegetables.

Sea Vegetables and Nutrition

Marine algae are among the most nutritious plants on earth. They contain all the elements the body needs for healthy growth. The nutritional value of sea vegetables are greater than those found in any other food source. Over fifty elements are found dissolved in the seawater in which sea vegetables grow. The elements available for the sea vegetables are much greater than the concentration of elements in soil that are available to land plants. The algae also have the ability to concentrate the elements present in the surrounding water more than a thousand times. Land plants will use up the elements in the soil, but the elements that algae takes from the seawater is constantly being replaced by nature. As is the case with land plants, the nutritional value of the sea vegetables varies from genus to genus and also with the season and the growing environment.

Water

Most sea vegetables are largely water when fresh, as are land vegetables. Tougher species will have less water. Algae are 70 to 90 percent water.

Carbohydrates

All algae contain carbohydrates (sugars and starches). They differ from other foods in that algal carbohydrates are polysaccharides. This is a natural colloidal substance referred to as a gel. The algal gels are used as stabilizers and gelatins in many prepared foods. At one time it was thought that humans could not digest the algal carbohydrates. However, if algae are eaten regularly for a few weeks, the human digestive tract appears to acquire the ability to digest it.

Fats or Oils

Many algae contain fats and oils. However, the calories and cholesterol are very small. The fat content in algae ranges from 1 to 8 percent. Algae that are above the water at low tide are often high in fats and oils. It is speculated that the higher amount of fats and oils is needed to keep them from drying out.

Protein

The amount of protein in algae may be as much 25 percent of the dry weight. The level of

protein depends on the species, season, habitat, depth in which it grows, age of the plant and the part sampled. Most algae contain proteins that are easily digested. Many species have a digestibility factor of more than 75 percent. Marine algae are similar to oats in both protein and carbohydrate value. Three ounces (100 grams) of dried *Porphyra tenera* (nori) supplies one-half the daily adult protein requirement. This is higher than rice or soybeans in protein value.

Vitamins

Marine algae are an excellent source of vitamins and possess all the vitamins. The algae obtain their vitamins from bacteria living on the plants or growing in the seawater surrounding the algae. The amount of any vitamin concentrated by a particular algae depends on the type of bacteria and the alga's ability to concentrate that vitamin. It appears that Vitamin B_{12} is actually synthesized by the plants themselves.

Most algae are rich in vitamins A and E. Oils from various algae contain a thousand times more vitamins A and D than are contained in equal amounts of cod-liver oil. The vitamins in the cod probably came from the algae it ate. The vitamin A content of Green and Brown algae is similar to the amount found in cabbage. Species of *Porphyra* also have been found with 36,000 to 50,000 IU per gram of vitamin A. Chicken eggs have 850 IU and chicken livers only have10,000 IU. Liver, which is the richest in vitamin B12, contains a smaller amount in grams by dry weight than do some of the Green algae. *Porphyra,* the genus richest in vitamin C, has as much vitamin C as lemons or 1.5 times that of oranges. The Red algae *Palmaria palmata* contains half as much vitamin C as found in oranges. Interestingly, the Angmagssalik Eskimos get 50 percent of their dietary vitamin C from sea vegetables. A hundred grams of algae can provide more than the necessary daily intake of vitamins A, B_2 and B_{12} and 67 percent of vitamin C.

Minerals

All species of algae are rich in minerals. Seawater and sea vegetables contain all elements necessary; however, seawater is low in both calcium and phosphorous. Algae also have the ability to concentrate the elements found in seawater. For example, one tablespoon of cooked hijiki (*Hizikia fusiforme),* is approximately equal to one glass of whole milk. Some species contain 50 times more iron than wheat while others contain as much iron as is found in whole wheat. Iodine is present in most sea vegetables.

Trace Elements

All sea vegetables contain trace elements. Our blood contains all of the elements found in seawater. Since algae remove elements from seawater, eating algae is the best way to provide the body with the needed trace elements.

Marine algae are not seaweeds but sea vegetables that provide the nutrients needed by people to remain healthy.

8. Who Are the Zooplankton and How Do They Get Their Food?

Marine Biologist _____ **Team** _____

The animal counterparts of the phytoplankton are the zooplankton. The zooplanktons include the temporary plankton. These include the larval stages of fish. The permanent plankton includes protozoans, cnidarians, ctenophores, mollusks and crustaceans. Crustaceans are the most numerous and widespread. They are a major part of the near-surface plankton communities. You are going to investigate several of the permanent zooplankton to learn more about their role and how they obtain their food.

Procedure:

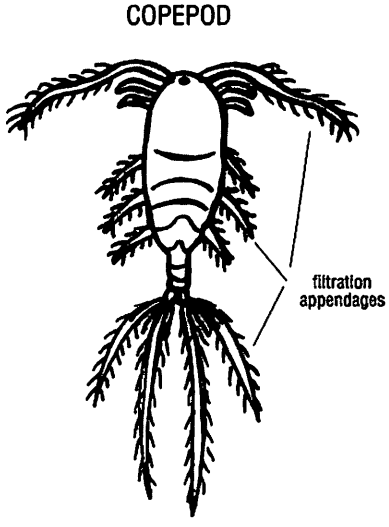
Part I: What are some of the common zooplankton

1. The foraminifera (forams) are in the phylum, Protista. They are single-celled zooplanktons that secrete a chambered shell of calcium carbonate. They are only two millimeters or less in size. What are the advantages and disadvantages of having a shell?

2. The planktonic forams are found in the top 100 meters of the oceans. Why are they found only in the surface water?

3. In order to get food, the shells of the forams have numerous pores. They extend the protoplasm out of their cell through the pores and capture small organisms such as diatoms and other bits of organic matter. The food is engulfed by the cytoplasm of the cell and chemically broken down by enzymes. Why are the forams called "armored" amoebas?

4. Copepods eat a range of organic particles including minute bacteria, diatoms, protozoans, small fish eggs and phytoplankton. They capture the smaller food with a basketlike filtering mechanism created by their feathery feeding appendages. The hair like projections on the appendages is so fine they can trap food particles that are 10 microns. The food particles are carried into the filter basket by currents that they create with the feeding appendages. Measure a length of 2 mm on a paper. This is the length of an adult copepod. Using its appendages it can filter as much as 1 liter of water per day.



5. The feeding action moves them forward in the water. They have feathery antennae with sensors that extend out to the sides. What is the function of the antennae?

6. If a food particle is detected, the copepod quickly adjusts its swimming direction to bring the particle within reach of a feeding appendage. The mouthparts then grab the food particle. When phytoplankton populations of a particular cell size become more abundant, copepods shift to feed on them. As a certain food particle increases in density, copepods will eat more of that size, up to a critical point. If the food particle concentration decreases, the copepods will shift to another food source. Explain how this keeps the phytoplankton populations balanced.

7. In contrast to the filter feeding devices of the crustaceans, many gelatinous plankton rely on nets or webs of mucus. How can this method be used to trap food?

8. The zooplankton use a variety of methods to remove food particles including phytoplankton from the water. Why are the zooplanktons an important link in the food chain, especially one that includes Baleen whales?

Part II: Why do the zooplankton migrate vertically?

1. The collections of zooplankton from different depths at different times through the day show that more animals are near the surface at night and move down during the day. Observations from submersible vehicles support this. Underwater echo sounding by ships has been used to study this movement. The animals ascend to the surface at dusk and then break up. At daybreak the layers of animals reform and they descend to their usual daytime depths. What are some possible explanations for the adaptive value of this vertical migration?

2. If they are moving up to eat in the photic zone, why are they moving up at night instead of during the day? Why don't they stay in the photic zone after eating?

3. If light intensity is the most likely stimulus for the vertical migration, what happens on a bright moonlight night? What would happen if lights were lower into the water at night?

4. What would be the effect of a solar eclipse on the vertical migration?

5. Examine this daily migration from a copepod's viewpoint. A copepod is 1 mm in total length. It spends its days at depths of 450 meters and migrates to within 150 meters of the surface at night. How many meters is the copepod traveling in this daily trip?

6. The total distance the copepod swims is equal to 600,000 body lengths. Multiply your height in feet by 600,000 body lengths. How many feet would you have to swim?

7. A mile is equal to 5,280 feet. How many miles would you need to swim to equal the copepods daily trip?

8. Not only does the copepod swim this distance, it does it very rapidly. A 1 mm copepod swims at a rate of 50 m/hour. This means it is moving about 14 body lengths per second. Olympic class swimmers swim at the rate of just 1.6 body lengths per second. How much faster does the copepod swim?

9. The force of the liquid is much greater on small objects like the copepod. For the small copepod swimming in seawater is like swimming in molasses. Explain why the daily migration of zooplankton like copepods is such a fantastic accomplishment.

9. What Is So Unusual about Coral and the Coral Reef?

Marine Biologist _____ **Team** _____

Coral Reefs are famous for a diversity of organisms like the rain forests. The reefs are known for its endless colors and for amazing biological interactions. The dense colonies of coral form an intricate network of habitats that provide for the diversity of other animals. A listing of the types, colors, sizes and shapes, specialized structures, habitats and behaviors would be encyclopedic. The great diversity of species on coral reefs is legendary and rivals that of tropical rain forests. Think of any land ecosystem, a rain forest, tropical jungle or a field. These are all dominated by a great variety of plants (the producers) and have only a handful of animal species (the consumers). The typical coral reef contains a large number of consumers and just a few plants. The coral animals that create the reef feed by removing plankton from the water. The sponges on the reef also feed on plankton, yet the tropical seas have little plankton. One of the most important requirements for reef building coral is clear, well-lighted water, yet coral is an animal, not a plant, which needs light. You are going to investigate this puzzle.

Procedure:

1. Think about the paragraph above. How can an ecosystem have very few plants and a great number of animals? What are some possible explanations?

2. One of the primary requirements of reef building corals is the presence of well-lighted water. The water must have a very low turbidity. So dependent are the reef building corals upon light, that below a depth of 50 meters most species disappear. Why would animals like the coral live only in clear, shallow water? List some possible explanations.

3. Reef organisms, such as corals and sponges, feed on plankton. The waters around the reefs have little plankton. Why don't the reef organisms starve to death? List some possible explanations.

4. Biologists found this puzzling too. To find the answer they began by examining the reef-forming corals in detail. They belong to the phylum, Cnidaria. The reef-building coral secrete calcium carbonate and are members of the class Anthozoa. All anthozoans have radial symmetry. This is an adaptation for animals that are immobile and permanently attached, such as corals and sea anemones. Anthozoans include the soft corals, sea fans and sea pens. They have eight featherlike tentacles. Another group has a mouth surrounded by groups of six smooth tentacles, which includes the sea anemones, stony corals, false corals and black corals. Only one group, the stony corals, form coral reefs. They

have a ring of tentacles around the mouth. The tentacles are armed with nematocysts (stinging cells) that capture their prey and push it into their gastrovascular cavity, where it is digested. Based on this information, are they corals, plants or animals? Are they herbivores or carnivores? What evidence is there to support your answer?

5. Examine Figure 1. Note that coral animals consist of a polyp, the body of the living organism, which is housed in a rigid calcium-carbonate exoskeleton called a corallite. The corallite is cup or sac shaped. The bottom of the corallite is divided into compartments by vertical partitions, or walls, know as septa. The polyp an opening at the top. Note that the opening is a combined mouth and anus that leads to the gut. What are some problems associated with having only one opening?

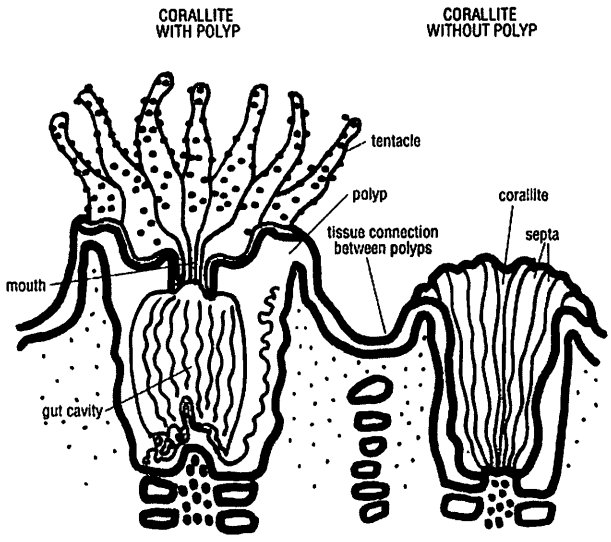


Figure 1

6. Tentacles surround the opening. The tentacles have stinging, mucus-secreting cells or nematocysts. How would the coral use these to capture its food?

7. Polyps live alone or in colonies. The colonial forms create the massive skeletal frameworks of coral reefs. New polyps grow on the sides. They secrete their own corallites, which share a wall with neighboring polyps. All polyps that make up the colony are interconnected over the tops of their corallites by a thin sheet of tissue called a cenosarc. See figure one. Touching a living coral colony in any way pushes the cenosarc against its own calcium carbonate skeleton and leaves the coral open to infection. How does divers touching or collecting coral or boats attaching anchors to coral reefs impact the reef?

8. Coral reefs are found where the water never drops below 18 °C. Reef-forming coral need to live in an area of high calcium carbonate deposition. This only occurs in warm water. Even in warm water, coral reefs may only grow vertically 1mm and up to 8 mm horizontally in a year. Why are coral reefs only found in tropical and subtropical regions (usually below a latitude of 30°) and not found in areas of coastal upwelling?

9. Another limit to the location of coral reefs indicates that coral animals cannot tolerate low-salinity. Reefs are rare on the eastern coast of South American because of the enormous

outflow of fresh water from the Amazon River system. Why are Flower Garden Banks located 100 miles from Galveston?

10. Non-reef forming corals can be found in the deep ocean and on shipwrecks. Yet the animal forming reef coral requires sunlight and its growth rate is affected by light intensity and day length. What is the answer to this puzzle? Biologists have found that masses of symbiotic zooxanthellae, unicellular algae, are living in between the cells of the outer layer of coral tissue of all reef-building coral. Why would this explain the sunlight requirement of reef-building coral?

11. Zooxanthellae is a term used for a variety of photosynthetic cells that are live in a variety of invertebrate animals. The photosynthetic pigments also provide the color seen in corals. These plant cells are very abundant. There may be up to 1 million cells per square centimeter of coral surface. This can represent up to 75 percent of the tissue weight of the coral polyp. The coral animals and the zooxanthellae benefit from this biological interaction called mutualism. Explain how the coral would benefit from this mutual relationship. Explain how the zooxanthellae benefit from living in the coral.

12. Tiny and hard to see, benthic algae are also found in the reefs. They are stony, crusting forming algae. They have a porous carbonate crust. These algae may be as important as the zooxanthellae are to the reef. Why are the algae so important?

13. However, the coral and the algae are competing for the same living space. When increased nutrients enter the area the algae can dominate the coral in the search for space on the reef. Why is this a problem?

14. Sea urchins and other animals graze on the algae in coral reefs. This prevents the algae from taking over the coral's space. What will happen if sea urchins die off?

15. When the corals become stressed, they expel the zooxanthellae. This results in whitening or bleaching of the colony and maybe even its death. This is the color of the calcium carbonate skeleton of the coral seen through the cenosarc. The zooanthellae had provided the color. Bleaching events have been correlated with increased sea-surface temperatures. What would be the effect of global warming on coral reefs?

16. Two common human causes of coral reef death are an increase of sediments and nutrients flowing over the reef. What human actions would increase the nutrients and sediments in the water? Explain why this can damage or even destroy a coral reef..

10. What Is the Anatomy and Life Cycle of the Oyster?

Marine Biologist _____ **Team** _____

The oyster, which can be prepared in a number of ways, is one of the most popular seafoods. The demand for oysters had created an important oyster fishery in Texas waters. The oyster has other value too. Its role in reef-building affects water circulation, navigation and fishing. Many reefs are as well known to the sport fisherman as they are to the commercial oyster fisherman. Even dead oysters are valuable. The old buried reefs are dredged and the shells are use in a variety of industrial processes. This is not true for other seafood. You are going to investigate the life of the oyster, which is in the phylum Mollusca.

Materials: Shells of oysters, medicine dropper, vinegar

Procedure:

Part I: What is the anatomy of the Texas commercial oyster?

1. The shell is made of two valves that are joined together at the anterior end by an elastic hinge ligament. Examine the oyster shell and locate the anterior end and the hinge. When the oyster relaxes its muscle the hinge opens the valves. Opposite the hinge is the bill, often called the mouth. Locate the bill on your shell. Use Figure 1 to locate these parts .

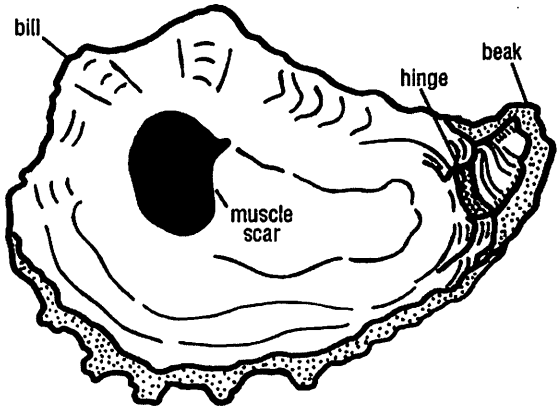


Figure 1

2. Each valve is composed of three layers. Use the dropper and add drops of vinegar to different parts of the shell. Vinegar is an indicator of the presence of calcium carbonate. It reacts with calcium carbonate producing a gas (fizz). Was any part of the valve made of calcium carbonate? This is why the shell has a variety of industrial uses.

3. Note the ring pattern on the outside of the valve. The ridges between the rings indicate the rate of growth. However, the ridges do not represent annual growth. Did the valve grow at the same rate?

4. Examine the interior of the valves. How does the interior differ from the exterior? Why would the interior of the valve differ from the exterior?

5. In the interior side locate a dark, oval-shaped scar. This is where the muscle was attached to the shell.

6. Use Figure 2 to locate each of the parts of the internal anatomy of the oyster. Lining the inside of each valve are the mantle flaps. The flaps completely cover the inside of the oyster. Along the edge of the flaps are small sensory tentacles. What is the function of these?

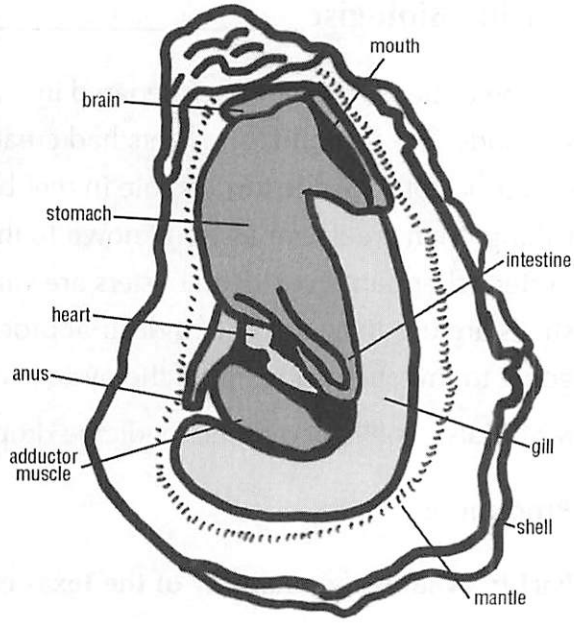


Figure 2

7. In the mantle there are special cells that secrete the shell layers and the hinge ligament. The mantle is also involved in the respiration of the oyster. Look on the inside of the valve, the muscle scar is where the well-developed adductor muscle is attached. When the muscle contracts, it pulls the valves together closing the valves. When it relaxes, the hinge opens the oyster. Shuckers or openers are employed by the oyster dealer to open oysters to sell. What will the shucker need to do to get the shell to open?

8. Above the muscle is the cavity where the heart is located. In a freshly opened oyster, the beating of the heart can be observed. The blood is colorless and is pumped by the heart to all parts of the body. It is returned to the heart by the gills, through the veins. The gills are long, fringe-like organs that are under the mantle flaps. They are covered by rows of very small hair-like cilia. The movement of the cilia creates water currents that move through the gills to bring in oxygen and carry away wastes. The water currents also bring in food particles. These are trapped in the gills and carried by the movement of cilia to the mouth (figure 2). Where is the mouth located? Note the flaps around the mouth. Like the gills, they are covered with cilia to help move food into the mouth and undesirable particles away from the mouth. From five to thirty quarts of water per hour may be strained through the gills.

9. Locate the mouth. A short gullet runs from the mouth to the stomach. Where is the stomach located? The intestine goes from the stomach towards the gills and muscle and circles back around the stomach. It ends in an anus near the muscle. Surrounding the stomach is a dark colored mass; this is the digestive gland.

10. The oyster has no brain. It only has several bunches of nerves and several small nerves that go to the various organs. What is the effect of not having a brain on the oyster and its interaction with its environment?

11. The reproductive organs or gonads are in the anterior part of the body beneath the mantle flaps. Ducts from the gonads open into the mantle cavity near the gills. The sperm or eggs are expelled from the shell into the water. Fertilization occurs in the water. A single female will discharge many millions of eggs during one spawning and may spawn several times a year. Explain why very few eggs are ever fertilized.

12. Compare the anatomy of the oyster to that of a clam.

Part II: What is the life history of the oyster?

1. There are about a hundred species or types of oysters in the world. However, only ten are of commercial importance. The commercial oyster in Texas has the scientific name, *Crassostrea virginica*. It is found along the Atlantic and Gulf coasts from Canada to Mexico. What is the temperature range in which the oyster can live?

2. Oysters thrive in estuarine or brackish water habitats. The commercial oysters are found in almost every Texas bay. However, in Laguna Madre, it is limited to a few reefs near Port Isabel. Explain what factor is limiting the growth of the commercial oysters in Laguna Madre?

3. Spawning of the oysters begins when the water temperature rises above 75 ° F. In Texas, the spawning season is from April to October. During spawning, feeding is reduced and the oyster uses its reserve fat supply. By the end of spawning season, the oysters are thin and watery. When would be the best time to take oysters for food.

4. Some spawning may occur throughout the year. When an oyster begins to spawn, others are stimulated to spawn also. Why is this important to the life cycle of the oysters?

5. Upon fertilization the egg begins to divide and in a few hours an embryo is formed. The embryo can swim through the water using cilia. In a few days the shell begins to form. However, the small oyster can still swim for a week or two. Then it settles to the bottom and searches for a firm, clean surface to cement itself to. There it will remain the rest of its life. Why don't oysters attach to mud or sandy bottoms? Why must the surface be clean *for* it to attach?

6. At this stage in its life, the small oyster is called a "spat" and one can barely see it. If the oyster does not find a place to attach, it dies. They can attach to tires, bottles, pilings, cans, rocks, but the most common site is another oyster shell, either dead or alive. As the oyster grows, it shell also grows. As the shell becomes larger, the adductor muscle must be relocated to enable it to close the valves. In some oyster shells there is a faint, dark colored muscle streak above the muscle scar. This indicates the trail of the muscle along the shell. Examine the inside of a large oyster shell to locate the muscle trail.

7. Oysters can reach 3 inches in less than a year. However, usually 18 to 24 months are needed for an oyster to reach the legal size of 3 inches. The shape of the shell is affected by environmental conditions. When the bottom is firm and the oysters are not crowded, they form broad, cupped shells. Overcrowding results in long, thin-shelled oysters. In what direction would oysters in mud grow to keep the bill above the mud? Examine oyster shells to determine what conditions they grew in.

8. Oysters feed on plankton. It rejects some plankton and eats others. Oyster larvas are plankton so they are often eaten by the adults. Because the oyster larvas are small, they do not feed on the same organisms as the adult. As the oyster grows, its food preference changes. Explain how this is an advantage to the growing oysters.

9. In spite of, or because of, its protective shell, the oyster has a number of enemies. The most serious is the oyster drill (*Thais*). This relatively small snail is an oyster lover. It can eat almost a hundred small oysters, mostly spates. To reach the oyster meat, the drill may drill a small hole in the shell or drill between the valves. The oyster drill lays large numbers of eggs in capsules that attach to shells, rocks or pilings. The drill larvas live as plankton for a while. Why does this make it difficult to control or eliminate oyster drills from an oyster reef?

10. Oyster drills cannot survive in water of low salinity. What natural event reduces the salinity in the bays? How does this factor keep the oyster drill from totally destroying an oyster reef?

11. Crabs are also serious oyster predators. The stone crabs can crush an oyster's shell, but they are not as numerous as the blue crab. The blue crab will chip away part of the oyster's bill and insert one claw as a wedge. It uses the other claw to reach in and tear off pieces of the oyster. Explain why the blue crabs own importance as seafood reduces the damage it could cause to the oyster reef.

12. There are also pests that do not prey on the oyster but their activities affect the oyster population. The fouling organisms are competitors of the oyster for either food or space. These include mussels, bryozoans and barnacles. Other fouling organisms such as the sea squirts, hydroids, algae and tube-building worms are also a problem. Explain why the oyster spats are often their own worst competitors.

13. In order to survive, an oyster must protect itself from the harmful action of physical, chemical and biological elements in its environment. How will each of the following impact the oyster.
    a. Floods carrying silt into the bays.
    b. Severe storms and hurricanes disturbing the bottom.
    c. Silt from dredging channels or dredging shells
    d. Severe floods causing bay waters to remain fresh for months.
    e. Industrial wastes discharged into bays.
    f. Sewage containing diseased organisms discharged into bays.

14. Long ago it was discovered that oysters could be transplanted from one area to another. In the United States, oyster farming has been carried on for over a hundred years. Today, although the total acreage is relatively small, oyster farms produce more than half of the total harvest. Use the information about the oyster and design a plan for farming oysters. Include in your plan, where they will be farmed; what will be the substrate; the physical environment that will be maintained; how they will be feed and prevention of predators and other factors that affect oyster reefs.

11. What Is the Life Cycle of Shrimp?

Marine Biologist _____ **Team** _____

Arthropoda is the largest animal phylum, primarily because it includes the insects. There are very few marine insects. The great majority of the arthropods belong to the Class Crustacea. The crustaceans include the barnacles, copepods, amphipods, isopods, crabs, shrimp, and lobster. Marine shrimp are the most popular seafood in the United States. Many kinds of shrimp live in the Gulf of Mexico. However, only a few are large enough to be considered for seafood. The brown, white and pink shrimp make up the most of the Texas shrimp landings. You are going to investigate the life cycle of this important seafood.

Procedure:

1. Shrimp, like other crustaceans, have a segmented body with an outer shell or exoskeleton. The rostrum, antennae and walking legs are attached to the head section. The edible portion or "tail" bears the swimming legs (pleopods) and the tail fan or uropod. Locate the parts on Figure 1.

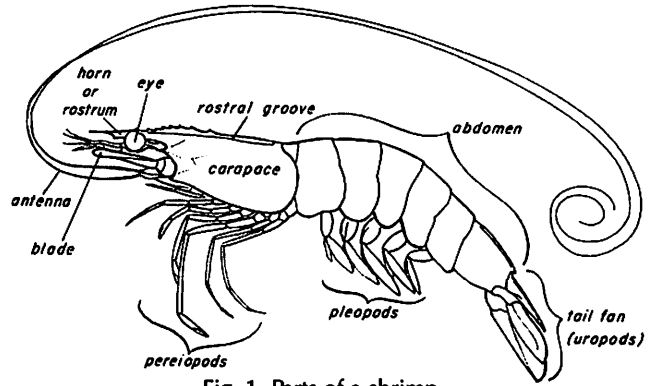


Fig. 1. Parts of a shrimp.

2. Brown shrimp are more easily caught after dark. The best catches are made during July and August. They are caught at depths from 60 to 120 feet. Pink shrimp are estimated to live 2 years or more. Fishing for pink shrimp occurs primarily at night. They are fairly abundant in catches off the central and lower coast in the spring and fall. They are also abundant along the west coast of Florida. White shrimp are usually fished during the day in bays and out to 120 feet deep in the Gulf. The best catches are in water less than 85 feet deep. They are the main shrimp caught in the bays in the fall. What are some possible explanations to the differences in the shrimp catching?

3. The life cycle of brown, white and pink shrimp are similar. They spend a portion of their life in estuaries, bays and the Gulf of Mexico. When shrimp mate, a sperm capsule is transferred from male to female. The female carries the sperm and approximately 500,000 to 1,000,000 eggs until the conditions are right. Shrimp spawning takes place off shore. The minute eggs are fertilized when released. Why would each shrimp produce so many eggs?

4. The fertile eggs float and hatch within 24 hours. The newly hatched shrimp larvae are planktonic and have a shell. For each new larval stage to develop, the outer shell must be cast off and a new shell formed. Why does this occur?

5. Locate each of the stages on Figure 2, Life Cycle of Shrimp. The first five larval stages are called nauplii. During these stages the larva are nourished by the yolk of the egg. The next larval phases include three stages called protozoea and the three mysis stages. During these, the larva feed on microscopic plants and animals. Where are these stages of the shrimp life cycle taking place?

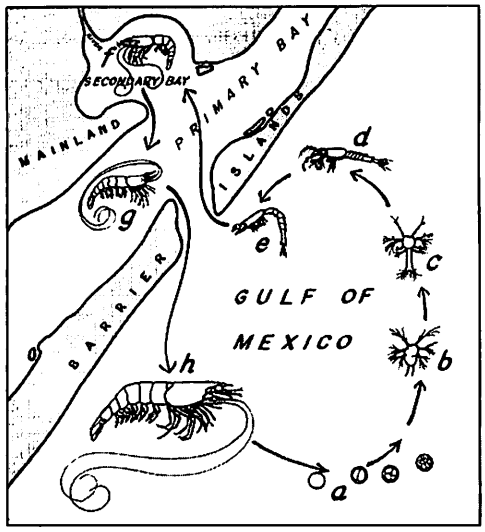


Fig. 2. Life cycle of a shrimp.

6. Parent shrimp do not guard their young. Many marine animals, including adult shrimp, feed on the shrimp eggs and larva. At what stage does the shrimp begin to acquire the familiar shrimp like appearance?

7. Larval shrimp are poor swimmers. In what direction are they moving? What would carry the shrimp in this direction?

8. The shrimp reach the early postlarval stage and enter the bays. Brown shrimp enter the bays from late winter through early spring while most white shrimp enter from May through October. What is the advantage of the larval shrimp entering the bays and the shrimp nursery grounds at different times?

9. The areas in the small back bays, bayous and salt marshes bordering the bay shore are the nurseries for the young shrimp. With what do nurseries provide young? Why are these areas good nurseries?

10. In the nurseries, the young shrimp change from plankton feeders to bottom feeders. Here they can use their walking legs to walk along the bottom or swim at different depths using their five pairs of swimmerets. They eat algae, small mollusks, marine worms and small crustaceans. Large shrimp may also attack and eat small fish. How would changing from plankton feeders to omnivorous bottom feeders benefit the shrimp?

11. When the brown shrimp are two inches long they leave the nursery and enter the larger

bays. Here they may grow three to four inches before leaving the bays. They enter the bays in the spring and the Gulf in late May and early June. Researchers have found that most movement takes place during a full moon. What is a possible explanation for this?

12. The white shrimp spend more time in the estuaries and reach a larger size (4- 5 1/2 inches) before leaving. They enter the Gulf between November and December. Why do all the shrimp migrate into the Gulf?

13 The size and when the shrimp enter the Gulf are affected by several factors including low temperatures, excessive fresh water inflow, storms and sexual maturity. How would each of these affect the shrimp movement?

14. In Texas, shrimp are caught for both food and bait. Why are shrimp used for bait? Which animals are sport fisherman catching using bait shrimp?

15. In recent years there has been an increase in bay shrimping. How might this affect the overall shrimp population and catch?

16. Trawls (nets pulled by boats) are used to catch the shrimp. Bycatch is the fish and other organisms that are caught in the nets. Bycatch makes up at least 80 percent of the total catch by weight in bay shrimp trawls. What is the effect of the increasing shrimp trawl effort on the bay bottom habitat and the bay fish populations?

17. The Texas Shrimp Fishery Management Plan provides guidelines for management of the shrimp fishery. Why are guidelines needed? How can knowledge of shrimp life history, abundance and size be used as valuable management tools?

12. What Can You Learn from Observing a Fish? Or Can You Read a Fish?

Marine Ichthyologist _____ **Team** _____

A fish, as most people think, is a scaly animal that has fins and lives in water. However, fish are the most numerous group of vertebrates. Presently there are at least twenty thousand known species of fishes and some ichthyologists (scientists who study fish) think that there may be as many as thirty thousand. On the Texas and Louisiana coasts, they have counted almost 550 species. The exact number depends on how far offshore one counts the fish. You can read books and look at pictures to obtain information. You can also "read" organisms by observing them. In this activity, you and your team are going to be ichthyologists and study fish to learn more about them, their adaptations and the way they live.

Materials: Pictures of a variety of fish or an aquarium with a variety of fish; colored markers or crayons, colored paper, transparency, plastic cups, water; different colored fish shapes

Procedure:

Part I: What can we learn from the color of a fish?

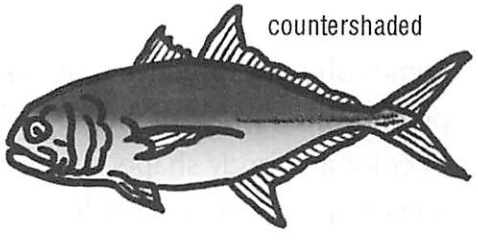
1. Obtain a fish or pictures of a fish. Give the fish a name.

2. Observe the fish, what is its coloration and color pattern?

3. What do you think the color of the fish can tell you about the fish?

4. The color and color pattern of a fish can provide information about the fish and the way it lives. Is the fish brightly colored or dull colored? A fish with bright colors wants to be noticed. Bright colors can be used to advertise. Why would a fish want to advertise its presence? A dull colored fish uses its color to hide. What is the color of the place the fish lives? Why would the fish want to hide?

5. Is the fish "countershaded"? This means that the top or dorsal side of the body is darker and the ventral or underside is lighter. Why would most fish that swim in the open water be "countershaded"?



6. Fill two plastic cups half full of water. Cut the shape of a fish out of a light colored and a dark colored piece of paper. Place a light colored paper fish in one cup and a dark colored one in the other cup. Place both cups on the table or paper that is dark colored. Look

into the cups from above. Now pick up each cup and hold it above your head and look at the paper through the bottom of the cup. Which color was more difficult to see when you were looking down on the cups on the table? Which color was more difficult to see when you were through the bottom of the cups above you? Explain.

7. Imagine you are a predator swimming in the ocean and you looked up toward the surface. Which would be easier to see, a fish with a light colored or dark colored underside. If you were a predator swimming along the surface and looking in the water below you, which would be easier to see, a fish with a light colored or dark colored back?

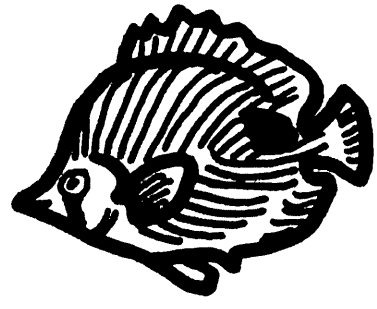
8. Does the fish have a "disruptive color pattern"? These are color patterns, bandings and patches of irregular contrasting colors such as dark vertical bars that break up the outline of the fish. This color pattern distorts the true shape or contour of the fish so one sees the patterns instead. Why would these patterns be helpful to a fish?


disruptive
color pattern

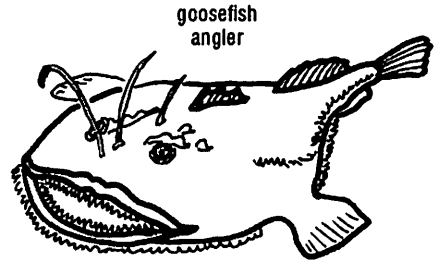
9. Cut a fish shape out of a transparency. Place the fish shape in the cup of water, what do you observe? Some fish have little or no color and some are actually transparent. How can this help the fish?

10. Deflective markings are found on many fishes. They draw the attention of a predator. Deflective marks draw the attention of an attacker away form the vulnerable body parts such as the head region and eyes. A common one is an eyespot on the dorsal fin or flank of a fish while the head may be hidden by a head stripe. This is a common feature among coral reef fishes. How does it help these fish survive?

deflective markings



11. Some fish have directive markings, which draw the prey towards a part of the body through a combination of color and body shape. An example is the lure of the anglerfish. How does it help the anglerfish?

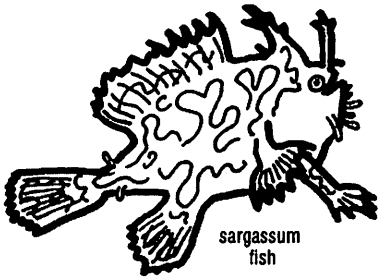

goosefish
angler

12. The color and color pattern of many fish match the environment in which they live. Fish may have camouflage markings to match the background of their surroundings and help them blend in and difficult to see.

13. Obtain a colored fish shape. Look around your classroom, select an environment for your "fish" so that it is camouflaged. Place the fish in the environment when you are directed to do so. Your instructor will direct you when to look for fish in your classroom. Which "fish" were difficult to locate? Which fish were easy to locate? How does the use of camouflage help fish? Explain.

14. Summarize what you learned about camouflage.

15. Some fish use resemblance or camouflage to match their surroundings. Some blend in by looking like seaweed or rocks. How does this help the fish survive? Fish that live in colorful coral reefs are also colorful. How would this be beneficial?



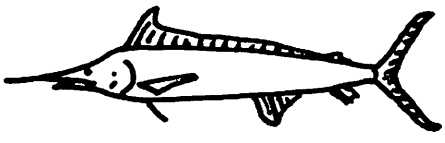
16. Weever fish, which often lie buried in the sand, have poisonous spines on their flaps. They will raise these poisonous spines if they are disturbed. They have black dorsal fin rays that indicate the danger of their spines. Sole fish don't have poisonous spines but they pretend that they do by raising a fin. How does this help the Sole? Some fish appear to be dangerous when they are not. One type of eel looks like a poisonous sea snake. How does this help the fish survive?

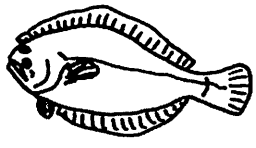
17. Reexamine the fish and pictures of fish. How does each of the fish use coloration, markings and patterns to survive?

Part II: What can we learn from the shape of a fish?

1. Observe a fish or pictures of a fish. Draw the outline of the shape of the fish.

2. The shape of the fish, its fins, the shape of its tail and its size are key to how and where it lives. What might the following shapes indicate about where a fish lives.
   a. Long, slender body and the fins are smaller and flattened against the body
   b. Small and thin body
   c. Flat stomach

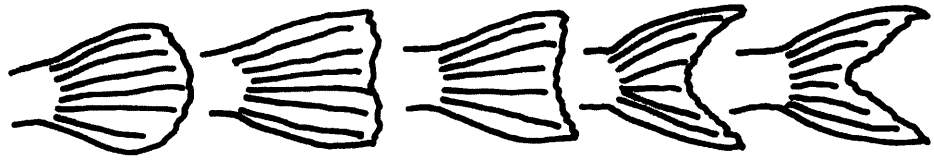




3. A fish that is fast moving has a torpedo shaped body. Fish that spend their lives on the bottom and feed on the bottom will have a flat belly. Some of the bottom dwellers have a horizontal disk shaped body. Some fish have a vertical disk shaped body. Which shape is more likely to be found in reef fishes. Explain.

4. The fins of many fish no longer provide lift during swimming, the swim bladder is used to control the buoyancy and vertical position of the fish in the water column. The presence of the swim bladder had enabled fins to be modified and adapted for different uses. The pectoral fins of flying fish are modified for gliding while those of the stonefishes, weeverfishes, tiggerfishes and others have spines for defense. The remoras, Lumpsucker and Clingfish have fins adapted for suction. Other fish have fins adapted for activities like display and courtship, signaling a warning, walking, hopping or even as a lure like the anglerfish. Fins of fast moving fish are reduced and thin and they can be flattened against the body or folded into grooves to reduce drag during swimming. The position of the broad pectoral fins of slow swimming fish are used as brakes and also control the rise and dive of the body or even produce a rolling motion. The trunkfishes, ocean sunfishes, porcupinefishes, pufferfishes and seahorses have unusual modifications of their fins. The fins perform a "sculling" motion to move the fish in any direction, including backwards. How does the fish your are observing use its fins?

5. Fishes that are slower swimmers or bottom dwelling have larger,= more round tails. For these fish, maneuverability is more important than speed. Fast moving fish have narrow, forked tails and a streamlined body form. What does the shape and tail of your fish tell you about its speed?



6. Observe a fish swimming and note how it uses its dorsal fin on its back and the anal fin on its stomach. Note the pectoral fins, located just behind the gill openings. Also note how the fish uses the pelvic fins, located below and sometimes behind the pectoral fins.

7. Reexamine the fish or pictures of fish and summarize what its fins, body shape and tail indicate about it.

Part III: What can we learn from the mouth of a fish?

1. Most fish are predatory and eat animals smaller or weaker than themselves. The head, jaw shapes and teeth are adapted to the food they eat and can provide clues to the dietary habits of many fishes. Look at the head, jaws, mouth and teeth of your fish. Where and what do you think it eats?

2. Fish can be filter feeders with mouth parts specialized for straining large volumes of water to extract plankton. For example herring-type fish have gills with long comb-like gill filaments that collect plankton as the fish swim open-mouth through the water. A fish that nibbles on plants or eats small animals will have a small mouth. Where would you find these fish?

3. A fish with a large mouth eats other fish and may swallow it whole. Elongated snouts are characteristic of carnivorous fish that roam the open water. They will have dagger like teeth. How will dagger like teeth help the fish obtain its food?

4. Fish that crush coral or shellfish will have a small mouth but very strong jaws. Fish that probe and nibble food from surfaces will have a small mouth at the tip of the snout. Some will have a sucking mouth or even a tweezer-like mouth. How will these fish obtain their food?

5. Examine the head, jaws and teeth of different fish, what do these indicate about its diet and eating habits?

6. The location of the mouth of the fish can tell you were it swims and feeds.
   a. Find a fish with the mouth opening upwards. Where does it swim and eat?
   b. Find a fish with a mouth pointing down. Where does it swim and eat?
   c. Find a fish with a mouth in the middle. Where does it swim and eat?

Part IV. Can You Design a Fish and its Habitat?

1. The great diversity of fish and their adaptations are the product of countless adaptations over long periods of time. The adaptations are for the most part, features that increase the animal's chances of surviving in their habitat. Look at pictures of actual fish and describe each fish's adaptations. Make inferences about its habitat and lifestyle by examining its coloration, body shape and mouth. Construct a table like the one below to record information about each fish you examine.

Table 1: Fish Adaptations and Lifestyle

Fish	Description of Coloration	Description of Body Shape	Description of Mouth	Habitat	Lifestyle

2. Select a habitat using the information from Parts I - III and Topic 12. Determine the adaptations that are an advantage to a fish in that habitat.

3. Design a fish for the selected habitat. After designing the fish, create an art form that represents the fish.

4. Prepare a report to the class about the attributes of the fish you have designed. Include information on its habitat, its adaptations and the advantages that they provide for survival.

13. What Factors Affect the Lives of Fishes?

Marine Ichthyologist _____ **Team** _____

Fish are important in our lives in many ways. They are a source of food and recreation. Sport fishermen consider fishing a relaxing activity. Fish watching is another form of relaxation whether it is in aquariums or by scuba diving in their natural habitats. Scientists, including medical researchers, study fish because they represent the "simplest" vertebrates. Many of the same systems are found in humans, but the fish is a less complicated organism to study. Also many species are easily maintained in laboratories.

Many factors in the marine environment affect the lives of fishes. The northwestern Gulf of Mexico, from Florida to the Rio Grande River, provides diverse habitats. Each fish is adapted to its habitat and these features increase its chance of survival. When a habitat changes, whether it is slow or fast, the fish with adaptations that allow them more options are more likely to survive. You are going to investigate some of the factors that affect the survival of fishes.

Materials: Small goldfish, aluminum foil pan, 500 ml beaker, 2 liter plastic bottles, ice and warm water or hot pot to heat water, thermometer.

Procedure:

1. Several factors affect the variety of the habitats. From the Mississippi River to the Rio Grande, rainfall and river discharge decrease and temperature increases slightly. Salinity of less than ten parts per thousand occurs in the marshes and bayous of Louisiana. There are moderate salinities along much of the east and central Texas coast. However the south Texas coast may have hypersaline conditions of 40 parts per thousand. What causes these variations and how might they affect the fish?

2. Hypersalinity had caused major fish kills in the Laguna Madre in the 1930's and 1940's, but since the completion of the Intracoastal Waterway to Brownsville in 1948, this has decreased. The amount of freshwater entering is a factor. When the amount of freshwater entering the bays and lagoons is decreased, fish such as pigfish, sharks and sea basses take the place of the more fresh water tolerant fish. The abundance of some species such as redfish is related to the amount of fresh water. How would a drought or the increased use of water inland affect the fish?

3. The temperature also varies. From Port Isabel south, it remains subtropical for most of the year while the salt waters on the East Texas and Louisiana coasts are usually colder in winter. Turtle grass beds are only found where the salinity does not fall below 25 parts per

thousand, while mangroves are limited by temperatures below 20°C. How would these differences affect the fish?

4. Obtain a small goldfish and a beaker. Observe the goldfish and note the movement of the operculum that is the covering over the gills. Can you count how often it opens and closes in the process of moving water with dissolved oxygen across the gills (respiration rate). You can set the goldfish in the beaker in an aluminum foil pan of ice or very warm water (below 120°F) to observe the effect of different temperatures. Plan your investigation. List the problem, hypothesis, identify the variables, procedure (step by step instructions) and data table. Have the instructor review your plans. Conduct the investigation, record the data, graph the data and summarize your findings.

5. Another factor is bottom composition. Limestone bottoms occur off the west coast of Florida. Fish that prefer limestone are found in this area but not west of the Mississippi river mouth. The fish that prefer muddier bottoms are not found on the west coast of Florida. The greater river discharge into the Gulf along the Louisiana and East Texas coasts results in large amounts of fine-grained sediments. Coarsely grained, sandy sediments are more common off the South Texas coast. Bottom sediments also become less sandy and muddier as one moves from the barrier islands into the Gulf. This distinguishes the "white shrimp grounds," which are closer to shore, from the "brown shrimp grounds," which are farther offshore. Rocky reefs occur off shore on the continental shelf. This provides a hard substrate for many invertebrates. How might these affect the fish in these areas?

6. Another important factor is variation in depth from the shore to the edge of the continental shelf. The shelf is often divided into inner, middle and outer zones. These zones differ in temperature, salinity and bottom type. What causes these variations in the zones and how might they affect the fish?

7. Currents play a role in effecting the distribution of marine and estuarine fishes. Most estuarine fishes actually spawn in the Gulf of Mexico. Examine the surface currents of the Gulf of Mexico in Figure 1. The estuarine areas are the nurseries for the larvae and young. How do you think that currents, both seasonal and wind-driven ones, affect the movement of the larvae and young?

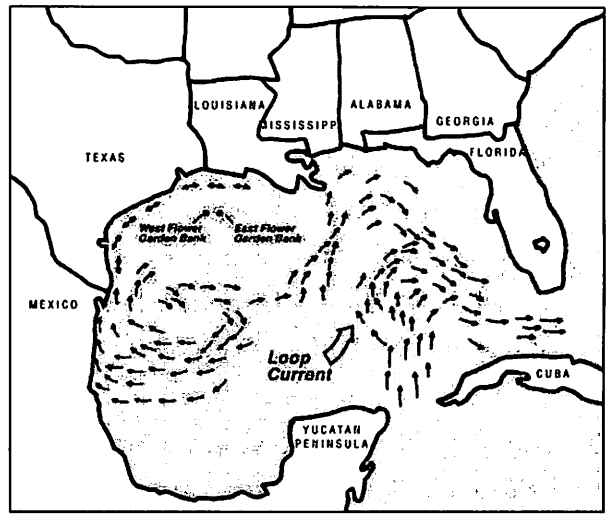


Fig. 1. Surface Currents of the Gulf of Mexico.

8. Offshore species, especially the tropical offshore reef fishes, are also dependent on the currents. The major feature is the Loop current (Figure 1) that brings Caribbean waters into the Gulf. The current contains a rich variety of larval tropical fish. How do currents impact the life cycles of fish? How might the Loop current impact the fish in the Gulf?

9. Extreme conditions of temperature, salinity or dissolved oxygen, as well as the occurrence of natural or human-induced substances, may cause fish kills. Red tides and brown tides have affected fish populations. Other significant causes are extreme freezes. Severe killing freezes have reduced populations of some species and it may take several years to recover. The freeze of 1989 killed fish and reduced the populations of some game fishes. Floods have a major impact on attached animals, but they seem to run fish offshore and wash fresh water fish into the estuaries. Why does this not cause fish kills?

10. In examining the life histories of the fish, many do not spend their life in the same habitats. Many inshore fishes spend part or all of their lives in the estuaries. A typical estuarine-dependent species spawns in the Gulf of Mexico and the young must enter the nurseries of the estuaries for about a year. Most grow rapidly and reach maturity in a year although some take several years. What factors make the estuarine habitat an excellent nursery for so many species?

11. Some fish spend their entire lives in the estuaries. Some species remain in the estuary and migrate to the Gulf only to spawn and then return to the estuary. Others migrate from the shallow estuaries to spend the rest of their lives in the deeper Gulf of Mexico. While those that live farther offshore may never be found in the bays. Most species in which adults live and spawn on the outer continental shelf live on the inner or middle shelf as young. What might be a possible explanation for this pattern?

12. An example of how ≠marine fish populations may change. Some tropical fish species such as tarpon and snook were more common in the past. Commercial fisheries for snook existed before the 1920s in Texas. Today they are rare. Tarpon, Texas was the original name of Port Aransas and many people came to Port Aransas to fish for tarpon. Today the fish are rarely caught. What caused this is not known. Recently, it appears that both tarpon and snook may be returning. There are other examples of fish population changes over the last 20 years. What factors might cause changes in the future? Explain.

14. A Diner's Delight?

Name:_____ **Team:** _____

You have been invited out to eat. You are told that you can select the restaurant and any items on the menu. You are not to worry about cost. What type of restaurant would you like to select. What would you order to eat?

Materials: none

Procedure:

1. Study the menu. It is a menu that would delight diners in many countries. Which items would you order? Explain. Which items would you refuse to eat? Why?

2. The menu would delight diners in Japan, China, Korea, the Caribbean, the Mediterranean and even France and Mexico. The Japanese, for example, eat nine sea mammals, 63 species of fish, eight varieties of shellfish, three kinds of clams and two of shrimp. Japanese eat 72 kilograms (158.7 pounds) of seafood per person per year. Most Japanese homes have seafood each day. Even though great numbers of these marine organisms live off the coasts of the United States, they are not eaten there. There may be more to eating seaweed and sea urchins than their being a treat. There is a relationship between the fish diet and heart disease. Eating more fish instead of red meat may improve one's health as well as adding variety to your life. There is a great variety of seafood available. Seafood can be the main ingredient in appetizers, soups, salads, entrees, side dishes, deserts and even beverages. Why do you think the Japanese eat so much more seafood?

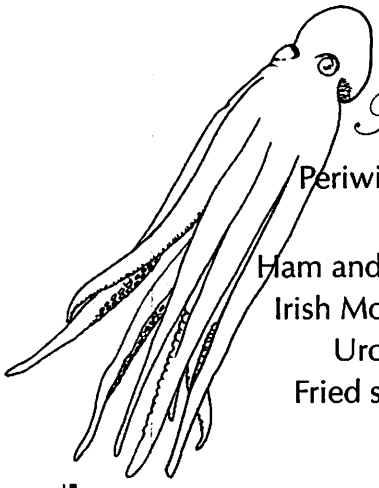
3. How would you explain the differences in the way you think of marine organisms and the way the Japanese, Chinese or other Southeast Asians think of them?

4. Could you live and survive in a country where most of the restaurant menus were like the one above? Explain. What factors have helped to determine what foods you will and will not eat?

5. What effect do you think advertising would have in encouraging people to eat a greater variety of marine organisms? Explain.

6. What are the pros and cons of encouraging the eating of a greater variety of marine organisms?

The Menu

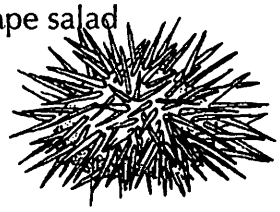


Appetizers

Periwinkle Appetizers
Boiled Limpets
Ham and Lamineria rolls
Irish Moss tomato aspic
Urchin Roe Estrella
Fried sweet kelp chips
Porphyra chips
Toasted Kim

Salads

Octopus salad
Kantan salad
Sea lettuce salad
Sea grape salad



Soups

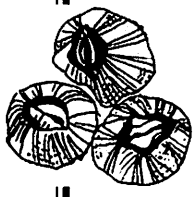
Chiton soup
Keys Conch Chowder
Irish moss soup
Dulse miso soup
Pacific sea vegetable soup
Octopus soup
"Needle" shark fin soup

Side Dishes

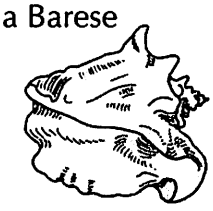
Hyiki and dried squid
Wakame in sweet and sour sauce
Sea vegetables in Tai Wan
Stir-fried Irish Moss

Entrees

Lobster a la Newburg
Octopus Pilafi
Pickled Whelk
Fried Eel
Lancet Teriyaki
Baked Sheepshead with rice
Urchin kelp rice roll
Boiled goose barnacles
Baked Abalone en Coquille
Scallops-k-Bob



Oysters on the half shell
Squid Neapolitan
Sautéed sea hare
Mola mola
Barbequed Seahorse
Pickled Sea Cucumbers
Baked mussels a' la Barese
Abalone steaks
Conch Fritters
Scallops in clouds



Desserts

European apricot candy
Irish moss mousse
Lime agar desert

Beverages

Hot dulse lemonade
Bladderwrack tea
Sea Moss Cocktail

15. Are You a Seafood Connoisseur?

Name _____ **Team** _____

The sea is a real supermarket. There are more than 100,000 species of marine invertebrates and probably more than 25,000 species of fish. A connoisseur is a person who is a keen judge in matters of taste. How do you rate?

Materials: pen or pencil

Procedure:

1. The accompanying chart contains a list of foods from the sea's supermarket. Indicate whether you have or have not eaten each item.

2. In Column 2, check the appropriate column to indicate whether or not you would eat the food if it were boiled, fried or smoked and served to you.

3. How many marine organisms have you actually eaten?

4. If you said you have actually eaten 20 or more, you are a seafood connoisseur. Congratulations! If you said between 9 and 12, then you are just average by world standards. If you have eaten less than 9, you are an average American.

5. How many marine organisms would you be willing to eat?

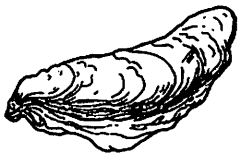
6. Would you be able to become a seafood connoisseur? Or would you be an average seafood consumer?

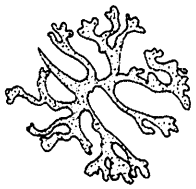
7. Why would you never eat some of the marine organisms listed?

8. Would you consider tasting them? Why or why not?

9. Urchin Toast Au Gratin (an appetizer made from sea urchins) and Calamari (a dish made from squid) are on the restaurant menu and your friends said that they had eaten them and plan to order them in the future. Would you be willing to taste them or even order them? Why or why not?

10. How will increasing the consumption of marine organisms impact the marine ecosystems?

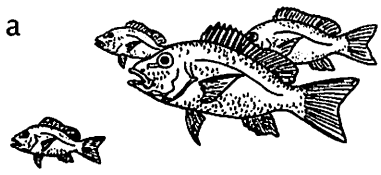



Marine Organism	Have Eaten		Would Eat	
	Yes	No	Yes	No
Abalone				
Algae				
Barnacles				
Clams & Quahogs				
Crabs				
Conch				
Eels				
Fish				
Jellyfish				
Kelp				
Lampreys				
Limpets and Chitons				
Mussels				
Octopus				
Oysters				
Perwinke				
Sea Anemones				
Sea Cucumber				
Sea Hare				
Sea Urchin				
Seaweeds				
Scallop				
Shark				
Shrimp				
Skates and Rays				
Squid				
Turtle				
Whale				

16. How Do Marine Organisms (Seafood) Taste?

Seafood Taster _____ **Team** _____



Some people say that all seafood tastes alike, that they all have a fishy taste. What do you think? You will be an official taster in a seafood fair. You have been given the opportunity to taste various seafoods.

Materials: numbered plates of a variety of seafood, small plate and toothpicks for each taster

Procedure:

1. Each seafood is identified by number. Construct a chart like figure one to record your results.

Seafood Tasting Report

Item Number	Description of Taste	Description of Texture	Rating of Taste	Possible Ingredients	Actual Ingredients
1.					
2.					

Use the toothpick to put a small piece of the seafood in your mouth. Close your eyes and concentrate on the taste and texture. Think about how you would describe the taste and texture. Write your description in the appropriate column of the report form. DO NOT MAKE ANY COMMENTS ABOUT THE TASTE during the tasting activity.

2. Rate the taste of the seafood item. Using the following scale:
   1 - Disliked the Taste
   2 - Did not totally dislike the taste
   3 – Neutral – did not really like or dislike the taste
   4 – Liked the taste and would eat it
   5 – Really liked the taste and would like to have more
   Place the number of your rating in the appropriate column of the report form.

3. Identify what you think the seafood is or the main ingredients in each item that you tasted on the report form.

4. How many seafood items did you like?
   What percentage did you like?

How many did you dislike?
What percentage did you dislike?
How many items did you feel neutral about?
What was the percentage?

5. Was there a relationship between the taste and texture of the items you like and dislike? Explain.

6. Compare your possible ingredients for each item with the list of actual ingredients.
How many did you get correct?
What percentage did you get correct?

7. Did any of the ingredients surprise you? If so, which ones?

8. Would you have tasted each item, if you had known the ingredients before tasting? Which ones would you have not tasted? Why? Explain.

9. What changes in your ideas about food from the sea have taken place as a result of the seafood tasting fair? What was your attitude about each item before tasting it? Explain.

10. How many items did the seafood tasters like? What is the class average?
What is the average percentage that your class liked?
How many seafood items did your class dislike? What is the class average?
What is the average percentage that your class disliked?

11. Discuss the differences in items liked and disliked by your class of seafood tasters. Write a summary paragraph of the results of your discussion below.

12. As a group, discuss why many people have a psychological barrier against eating many kinds of seafood, even if they have never tasted or eaten them.

13. A group is proposing to conduct a campaign to increase the types of seafood eaten including the use of algae as a sea vegetable. Would you support a campaign to increase the kinds of seafood that is eaten?
Reasons for supporting:
Reasons for opposing:
Your decision:

17. What's Special about Seafood?

Nutritionist _____ **Team** _____

How often do you eat seafood? When do you eat seafood? In the past the eating of fish was not a regular meal for most people or families. Fish was part of a meal if someone had gone fishing and then the catch was eaten. Seafood is becoming more popular. There are even restaurants that specialize in serving primarily seafood. There are even fast food restaurants that serve primarily seafood. People are enjoying eating seafood more often. People are enjoying seafood for the taste. It is easy to prepare and can be prepared in a variety of ways.

However, how good is it for you? You have probably heard news reports that eating this food is bad for you and eating this food is good for you. Sometimes you even wonder what you can eat. You and your team will analyze what is known about seafood and nutrition to determine if eating seafood is beneficial or not.

Materials: copy of "Seafood is Healthy!"

Procedure:

1. The Food and Drug Administration's new system for labeling foods is very similar to the dietary guidelines developed by the American Heart Association. Each packaged food item that you purchase has a food label that gives the nutrition facts. The labels include the following:
   a. Serving Size – Serving size is close to the amounts that people eat.
   b. Calories – Includes the total calories and the amount of calories per serving.
   c. Calories from Fat – Try to avoid any food that gets more than one-third of its calories from fat.
   d. % Daily Value (DV) – This tells you what percentage of the daily requirement for a nutrient you are getting.
   e. Total Fat – Note the amount of saturated fats; they cause clogged arteries. Fatty foods should make up no more than 30 percent of your diet.
   f. Cholesterol – High levels of fat—such as cholesterol molecules—in the blood can lead to clogged arteries. We should not exceed 300 mg daily.
   g. Sodium – Too much sodium can cause high blood pressure. A person's daily sodium intake should be less than 2400 mg. 60-100 mg of sodium per 3 1/2 ounces is considered low sodium.
   h. Total Carbohydrates – Getting enough carbohydrates, especially complex ones, is important. Cells use carbohydrates as a source of energy. Carbohydrates should compose 50 to 55 percent of your diet. Foods containing refined sugars like candies and soft drinks should be avoided.

i. Protein – The government has not set a percent DV for proteins, it is agreed that they should compose no more than 15 percent of the total daily calories.
j. Vitamins and Minerals – A Daily Value of about 10 percent indicates that the food is a good source for these.

You and your team will analyze what is known about seafood and nutrition to determine if eating seafood is beneficial. Use the guidelines above to analyze the nutritional value of seafood. Analyze Table 1 to compare calories per serving of different foods.

Table 1: Calorie Comparison:

Food:	Calories Per 3 1/2 Ounce serving Raw edible portion
Pork Chops	298
Finfish	101
Beef (rump)	303
Shrimp	158
Eggs (2)	163
Crab	81

2. What is your conclusion about the calorie content of the different foods?

3. The amino acids in proteins are needed by your body to make and maintain body tissue. Proteins are one of the basic keys to proper and balanced nutrition. Analyze Table 2. What is your conclusion about seafood as a protein source?

Table 2: Protein Comparison:

Food:	Protein per 3 1/2 Ounce serving Raw edible portion:
Pork Chops	17.1
Finfish	18.0
Beef (rump)	17.4
Shrimp	18.6
Eggs (2)	19.9
Crab	15.7

4. How does seafood compare to other foods as a source of protein?

5. Although the government does not have a required daily requirement for protein, what amount is suggested?

6. Based on the data in Tables 1 and 2, which food sources are the best for high protein content with low calories?

7. Analyze Table 3, Cholesterol Content of High Protein Foods. How does the cholesterol level of seafood compare to that of other high protein food?

Table 3: Cholesterol Content of High Protein Foods 3 1/2 Ounce serving (cooked)*

Food:	Cholesterol Content in Milligrams:
Recommended Maximum Daily Intake	300
Chicken Liver	745
2 Large Eggs	550
Calf Liver	440
Squid	250
Shrimp	150
Eel	125
82 percent Lean Ground Beef	100
Chicken, Light Meat	85
Spanish Mackerel	80
Flounder/ Sole	50
Scallops, Mussels	35

8. How does the cholesterol level of seafood compare to that of other high protein food?

9. Explain the statement "Most of the calories in seafood are from protein". Use the data tables to support your explanation.

10. Analyze Table 4, Nutrient Composition of Finfish and Shellfish. Write a generalization about the protein, fat, cholesterol and calories in seafood.

11. High levels of sodium intake can cause heart disease. Refer to the explanation of the Food and Drug Administration nutrition labeling and Table 4; determine whether or not seafood would be included in a low sodium diet. Explain.

Table 4: Nutrient Composition of Fish and Shellfish

Finfish 3 1/2 oz raw edibleportion	Percent Protein	Percent Fat	Calorie Per 100gms	Sodium mg	Cholesterol mg	Minerals Calcium (Ca)	Phosphorous (p)	Potassium (K) mg	Magnesium (Mg) mg
Catfish	17.6	5.2	157	60		64	228	322	34
Cod	17.4	0.5	74	90	43	42	222	364	23
Croaker	18.5	2.5	98	72	60	42	232	259	30
Flounder	18.1	1.4	88	121	50	27	203	220	44
Haddock	18.2	0.5	77	98	65	62	211	342	24
Halibut	18.7	4.3	119	156	32	47	221	398	23
Mackerel	19.5	9.9	106	33	53	58	267	320	30
Mullet	20.1	4.6	122	70	49	40	258	303	29
Salmon	19.9	9.3	163	76	62	22	273	240	27
Sea Trout	17.7	3.8	123	38	83	23	221	395	29
Tuna	24.7	5.1	168	63	38	37	224	363	50
Whiting	18.9	1.3	90	50	28	72	221	326	21
Yellow Perch	18.8	1.1	85	67	42				21
Shellfish									
Clams	11.0	1.7	63	253	34	41	194	143	43
Crab	15.7	2.7	81	330	65	102	272	233	48
Lobster	18.1	1.4	98	296	80	47	237		
Mussels	11.9	1.4	77	214	28	105	145	327	
Oysters	8.5	1.8	68	386	50	36	145	248	32
Scallop	14.6	0.7	78	163	35	32	207	278	30
Shrimp	18.6	1.6	209	133	150	50	253	248	54
Squid	17.1	1.0	84	158	250	50	221	275	20

12. Read "Seafood is Healthy!" and use the Data Tables to explain why, for those who are calorie conscious or trying to loose weight, substituting seafood is recommended.

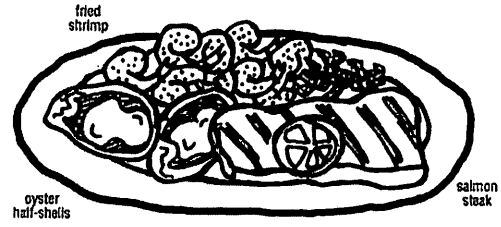
13. List the benefits to one's health that eating seafood can provide. Explain how seafood provides each benefit.

14. Explain the statement that seafood is a "nutrient dense and lean food." Or that seafood is an excellent "nutrient filled fast food".

15. Work together with your team and prepare a brochure, poster, TV ad or radio announcement that promotes the awareness of the value and benefits of seafood.

Seafood is Healthy!

Throughout the years of human existence, fish has played an important role in people's diet. Until recently, very little attention has been given to the nutritional and dietary importance of seafood. Recently people have begun to realize that seafood not only can satisfy the appetite and taste, but also provides valuable proteins and minerals.



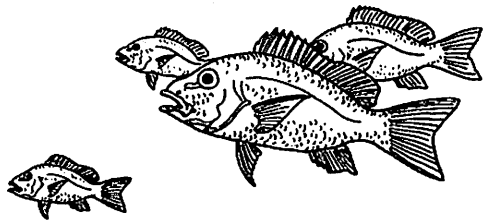
Several studies have focused on the health benefits of eating seafood. The findings published in the *New England Journal of Medicine* indicate that eating fish, along with other complete protein sources, can have important health benefits. It appears to lower the risk of coronary heart disease. The study indicates that eating as little as two fish dishes per week may be important in preventing heart disease.

The studies have found that omega-3 fatty acids refer to the structure of fatty acids found in many plants and animals from the sea. Eating large amounts of this fatty acid can decrease the possibility of blood platelet cells, involved in clotting, to stick or clump together. This decreases the chances of forming clots that block the blood flow to the heart. These clots can result in heart attacks. It appears that the omega-3 fatty acids from fish actually reverse damage to arteries that can cause heart attacks. Fatty fish are the best sources of omega-3 fatty acids. Salmon, tuna, mackerel, herring, halibut, and sardines are excellent sources.

Fish are low in fat and cholesterol. The American Heart Association's recommendation for cholesterol is not over 300 mg per day. The majority of finfish and shellfish fit well in a low cholesterol diet. Most have less than 80 mg per 3 1/2 ounce serving and many have less than 60 mg. Shrimp, squid and crawfish are the exceptions. This can increase if the preparation of the seafood includes adding oil.

Because seafood is low in fat, it is also low in total calories per serving. A 3 1/2 ounce serving can have as little as 82 calories or up to 185 calories for an oily fish like salmon. Even an oily fish has fewer calories than many other high protein foods in equal amounts. Most of the calories in seafoods are from proteins.

Seafood is high in quality protein. On the average, fish will contain 18-22 grams of protein per 100 grams of edible fish. The amount of protein in a species of fish will vary with feeding habits, age and sex of the fish. Mollusks contain less protein and crustaceans contain more than finfish. A serving as small as 4 ounces of fish will supply about half the total amount of protein required each day by the body. The total amount of protein varies between lean and fatty fish. However, the amino acids and quality of the protein is constant. The quality of the protein in fish is high. Fish protein is also more digestible than animal protein. It is 90 to 100



percent digestible. This is because fish protein has a very small amount of connective tissue present. The connective tissue is also gelatinized during cooking. This causes it to "flake" when cooked. Fish muscle fibers are short and easy to digest. It is also easy to digest because of the low fat content. Fats slow down the digestive process. Since seafood is easily digested, it is important in the diets of young children and elderly people, who need easily digested foods. It is also included in many special diets of people with digestive disorders.

Fish are important sources of vitamins. The thirteen common vitamins are divided into two major groups, fat-soluble vitamins and water-soluble vitamins. In fish products, fat-soluble vitamins are found in the oil. Vitamins that are water-soluble are found in all parts of the animal. Fatty fish are an excellent source of vitamin D. The vitamin A content of most fish is low except for swordfish and whitefish, which contain high amounts of vitamin A.

Four of the eight members of the Vitamin B family can be supplied in adequate amounts by eating fish and shellfish. Fish and shellfish are especially rich in vitamin B_6, which is essential in using proteins. Dark-fleshed fish are good sources of riboflavin and niacin, which is necessary for energy conversion. Anchovies, herring, sardines, oysters and clams are rich sources of vitamin B_{12}, which is important for healthy blood cells. The B vitamin content of fish is the same as the meat of land animals.

Fish contain relatively large amounts of phosphorus, potassium and iron while the sodium and chlorine is low. Many fish and shellfish such as bonito, mackerel, bluefish, sardines, clams, oysters and mussels are a good source of iron. Seafood is also a rich source of potassium with many fish, having 300 to 400 mg per 3 1/2 ounces. Zinc is plentiful in marine organisms. Magnesium is an important nutrient that is needed in producing energy. Fish are a good source for magnesium. Fish flesh contains most of the elements present in seawater. Some are nutritionally important: iron, copper, iodine, fluorine, cobalt, zinc, chromium and vanadium. The amount of each element present in fish is determined by such variables as the amount present in the food chain and the size and age of the animal. Also, certain types of fish accumulate more of some of the elements than do others. Most essential trace elements are present in amounts equal to that of meat and higher than that of vegetables and dairy products.

Fish have low sodium levels even though they spend their lives in saltwater. Most fish are in the 60-100mg range for 3-1/2 ounces. Shellfish have 200-400 mg per serving. For good health, an intake of 1,100 to 3,300 mgs of sodium is recommended. Seafood is one of the excellent sources for a low sodium diet. However, if it is smoked or cured then it will be higher since salt is used in the processing.

Another important factor is that the nutrients in fish are not lost in cooking. Baking, broiling and pan frying results in retaining more than 90 percent of the fish's original protein.

Seafood also has a high retention of vitamins and minerals during cooking.

Seafood also fits well into our fast paced lifestyle. It cooks in only ten minutes per inch of thickness. This means that a seafood meal can be complete in 20 minutes or less. Seafood has little waste and can be prepared in variety of ways. Although the flavor, texture, appearance and size vary according to the species. The rules for cooking it are few and simple. Seafood can be easily substituted in casseroles, chowders, salads, main dishes and sandwich fillings. It is always in season. Seafood can also be part of a wise eating plan. It is a nutrient dense and lean food.

18. What Are the Characteristics of Sea Turtles?

Scientist(s) _____ **Team** _____

The sea is not a typical habitat for reptiles. Of the about 6,000 know species of living reptiles, less than two percent live in marine or brackish environments. The sea turtles are the best known of the marine adapted reptiles. However, some predominantly freshwater terrapins and turtles also live in estuarine habitats and regularly use coastal beaches and the dunes as nesting sites.

Sea turtles have roamed earth's oceans and seas since before the dinosaurs. The first sea turtles were here 150 million years ago. The ancestors of the turtles we see today entered the ocean 60 million years ago and probably evolved from marsh-dwelling species. Modern sea turtles are less specialized and diverse than their ancestors. They are the only living group of reptiles that spend their lives in a marine environment, with the exception of a few species of sea snakes. Today there are seven recognized living species of sea turtles found throughout the world in both tropical and subtropical areas. Five species of sea turtles are found in the Gulf of Mexico. You are going to compare the characteristics of the sea turtles.

Materials: Graph paper, ruler

Procedure:

1. Examine the data in the Table 1.

Table 1. Characteristics of Gulf of Mexico Sea Turtles

Turtle	Body Length	Weight
Green	31-44 inches;78-112 cm	150-410 lbs.;68-186 kg;
Hawksbill	21-45 inches;53-114 cm	60-190 lbs.;27-86 kg.
Kemp's Ridley	26-29 inches;64-70cm	80-100 lbs; 36-45 kg
Leatherback	55 inches;120-190 cm	441-1,116 lbs.; 200-506 kg
Loggerhead	32-41 inches;82-105 cm	146-223 lbs.;66-101 kg

a. Which turtle is the longest?
b. Which turtle is the shortest?
c. Which turtle is the heaviest?
d. Which turtle is the lightest?

2. Determine your height and weight.
   a. Which turtle's length is the closest to your height?
   b. Which turtle's weight is the closest to your weight?

3. Create a graph that compares your height to the length of the carapace of the sea turtles. How does your height compare to the length of the sea turtles?

4. The larger land turtles have a carapace length of less than 30 centimeters or 12 inches. Add the length of a land turtle to your graph. Most are less than 20 centimeters and weigh only several pounds. How does the size of the land turtles compare to the sea turtles?

5. Create a graph of your weight and the weight of the sea turtles. How does your weight compare to that of the sea turtles.

6. How many students (that weigh the same as you do) does it take to add up to the weight of each of the five turtles? Use the weight of the adult turtles.
   a. weight of one Green turtle = _____student(s)
   b. weight of one Hawksbill turtle= _____student(s)
   c. weight of one Kemp's Ridley turtle =_____student(s)
   d. weight of one Leatherback turtle= _____student(s)
   e. weight of one Loggerhead turtle= _____student(s)

7. Why do you think that sea turtles can be so much larger and heavier than land turtles? What is a possible explanation for the difference in size of land and sea turtles?

8. What problems would a land turtle encounter if they were as large as the sea turtles?

9. Examine Figure 1. Compare the sea turtles to turtles that spend most of their life on land. Make a Venn diagram to compare the turtles.

10. Summarize how the land and the sea turtles are adapted for their habitat.

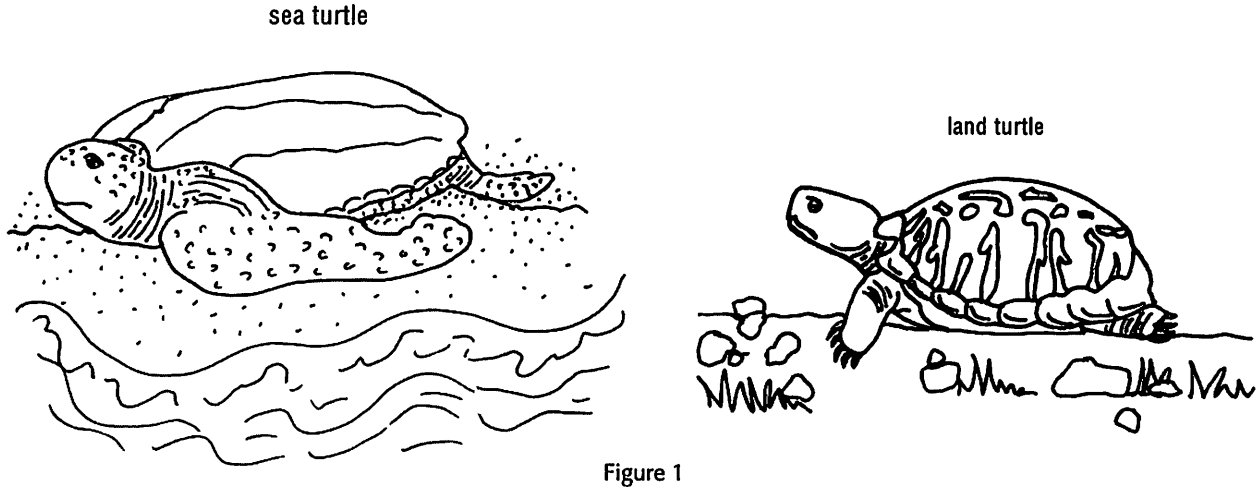


Figure 1

19. What Is the Relationship of Sea Turtle Characteristics, Diet and Habitat?

Scientist(s) _____ **Team** _____

Each species of sea turtle both looks and behaves differently. They do have several common characteristics. They have a protective shell like land turtles. The upper shell is called a carapace and is made of bone. On top of the bone are plates made of keratin called scutes, which give the shell a shiny look. Hard scales or plates (scutes) cover all but the leatherback and the number and arrangement of these scutes can be used to determine the species. The scutes are firm but flexible, not brittle. Side bridges connect the carapace to a smooth plastron on the underside. The turtle's backbone and ribs are fused to the carapace so it cannot bend its back. The leatherback is the only sea turtle without a hard shell. Its shell is made of a layer of thin, tough, rubbery skin that looks like leather.

Turtles do not have teeth but their jaws are modified "beaks" which are suited to their feeding and diet. They do not have visible ears but do have eardrums covered by skin. Turtles hear best at low frequencies and have an excellent sense of smell. They have large upper eyelids that provide protection for their eyes. Their vision underwater is good, but they are nearsighted out of the water.

All have flippers that are adapted for swimming, which makes them awkward and vulnerable on land. The front flippers are long and paddle like. This enables them to swim with powerful wing-like beats of its foreflippers. The hind flippers serve as rudders, stabilizing and directing the turtle as it swims. The hind flippers of some species are very well adapted for digging nests. You are going to investigate the differences in the turtles and their habitats.

Materials: Graph paper, ruler

Procedure:

1. Use the descriptions and data in Table 1 to draw a picture of each turtle on graph paper.

Table 1: Characteristics of Gulf of Mexico Sea Turtles

Turtle	Body Length	Body Shape	Head Shape	Weight	Color
Green	31-44 inches; 78-112 cm	Oval-shaped	Small and rounded, biting edge of lower jar is serrated for tearing plants	150-410 lbs; 68-186 kg	Variable usually with dark striations
Hawksbill	21-45 inches; 53-114 cm	Heart-shaped or Elongated with tapering behind; 4 costal scutes	Small,narrow with pro-nounced sharp beak like a hawk	60-190 lbs.; 27-86 kg.	Brownish with variable light mark-ings, very attractive
Kemp's ridley	26-29 inches; 64-70cm	Disc-shaped	Fairly large, Powerful jaws for crushing/ grinding	80-100 lbs; 36-45 kg.	Grey to olive green
Leatherback	55 inches; 120-190 cm	Elongated with 7 narrow ridges down the length of carapace to blunt point at rear	Medium-sized and rounded, delicate, scissors-like jaws	441-1,116 lbs.; 200-506 kg.	Black
Loggerhead	32-41inches; 82-105 cm	Heart-shaped or slightly elongated; 5 or more pair of costal scutes	Very Large, triangular, powerful jaws for crushing	146-223 lbs.; 66-101 kg.	Reddish brown carapace; dull brown to yellow plastron

2. Compare your drawings to the actual pictures of the different sea turtles in Figure 1. How did your drawings compare?

3. Use the sea turtle information in Table 1 to identify each turtle in figure 1. Write the name of the turtle under the drawing in Figure 1.

sea turtles

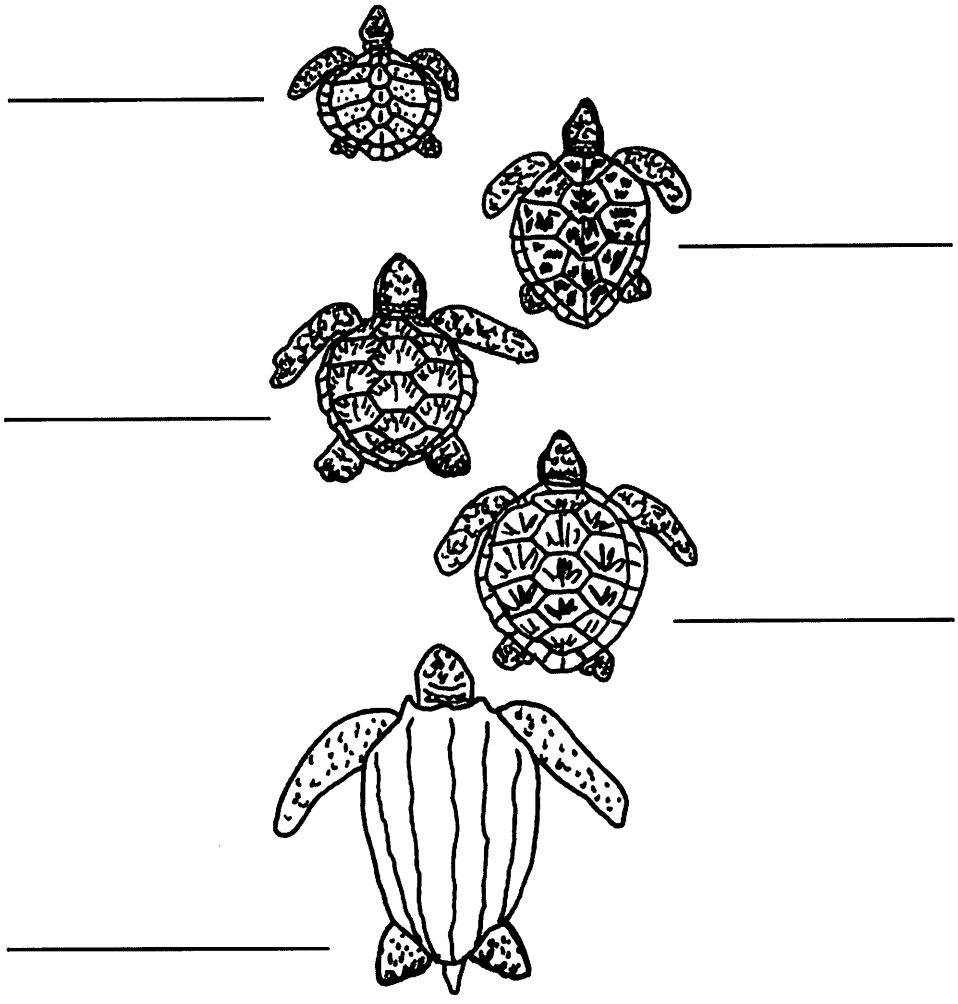


Figure 1

4. Sea turtles may use different feeding areas during each stage of growth. It is believed that all hatchlings head out toward the open ocean from their hatching beach. At sea they live in the sargassum or other flotsam caught in the surface currents. The hatchlings are about the size of a half dollar or around 3 centimeters. What would they find in the flotsam and be able to eat in this stage in their life?

5. After years of riding the currents as juveniles, they venture into nearshore areas and estuaries to continue their development into adulthood. Once they reach adulthood, they move into their traditional feeding areas that they will use for the rest of their lives. Each species of adult sea turtle eats, sleeps, mates and swims in a distinctly different area. Sometimes their habitats overlap, but most of the time they have different preferences. Explain how this is beneficial to the turtle's survival.

6. Different species of sea turtles like to eat different kinds of food. Sea turtles have mouths and jaws that are specially adapted to help them eat the foods they like and find in their feeding area. Examine Figure 2, what differences do you notice in the heads of the turtles. What do you think each turtle would be able to eat?

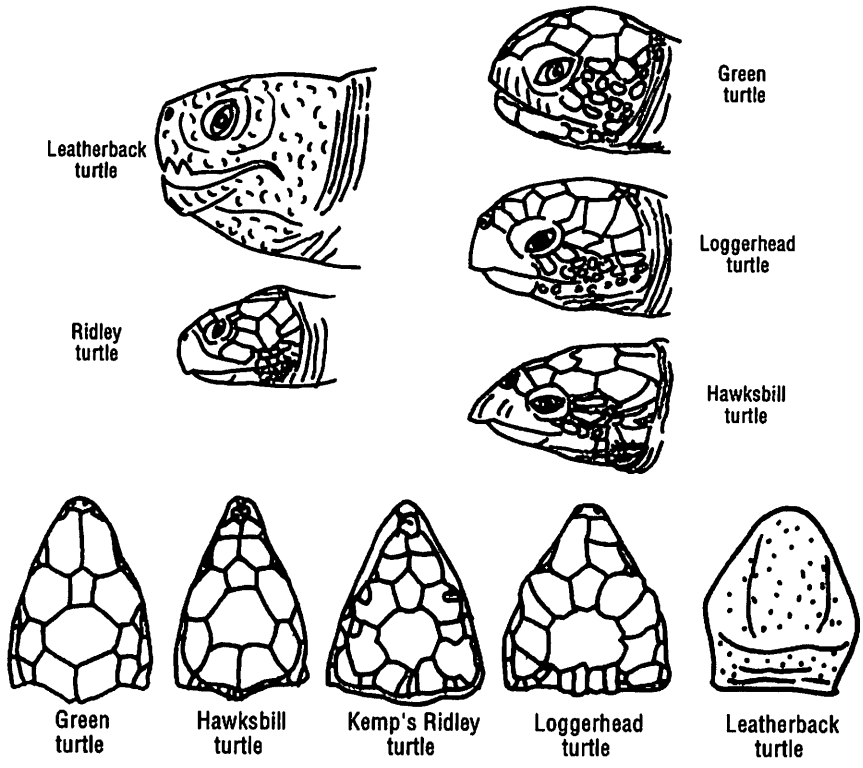


Figure 2. Source: Sealife, A Complete Guide to the Marine Environment, Smithsonian Press.

7. Use Table 1 and Figures 1 and 2 to determine what each turtle would eat. In Table 2 write the name of the turtle next to the food that you think it eats. For example, a turtle that has large, powerful jaws can eat organisms such as clams and mussels. It has the powerful jaw muscles needed to crush the shells of clams and mussels.

Table 2: Sea Turtle Diet and Habitat

Sea Turtle	Sea Turtle's Diet (adult)	Habitat of OrganismsEaten	Feeding Area/ Habitat of Turtle
	Sponges, anemones,squid, shrimp		
	Horseshoe crabs, crabs,clams, mussels, shrimp		
	Crabs, clams, mussels,shrimp, sea urchins,squid, jellyfish		
	Jellyfish		
	Grasses and algae		

8. To determine the turtle's habitat preference, analyze the turtle's diet. Where are the organisms found that make up the diet of the turtle? In the third column of Table 2, list the habitat in which the turtle's food would be found.

9. The habitat of the turtle's food is its feeding area. It lives where it can find its food. For example the first turtle listed in Table 2 eats sponges and sea anemones. Where do sponges and sea anemones live? This will also be the habitat of that turtle. Complete column 4, the turtle's feeding area or habitat for each turtle.

10. Summarize the relationship of the sea turtles characteristics, their diet and the habitat in which they live.

20. How Do Sea Turtles Navigate through the Ocean?

Marine Biologist: _____ **Team:** _____

Turtles have roamed the earth for a very long time, perhaps 100 to 150 million years. They were here before the dinosaurs. Sea turtles as we know them today have been around at least 10 million to 150 million years. In spite of all of the research on sea turtles in the last twenty years, there is still much to be learned. Very little is known about what happens to the turtles between birth and their return to nest. As soon as the turtles hatch, they head to the ocean. There they swim across hundreds of miles of ocean. Then, as adults, the females navigate back to the beach were they hatched to nest. How do they find their way to the ocean after they hatch? How do they find their way back to their nesting site years later? How do they navigate in the dark featureless ocean? What do they use as cues? Researchers have begun to identify the biological compasses and maps that guide sea turtles. Your team will act as researchers to investigate these questions.

Procedure:

1. In these investigations, you will be studying the loggerhead sea turtles that hatch along the Florida Coast. The following has been observed: The sea turtles hatch after sunset on summer nights. Therefore, the temperature is cooler and they are avoiding the heat of summer days. The hatchlings, that are no bigger than a child's hand, immediately scramble toward the ocean and plunge into the surf. They continue swimming for 30 to 50 miles offshore until they reach the relative safety of the Gulf Stream. Here they find shelter and food in floating sargassum. The turtles that survive to become adults, will years later return to the beach where they hatched. Your team will begin studying the sea turtles to answer the question of how do sea turtles find their way to the beach and around in the ocean.
   Question: How do the hatchlings know which way the ocean is?
   Possible hypotheses are:
   - the position of the stars
   - polarized light
   - odors
   - wind direction
   - low frequency sound like waves breaking on the beach
   - the earth's magnetic field

   a. Select one of the hypotheses to test. What will be your independent or manipulated variable?
   b. What will be your dependent or responding variable? Which variables will you need

to control?

2. During the past 15 years, researchers have found that various migratory birds and fish (such as salmon, tuna and shark), as well as certain amphibians, insects and mollusks, use the earth's magnetic field to guide their movement. To test this in turtles, researchers used a water-filled dish (over 1 meter in diameter) in which to test the turtles. Each hatchling was attached to a nylon harness and tied to a lever arm. The turtle could swim freely and the arm tracked its movement. The turtles' swimming directions are recorded by a computer. The researchers put a dim light in the magnetic east as a cue so that the hatchlings would begin swimming to the ocean. In the natural habitat, the turtles come out of their nests at night. The ocean reflects more starlight or moonlight than the land does so a light appears in the direction of the ocean. After more than an hour, the light was turned off and the hatchlings were swimming in the dark. For several minutes, the hatchlings circled the dish like they were confused. Then the turtles would swim in a specific direction for several minutes, and then they would circle. The turtles repeated this pattern all night. When the data was analyzed, the researchers found that the hatchlings did not swim randomly. They swam towards a point between magnetic north and east. This direction would lead them away from the coast of Florida to the Gulf Stream.
   a. What was the independent (manipulated) variable the researchers were testing?
   b. What was the dependent (responding) variable being tested?
   c. What variables did the researchers control?
   d. Analyze the findings. Summarize the researchers' findings.

3. The researchers hypothesized that the direction the turtles swam was based on magnetic orientation. To test their hypothesis, the researchers needed to show that changing the direction of the magnetic field changed the direction in which the turtles swam. They used a coil that could generate a magnetic field greater than that of the earth's field but in the opposite direction. They placed this coil around the dish in which the turtles would swim. The coil would change or reverse the magnetic field experienced by the turtles. The researchers used this to test the direction the hatchlings would swim in two different magnetic fields. Each turtle would begin swimming with a dim light and then the lights would be turned off. When the magnetic fields were reversed, the turtles swam in the opposite direction.
   a. What was the independent (manipulated) variable the researchers tested?
   b. What was the dependent (responding) variable?
   c. What variables were controlled? Analyze the researchers' findings.
   d. Summarize what the researchers learned.

4. The hypothesis was tested in the laboratory. Now the researchers needed to test it in natural surroundings. To test their hypothesis, they built a floating orientation cage in which to test the turtles in the ocean. The turtles paddled in the direction of the open ocean, even when tested 15 miles from shore. What is the possible explanation for how the turtles knew in which direction to swim?

5. A few days later, on an unusually calm morning with little or no wind, the behavior of the hatchlings changed. The researchers observed that the turtles swam as though they were confused. They no longer swam in one direction.
   a. What is a possible cause for the turtles no longer swimming in one direction?
   b. How does this affect the idea that turtles used the earth's magnetic field for direction?

6. The researchers were puzzled. Then the wind began to gently blow causing small waves that moved toward the shore. Immediately the turtles began swimming in the direction of the open ocean. The turtles were swimming into the waves. The researchers now wondered if the hatchlings were using wave direction as a cue for swimming. How could they test this?

7. As a result of their laboratory testing, the researchers learned that hatchling turtles could orient themselves by detecting waves as well as by detecting the earth's magnetic field. But in the ocean, do sea turtles use waves, the geomagnetic field or some completely different cue to guide their movements? Which cue was more important, the waves or the magnetic field? To determine whether waves were the most important cue, the researchers needed a day in which waves moved in an unusual direction. In other words, the waves had to move in a direction that was not towards the shore. In this situation the hatchlings would have to decide whether to swim toward the waves or move to the ocean using another cue. A hurricane moving along the coast provided the chance to conduct the experiment. After the hurricane passed the waves were moving away from the shore instead of toward the land. Your research team has been asked to write up the experimental plan to gather data to answer the question. Complete the research plan.
   a. Question: (Write the question your team will investigate)
   b. Hypothesis: (Write an if... then... statement that explains what you think will happen in your investigation)
   c. Design for the Investigation
      What is the independent variable in the investigation?
      What is the dependent variable in the investigation?
      What are the variables that are controlled?
   d. Procedure: (Explain the steps you are going to take to investigate the question.)

8. During several weeks of unusual weather, the waves were moving away from land instead of towards land. In an area five miles from shore, the waves were clearly moving toward the open ocean and away from land. Under these conditions your research team released the turtle hatchlings one by one and observed the direction in which they swam. Your team repeated the experiment several times over a couple of weeks. Most of the turtles swam toward the waves even though this lead them back toward land. What is your conclusion? Compare your research teams results (d) to your hypothesis (b). Explain if the results support or refute your hypothesis (b). Summarize your findings.

9. Another question that researchers asked was, "Why might the baby sea turtles use ocean waves as a cue"? Researchers found that wave movement is normally a very reliable cue of offshore direction. The waves generally move towards the beach so hatchlings that swim into the waves will move toward the open ocean. Can the hatchlings use the waves as a cue to leave their Florida nesting beach and swim to the Sargasso Sea where they remain until they are half grown? Examine Figure 20.1, which shows migratory paths of sea turtles and the direction of the current. What inferences can you make about the migratory paths of turtles and the ocean currents?

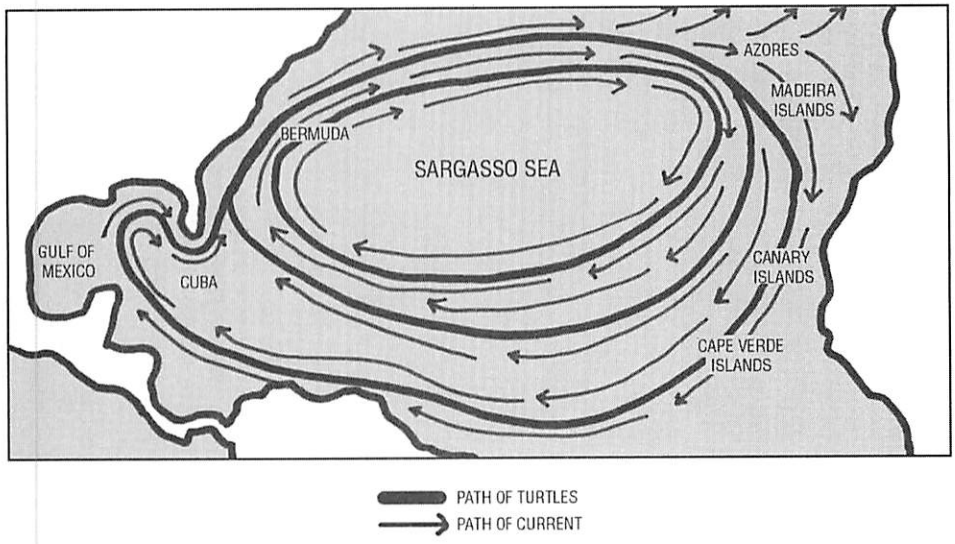


Fig. 20.1. Migratory paths of sea turtles in relation to the direction of the current.

10. Observations indicate that juvenile and adult turtles might not rely on waves alone. Adult turtles swim in directions other than straight toward waves. The adults may also use magnetic fields to find their way back to their nesting beach. However, researchers do not know how the adult turtles navigate and what cues they use. The navigation abilities of the sea turtles have enabled them to survive. In spite of this, sea turtles now face serious

threats to their survival. Five of the seven species live in the Gulf of Mexico. Four of the five are endangered and the Loggerhead is threatened. How can knowledge of the orientation cues of the hatchlings help increase the chances of laboratory-raised turtles successfully reaching the ocean?

11. How could understanding the navigation mechanisms of sea turtles help save them from extinction?

21. How Is the Survival of Sea Turtles Threatened?

Marine Biologist: _____ **Team:**_____

Each year thousands of hatchling sea turtles emerge from their nests, but only an estimated one in 1,000 to 10,000 will survive to adulthood. The total population figures are really unknown because young turtles and male sea turtles do not come ashore and are difficult to count. Population data are based on the numbers of adult females that come ashore to nest and even then the numbers are not reliable. Some females nest every two or three years and some nest more than once on the same beach in a season. Researchers rely more upon the changing numbers of nesting females from year to year to determine if the populations are increasing or decreasing. Since the numbers can vary greatly from year to year, surveys of a decade or more would be the best indicators.

a. The Kemp's ridley has been labeled the most endangered. In 1947, more than 92,000 nests were estimated. Surveys conducted between 1978 and 1988 indicated an average of 800 nests per year, reaching a low of 300 or so nests by the mid-1980s. Since 1985, the ridleys' numbers increased to the point that 1,400 nests were found at the main site in 1997.
b. The green turtles' nesting populations have not been surveyed long enough to determine trends. However, observations of nesting sites indicate a big decline in nests.
c. The loggerheads show a decline in some nesting areas. More years of nesting data and population studies are needed to assess the trends in Florida.
d. Basically no data is available on the hawksbill population.
e. It is estimated that there are less than 115,000 adult female leatherbacks worldwide. The records are too few to predict what is happening.

Sea turtles are given legal protection in the United States and its waters under the Endangered Species Act, which lists the hawksbill, leatherback, Kemp's ridley, and green turtles as endangered and the loggerhead as threatened. This designation makes it illegal to harm, harass or kill any sea turtles, hatchlings or their eggs. It is also illegal to import, sell or transport turtles or their products.

In nature, the new-hatched turtles face the greatest danger. Predators such as raccoons, crabs and ants raid the eggs and hatchlings while they are still in the nest. Once they leave the nest, the hatchlings are bite-size meals for birds, crabs and a host of predators in the ocean. Once the turtles become adults, their only predator is an occasional shark attack. Your team is going to analyze factors affecting the survival of sea turtles.

Procedure:

1. To understand what really threatens sea turtle survival, your team will look at the actions of

humans in Table 1. For each action, specifically explain how it impacts the turtle population. Does it affect the eggs? Egg laying? Food supply? Directly kill the turtle? Cause disease? Does it affect the young? Adults? All? Analyze each action in the Table 1, and cite the specific effect(s) of each action in the Impact column.

Table : Human Action and Its Impact on the Sea Turtle Population

Human Actions	Impact on Turtle Population
Many cultures harvest eggs for food; Adult turtles harvested for meat	
Turtle shells are used for jewelry and souvenirs.	
Commercial Fishing; shrimping	
Nondegradable debris (balloons, pellets, bottles, vinyl films, Styrofoam, plastic bags)	
Artificial lighting; lights from beach developments (hotels, businesses, homes)	
Building structures such as seawalls, jetties, etc. to protect beachfront property	
Beach Nourishment, which consists of pumping, trucking or depositing sand on a beach to replace what has eroded.	
Pollution: oil spills, urban run-off of chemicals, fertilizers, oil, etc.	

2. How does our population growth in the coastal area impact the sea turtles? Explain.

3. As a team, discuss how sea turtles can be protected as development of the coastal areas continues? Is it possible to do both? Explain. Include suggestions.

4. Most people who live inland feel that what they do does not impact the sea turtle populations. Review the human actions in Table 1. Which actions are not direct action on turtles or limited to the beach?

5. As a team prepare a survey to determine if your classmates are aware of how their actions every day and when they go to the beach may impact sea turtles. List the questions you will include in your survey below.

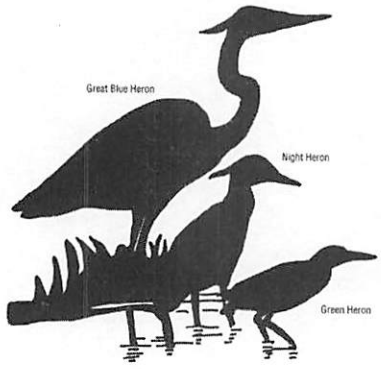
6. Each member of your team should use the survey you created and interview five people (in school and outside of school). Summarize your survey results.

7. The numerous threats facing sea turtles are primarily related to human intervention. Solutions would be more difficult to find if potential extinction were due to geologic or climatic changes. As a team use the survey results to plan a way to increase public awareness of the sea turtle problem. You might create a brochure, poster, newsletter, TV or radio announcements or other methods to increase awareness in your school and community.

22. How Are Birds Adapted to Their Environment?

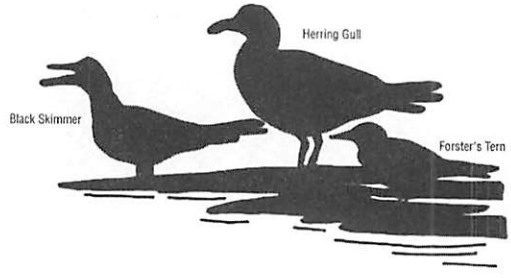
Ornithologist: _____ **Team:** _____

Birds have always held a fascination for people. Birds have enriched our history and our lives in symbols, stories, art, songs, and recreation. Birds and bird studies have contributed greatly to the study of ecology. They have contributed to the studies of mating and family behaviors, adaptation to natural and human-made environments and of navigation and flight. Over time the birds have developed unique features that allow them to function in a great variety of habitats. They are the only vertebrates that live on land, water and in the air. The diversity of birds and their body structures and functions reflect millions of years of adaptation and change. Texas has more than 600 species of birds. Of these, more than 75 percent have been seen along the coast. You are going to investigate the diversity of birds found along the Gulf coast and their adaptations.



Materials: 5 x 15 cm pieces of cotton cloth, petroleum jelly or baby oil, plastic cup, water, feathers (available from craft stores), hand lens, Some of the following to represent bird beaks - scissors, chopsticks, clothespins, spoons, tweezers, toothpicks, strainers, knitting needles, straw, nut cracker, pliers, eyedropper, fishnet, large scoop, slotted spoon, tongs or popsicle sticks. Some of the following to represent bird food- pan with oatmeal and marble, pieces of gummy worms, grapes and raisins; whole walnuts or peanuts; rice in a pan of water; half pieces of bread; blades of grass in water, small paper cups. Bird books, Internet

Procedure:

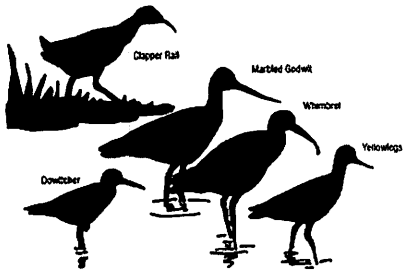


Part I: What are the general features of birds?

1. Draw an outline of a bird's head. Draw in the bird's eyes. Where are the eyes of most birds located? In front or on the sides? Where are your eyes located?

2. People have eyes that are in the front of their head and face forward. They have binocular vision which means that both eyes focus on the same image. Birds have monocular vision most of the time. Each of their eyes focuses on a different image. Most birds only have binocular vision when they focus straight ahead. Cover one eye with a hand and look around. What is the difference between one-eyed sight and two-eyed sight?

3. Birds have an oil gland that is not found in other animals. The oil gland or preen gland is right above the base of the tail on the bird's rump. The gland secretes an oil and the bird squeezes it out with its bill and spreads on its feet and feathers. To determine the function of the oil, cut two 5 cm x 15 cm pieces of cotton cloth. Apply petroleum jelly or baby oil on one of the pieces of cloth. Dip each piece into a cup of water and then pull them out. Based on your investigation, how does the oil gland help the birds?



4. Birds are the only animals in the world with feathers. There are two main types of feathers. The contour feathers, which are found on the bird's body, wings and tail and the down feathers which are fluffier and softer. The down feathers lie close to the bird's body under the contour feathers. Obtain a feather. Is the feather a contour or down feather?

5. Look closely at the contour feather. The hard tube in the center is the shaft. The rest of the feather is the vane. The vane is made up of hundreds of barbs that look like shiny hairs coming off the shaft in parallel rows. Tiny barbules grow off each barb. Use a hand lens to observe them. The barbules function like a kind of "Ziploc" seal. The bird can "zip" the feathers back in shape by pressing the barbs together with its beak. Move the barbs apart or unzip them. Press your figures slowly over the barbs from the shaft to the outside. Where you able to move the barbs together or "zip" them? Why is it important to the birds to keep their feathers smooth for flying? Why do the birds preen?

Part II: How do different birds fly?

1. Hold your arms straight out. A bird's wing is similar to your arm. What is your upper arm connected to? Both birds and people have their upper arm connected to the shoulder. What connects your upper arm to your forearm? What connects the forearm to the hand?

2. A bird's hand is a little different from the human hand. It has a bony thumb stuck off to one side and two fingerlike bones on the end. The upper arm and forearm make a bird's inner wing. The rest of the wing is the hand. Gliding birds, such as gulls, have long inner wings compared to their small hand sections. The inner wing provides the lift they need to soar. Flapping birds have small inner wings and long hand sections. The hand acts as a propeller and pulls the bird forward as it flaps its wings. Birds that fly at high speeds have long, narrow wings that allow them to cut through the air quickly. Those that soar have broad feathers that allow them to take advantage of upper wind currents. What can you conclude about a bird's wing and it's flying?

3. Try out your wings by extending your arms and flapping away. See how long you can keep up the pace of one flap per second before you get tired. Some birds can fly for 48 hours straight, flapping the whole time.

4. Did your arms ache from the flapping? Where your chest muscles and arm muscles tired? Do you get tired walking as quickly as you did "flying"?

5. We get around by walking, our leg muscles are more developed than our chest muscles. The bird's chest muscles are very developed to power its wings while their leg muscles are weaker. Some birds have well-developed leg muscles. Which birds would have well developed leg muscles? Well-developed wing muscles?

6. The wingbeat of birds varies. Some have a wingbeat of 20 per 10 seconds while the hummingbird has a wingbeat of 700 per second. What is the rate of wingbeats that you could maintain for several minutes?

Part III: What type of beak is most effective?

1. Because of the different habitats in which birds live and the types of food available, birds have may different shapes and types of beaks. Their beaks are adapted to fit the kind of food that they eat. Design an investigation to determine which beak is best for each type of food.
   a. The following materials are available to represent beaks: scissors, chopsticks, clothespins, spoons, tweezers, toothpicks, strainers, knitting needles, straw, nut cracker, pliers, eyedropper, fishnet, large scoop or slotted spoon, tongs or popsicle sticks.
   b. The following items are available to represent food items: pan with oatmeal and marble, pieces of gummy worms, grapes and raisins in it (animals buried in mud or sand); whole walnuts or peanuts to represent clams and mollusks; very small styrofoam pieces of fish food floating on water to represent small marine organisms; rice in a pan of water to represent small marine plants and animals; half pieces of bread to represent larger fish; blades of grass in water to represent sea grasses; and other items your may want to test.
   c. A small paper cup will be used to represent the bird's stomach. The cup must be kept upright at all times. Food cannot be scooped into the cup.

2. What is the hypothesis being tested?

3. What procedure will be used to conduct the tests? Time for eating? Number of trials? Types of food? Types of beaks? Etc.

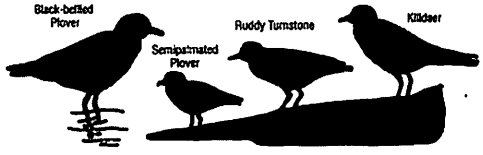
4. Prepare a data table similar to Table 1 to record your results.

Table 1: Amount of Different types of Food eaten Using Different Beaks

Beak Type	Amount of Food Type #1	Amount of Food Type#2	Amount of Food Type#3	Amount of Food Type#4	Amount of Food Type#5

5. Graph the results. What type of beak was best for each type of food?
6. Summarize the relationship between the beak of a bird and the best food for it. What enables a number of birds to share the same habitat?
7. Conduct an experiment to determine if it is easier to get more food with only one item present or with all the food items together. How would crowding and competition affect the food gathering of the birds?
8. What evidence did you gather that supports or refutes the statement that the more diverse the ecosystem, the greater the number of birds that can share the habitat.

Part IV: Can you analyze a bird and its adaptations for its habitat?



1. Select one of the following groups of birds: grebe, pelicans, cormorant, frigate bird, bitterns, heron, egret, isbis, spoonbill, ducks, geese, osprey, caracaras, krestrel, rail, coot, crane, plovers, oystercatchers, stilts, avocet, sandpipers, phalaropes, gulls, terns, skimmers, kingfisher, blackbirds and pipits. Use the Internet and reference books to learn which members of the bird family live along the coast. Select one member of the family to research. What is the habitat of the bird?
2. Sketch the beak of the bird. What is the diet of the bird? How does it obtain its food?
3. The legs and feet of birds are also extremely varied in shape. They are designed for the environment in which the bird lives. Sketch the bird's feet. How are its feet designed for the environment? How does its diet or obtaining of its food relate to its legs and feet?
4. Birds have distinctive shapes and silhouettes both standing and in flight. Sketch the standing and flying silhouettes of the bird.
5. Birds vary greatly in size. What is the size of the bird? Research to determine if the bird is large, in what ways it gets extra help in taking off? Is it using powered flight or a glide?
6. Ducks, geese and even brown pelicans fly in formation. What is the benefit for birds to fly in formation especially when migrating?

7. Birds are the most brilliantly colored members of the animal kingdom. There are two reasons why feathers appear to be colored. They have built into them structural elements that reflect light in different ways or they contain pigment or dyes. Color functions in every aspect in the life of birds. The colors either help camouflage the bird or make the bird extremely visible. The colors may aid in the recognition of species and sex by particular birds. The colors may be used in threats or courtship. Describe the colors of the bird. What is the relationship of the color to the bird's environment or behavior?

8. Many of the groups of birds that swim, swim in different ways. If the bird swims, try to determine if it primarily uses it legs and how it uses its legs. Swimming birds have adaptations to overcome buoyancy in diving, insulating against the cold and long periods in the water. If the bird, swims, floats, dives or spends long periods of time in the water in what ways does its behavior or adaptations enable it to do so?

9. Does the bird spend all or only part of the year on the Texas coast? Where else does the bird live? Is it a migratory bird? If so from where does it migrate?

10. Use the information you have learned about the bird to design a life size picture of the bird in its habitat. Prepare a presentation about the bird to the class.

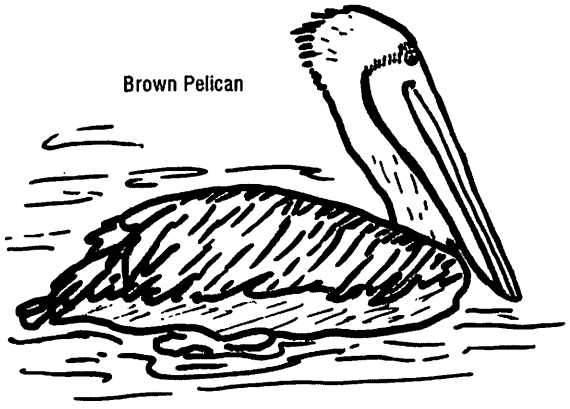
Part V: Can you design the bird's beak and feet?

1. Use what you have learned about the adaptations of birds to design a bird that fits each description below.
   a. This birds feeds on small mollusk (Donax), crustacea and insect larva found in the sand. Design the beak and feet for walking on the sand and probing for food.
   b. This bird feeds largely on oysters, clams and marine worms. Design the feet of a bird that wades in the water and uses its beak like a knife to go into the shell and cut the muscle that keeps the shell closed.
   c. The bird swims completely underwater to catch slow-moving fish. Design the feet for swimming and a beak so the bird can cock its neck back, spear the fish out of the water and swallow it.
   d. This bird eats small insects in the water. Design the feet to wade in the water as it swings the beak from side to side to capture small organisms.
   e. Design the beak and feet for a bird that feeds by sunning along shorelines and snapping up small marine invertebrates.

2. Describe a bird's feeding behavior and diet and have your classmates design the bird.

23. What Caused the Brown Pelican Problems?

Ornithologist: _____ **Team:**_____



Imagine you are sitting on a jetty along the coast in the early morning or late evening. Low over the water a line of very large dark birds fly slowly in a precise formation. Their wings beat no more than once per second. With their heads pulled back on their breasts, they alternate a short flapping flight with short arrow glides. It doesn't seem possible that they can fly with so little effort. These large birds that average eight pounds are the brown pelicans. You are going to investigate why they almost became extinct along the Texas coast.

Materials: 25 pieces per student of Multicolored pasta or dog food or poker chips or colored paper squares approximately 4 cm x 4cm, (one-third need to be one colored or marked so they can be identified), brown paper bags (lunch bags) or plastic sandwich bags, white cloth and brown cloth.

Procedure:

1. The bill of the brown pelican is several times longer than its head. On the underside of the bill are long extensions of the lower jawbones. The bones join only at the tip and can be spread apart. Between these jaws hangs the pouch. The pouch can contract when it is not in use or serve as a dip-net when opened. What inferences can you make about how the pelican gets its food and what it eats?

2. Brown pelicans feed by diving, sometimes from heights of 50 to 60 feet above the water. They fold their wings and dive headfirst into the water. The pelicans net the fish in their pouches and surface again after scooping up its catch along with up to a gallon of water. What will the pelican need to do before it can swallow the fish?

3. In the 1920s there were an estimated 5,000 brown pelicans nesting on the Texas coast. Observers noted a major decline in the 1950s with fewer and fewer adults. No young were born between 1964 and 1966. A 1969 survey counted only 116 brown pelicans along the Texas coast. What happened? What are some possible hypotheses?

4. You are going to participate in a simulation to collect data and help determine what hap-

pened to the brown pelicans. Divide the group into three teams. In a class of 28 students, there should be 16 small fish, 9 large fish and 3 Brown pelicans. To identify each group, the large fish can wear a white cloth around their arm and the brown pelicans can wear a brown cloth or bag over their arms. Give each small fish a paper bag. The bag represents their stomachs.

5. Without the students watching distribute the food (colored pasta, dog food, poker chips or squares of paper) around a large open space. The instructions are:
   a. The pieces (pasta, chips, etc.) that are scattered about represent microorganisms in the water.
   b. The small fish are the first to look for food. At the signal, they will enter the area and collect as many microorganisms (food tokens) as possible in their stomachs (the brown bags or plastic sandwich bags).
   c. At the end of 30 seconds, the large fish will enter the area to hunt the small fish. Each large fish will catch or tag small fish. When a small fish is caught, it gives its food bag to the large fish and goes to the sidelines.
   d. Give each large fish time to catch at least one small fish. The size of the area will determine the time the large fish have to hunt for small fish. In a small area, 15 seconds may be enough while in a larger area 60 seconds may be needed.
   e. Next allow 15 to 60 seconds for the brown pelicans to swoop in and catch the large fish. When the pelican catches a large fish. The large fish goes to the sidelines and the pelican gets its food bag.
   f. At the end of the designated time period, have all the students come back together and sit down. Ask the student who have been eaten, what animal they were and what animal consumed them.
   g. Ask any animal that is alive to empty their food bags on the floor or on paper. They should count the number of marked or designated color of food pieces and the total number of food pieces they have. List any small fish and their total number of marked pieces, list the number of large fish and their total number of marked pieces and list the brown pelicans and the number of marked and total pieces that each has.
   h. Inform the students that there was a pesticide in the environment. The pesticide was sprayed on crops in nearby fields to prevent pests from eating or damaging the crop. Why are pesticides used to prevent crop damage?
   i. If any small fish have marked pieces that represent the pesticide in their food supply, they are considered dead. Any large fish that have more than half of the marked pieces in their food will be considered dead from the side effects of the pesticide.
   j. The two pelicans with the highest number of marked food pieces will not die. However, they have accumulated so much pesticide in their body that the eggs produced by

it and its mate is infertile or the shells are so thin that the eggs will not hatch. The other pelican does not appear to be affected at this time.

6. Discuss what you have just experienced in the simulation. How does the food chain work and how do toxic substances like pesticides enter the food chain with a variety of results? Discuss how substances can accumulate in higher species in a food chain.

7. DDT and other chlorinated-hydrocarbons pesticides were sprayed on the land in large amounts. DDT and toxic chemicals washed into the streams and the sea. Microorganisms absorbed them. These microorganisms were eaten by the small fish. The small fish were eaten by larger fish. The large fish were in turn eaten by the pelicans. Concentrations rarely kill the birds but it does upset the body chemistry and result in the production of infertile or thin-shelled eggs. Explain what happened to the brown pelicans in the 1960's?

8. The brown pelicans weren't the only victims; bald eagles, ospreys and peregrine falcons also declined significantly and were listed as endangered species. Explain why.

9. White pelicans are also found along the Texas coast. They do not dive for food. Instead they float on the water, paddling along and scooping up fish in their enormous beak and pouch. Their pouch can hold three gallons of water. The white pelicans move to fresh water during the breeding season and feed in a variety of locations. The white pelicans were watched but their populations did not decline like the brown pelican. What are some possible explanations?

10. DDT was banned for most uses in the United States in 1972. Bird populations began to recover quickly. Brown pelicans are again flying along the coast. Chlorinated hydrocarbons are still used in other countries. They are also the by-products of other chemicals. Why could this still be a threat to the Texas coast and in other locations?

11. Pesticides are not the only problems that the brown pelican are facing. In the early 1900s, fisherman, both commercial and recreational, thought that the pelicans were catching fish that they wanted to catch so they began to destroy entire colonies of nesting brown pelicans. By the time ornithologists proved that the birds were eating mostly the "trash" fish menhaden, most of the brown pelicans were gone. The birds need deep, clear water in which to plunge dive and they usually nest on the ground in the vicinity of a pass or on an island. Pelicans have trouble surviving around humans. They can't tolerate the disturbance particularly when they are starting to nest. If disturbed they will abandon the area. How is the increasing human population with more fishermen, recreational boaters, picnickers and campers going to impact the pelicans?

12. Fire ants, raccoons, coyotes, dogs and cats, water and food polluted by heavy metals and

habitat loss and destruction make up what the brown pelican must deal with as it is coming back from the impact of pesticides. What could be done to help the brown pelican survive?

13. Brown pelicans with a wingspan of up to seven feet are excellent flyers. However, they frequently have fatal accidents navigating human-made obstacles such as power lines, fishing lines, mirrored glass reflecting the sky, cars and trucks, and the South Padre Island causeway. The causeway has become a death trap to the birds. The birds feed on the south side of the causeway and then when storms come up or there is a strong north wind, they can't make it over the bridge. The brown pelican death toll on the causeway during a storm has ranged from 4 to 15 birds. There is also a wind shear effect on the causeway at certain times that affects the pelican. What might be done to help the pelican in navigating human-made obstacles?

24. What Type of Swimmers Are Marine Animals?

Biologist _____ **Team** _____

Most animals can swim, but only a few have developed specific adaptations for efficiency in the water. Animals, such as fish, whose ancestors also swam, are considered primary swimmers. Swimming animals whose ancestors lived on land before they returned to the water are called secondary swimmers. All swimmers must reduce drag; propel themselves through the water; control their vertical position in the water; and maintain their orientation. You are going to create a model to study the breathing and stability of primary and secondary swimmers.

Materials: Large pan or container filled with water, a cucumber, waterproof marker, Styrofoam plate or recycled Styrofoam egg carton, scissors, plastic knife (optional) or toothpicks.

Procedure:

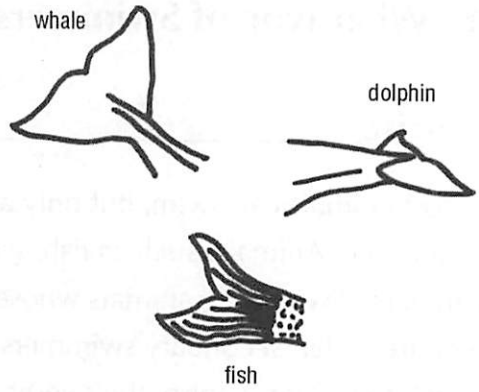
1. Use the cucumber to represent your animal. On the cucumber mark sports for a non-adapted nose (in front of the face) and an adapted nose or blowhole (on top of the head). Take the cucumber and place it in the water. Let it "swim." Make it come to the surface for air.
   a. How much of the animal must come to the surface if it breathes from a nose like a primary swimmer such as a fish?
   b. How much if it uses a blowhole like a secondary swimmer such as a whale?
   c. Which way of breathing would take the least amount of effort? Explain why.
   d. Which way is safer? Explain why.

2. How stable is the "cucumber" animal in the water? Does it spin and roll with ease?

3. What kinds of structures do aquatic animals have to control their movement in water?

4. Use the Styrofoam and scissors to make fins and tails for the sea animal. Fins can be attached by making a slit in the cucumber with a plastic knife and inserting the fin or attach it with toothpicks. Try different arrangements of the fins. What is the minimum number of fins that are needed to keep the sea animal from rolling in the water? What is the best arrangement for the fins? Make a sketch of the arrangement of the fins.

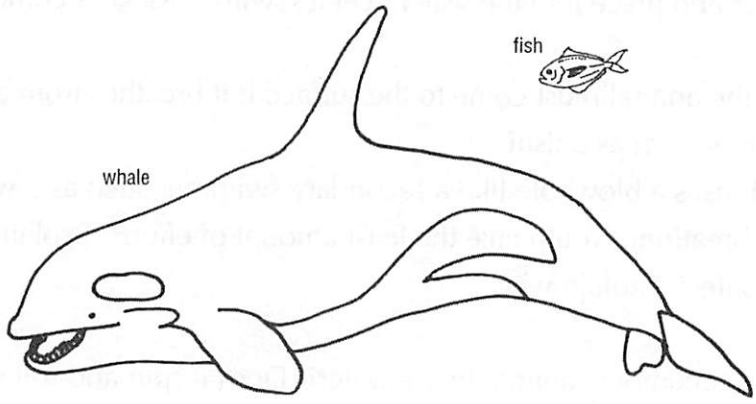
5. Compare the tails of a dolphin, whale and fish in Figure 1. How does each move its tail as it swims?



6. Why did secondary swimmers need to develop modified legs and tails when they adapted from land to a marine life?

7. Below is a list of changes that had to occur in secondary swimmers for them to change from living on land to living in water. For each listed below explain why it was needed.
   a. Longer periods between breaths
   b. Adapt to pressure changes and greater pressure
   c. Control their body temperature
   d. Their reproduction and birth of young
   e. Their senses
   f. Respiratory system changes

8. Summarize the differences between primary and secondary swimmers.



25. Is It a Whale? A Dolphin? Or a Porpoise?

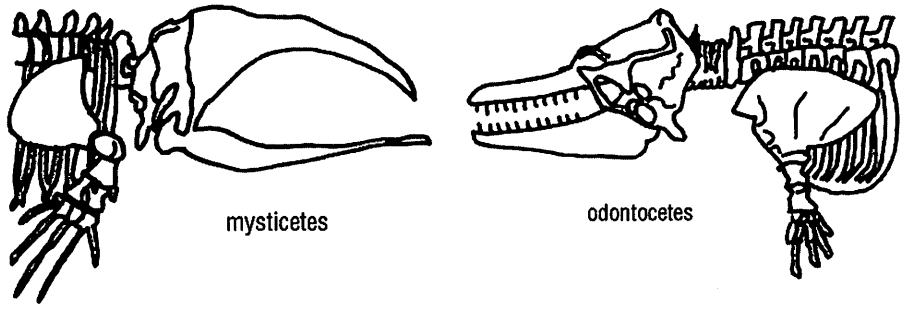
Marine Biologist _____ **Team** _____

The words "whale," "dolphin" and "porpoise" are misleading. They have no real scientific basis so they are confusing. In theory, whales are the largest of the order of mammals called cetaceans. Dolphins are of medium size and porpoises are the smallest. This doesn't work very well either. Some whales are smaller than the largest dolphins and some dolphins are smaller than the largest porpoises. To make it even more confusing, there are six "whales" that should really be called "dolphins." These are the killer whale, short-finned pilot whale, long-finned pilot whale, false killer whale, melon-headed whale and pygmy killer whale. They are all members of the dolphin family, Delphinidae.

Ironically there is even a "dolphinfish" that is really a white-fleshed saltwater fish known as the mahi-mahi or dorado. When you go out to eat and see dolphin on the menu, you don't have to worry that you are eating the mammal. Dolphins are protected by U.S. law. It is really a fish you are eating. Many cetaceans are known by many common names in many different languages. You are going to examine the differences between whales, dolphins and porpoises.

Procedure:

1. Instead of three groups (whales, dolphins and porpoises) think in terms of two distinct groups. The odontocetes and the mysticetes. These two groups have a strong scientific basis and avoid all the confusion normally associated with "whales," "dolphins" and "porpoises." Examine Figure 1 that shows the skeleton for each. How do they differ?



2. The Mysticetes are the baleen whales. Mysticeti from the Greek words *Mystax* meaning "moustache" and *Ketos meaning,* "whale." The odontocetes are the toothed whales. Odontoceti (from the Greek words *Odontos* meaning, "tooth" and *Ketos* meaning "whale." Which cetaceans have the greater number of different species?

Table 1: Whales, Dolphins and Porpoises

Family		No. of Species
Odontocetes	**Toothed Whales**	Total number =70
Kogiidae	pygmy and dwarf sperm whales	2
Physeteridae	Sperm whale	1
Monodontidae	Narwhal and beluga	2
Ziphiidae	Beaked whales	21
Delphinidae	Oceanic dolphins	33
Iniidae	Boto (Amazon River Dolphin	1
Pontoporiidae	Yangtze River Dolphin & franciscana	2
Platanistidae	Indus and Ganges River dolphins	2
Phocoenidae	Porpoises	6
Mysticetes	**Baleen whales**	Total number = 11
Balaenidae	Right whales and bowhead whales	3
Neobalaenidae	Pygmy right whale	1
Eschrichtiidae	Gray whale	1
Baleanopteridae	Roroqual whale	6

3. In which group are the dolphins and porpoises found?

4. Use Figure 1, 2, 3 and 4 and Table 1 to complete a table like Table 2, comparing the two groups of whales.

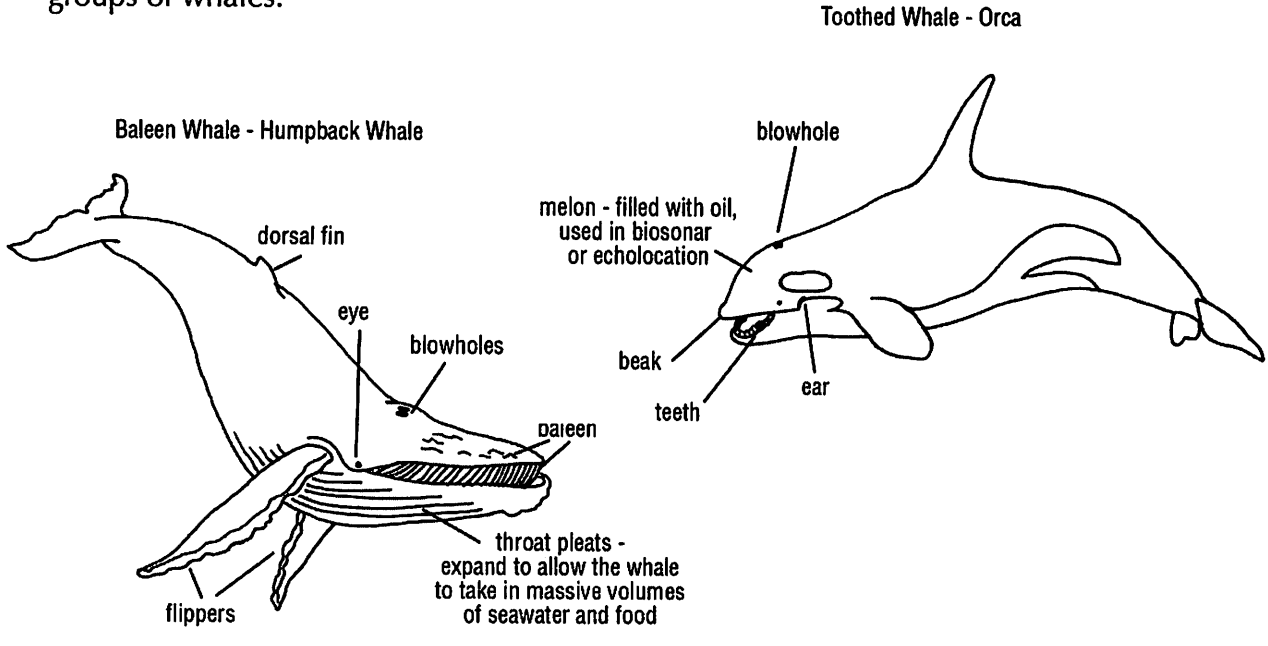


Fig. 2. Toothed and Baleen Whales. (Source: Minerals Management Service: Whales and Dolphins of the Gulf of Mexico. A Teacher's Companion)

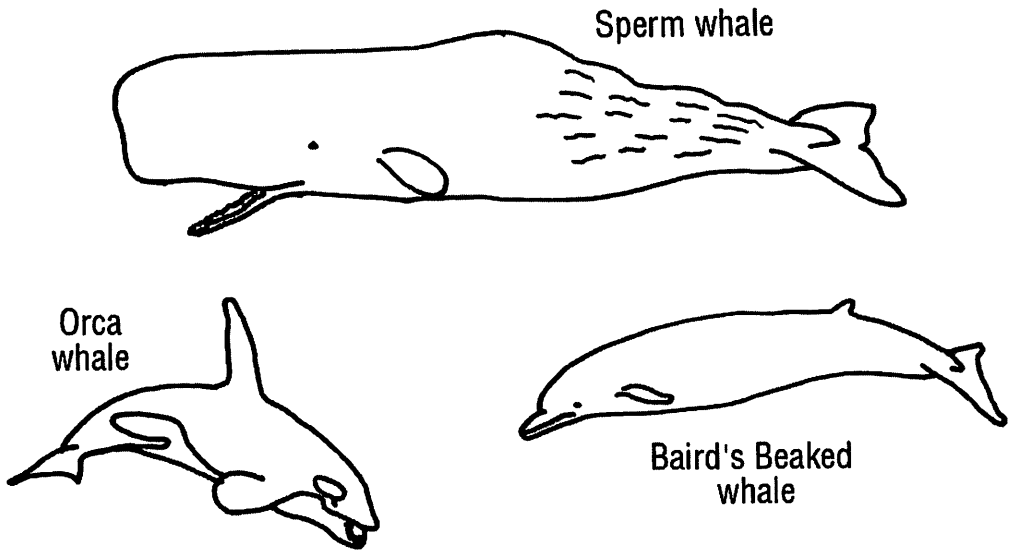


Fig. 3. Examples of Toothed Whales (Source: Minerals Management Service: Whales and Dolphins of the Gulf of Mexico. A Teacher's Companion)

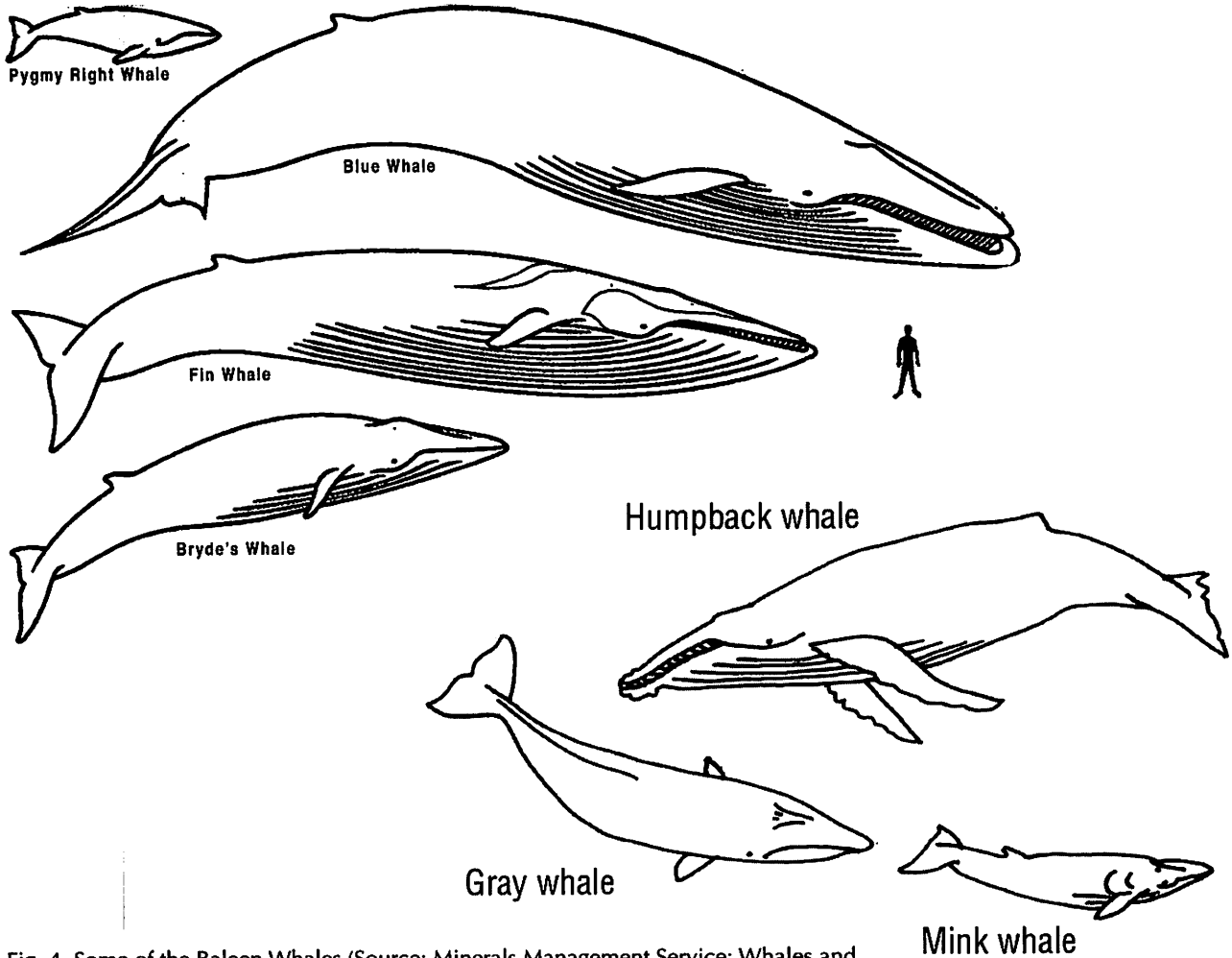


Fig. 4. Some of the Baleen Whales (Source: Minerals Management Service: Whales and Dolphins of the Gulf of Mexico. A Teacher's Companion)

Table 2: Comparison of Whales

Characteristic	Mysticetes-Baleen Whales	Odontocetes-Tooth Whales
Rostrum		
Mouth/teeth		
Uses Echolocation		
Number of Blowholes		
Size		
Number of Families		
Number of Species		
Other (list)		

5. Based on the characteristics of the whales, which group would feed on fish, squid and, in some cases, other marine mammals? Which group will feed on small schooling fish and crustaceans such as krill and copepods?

6. The toothed whales are generally the faster swimmers. Why would they be faster?

7. Most baleen whales migrate long-distances. Few toothed whales have long yearly migrations between separate feeding and breeding grounds. What might explain this difference?

8. Groups of toothed whales are more highly organized than baleen whales, possessing a social hierarchy. Young toothed whales stay with their mothers longer than young baleen whales. Why would a toothed whale need to remain with its mother longer?

9. Twenty-eight cetaceans are known to occur in the Gulf of Mexico. Seven are baleen whales and 21 are toothed whales. Why do you think more toothed whales are found in the Gulf of Mexico?

10. Summarize what you have learned about whales, dolphins and porpoises.

26. Is it a Dolphin or Porpoise?

Marine Biologist _____ **Team** _____

People have always been affected by the dolphin and porpoise. The animals' images are represented in paintings, sculptures, pottery, mosaics and even coins. The dolphin is the marine animal most represented in the decorations of ancient Greece and Crete. It is also the hero of numerous legends, fables and myths. In every civilization we find stories of a man reincarnated as a dolphin and even today there are tales of shipwrecks and drowning accidents that were avoided thanks to dolphins. Some European cities have included images of dolphins in their coats of arms. During the nineteenth century the French marines were nicknamed *marsouins* (porpoises) and used the animal as their symbol.

However, during the course of history, little scientific attention was paid to the dolphin. Most simply considered it a fish. It wasn't until 1551 that a French researcher classified the dolphin as a "fish with lungs." The terms "dolphin" and "porpoise" are often used interchangeably. However, you are going to group them into two families of toothed whales.

Procedure

1. Examine the dolphins in Figure 1.These are some of the 33 species of oceanic dolphins.

dolphins

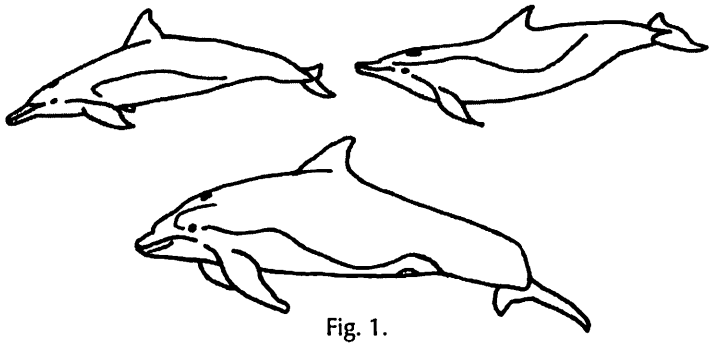


Fig. 1.

2. Examine the porpoises in Figure 2. These are some of the 6 species of porpoises.

porpoises

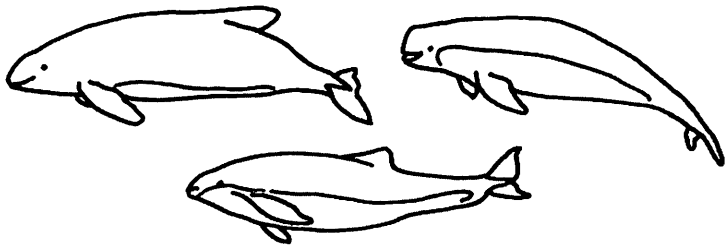


Fig. 2

3. How do the dolphins differ from the porpoises? How does the dorsal fin of the dolphin differ from that of the porpoise?

4. The teeth are the best characteristic for distinguishing between a dolphins and porpoise. Note the teeth of the dolphin and porpoise in Figure 3. How do they differ?

5. In the Gulf of Mexico, it is even easier to determine whether it is a dolphin or porpoise. In the Gulf of Mexico, there are only dolphins.

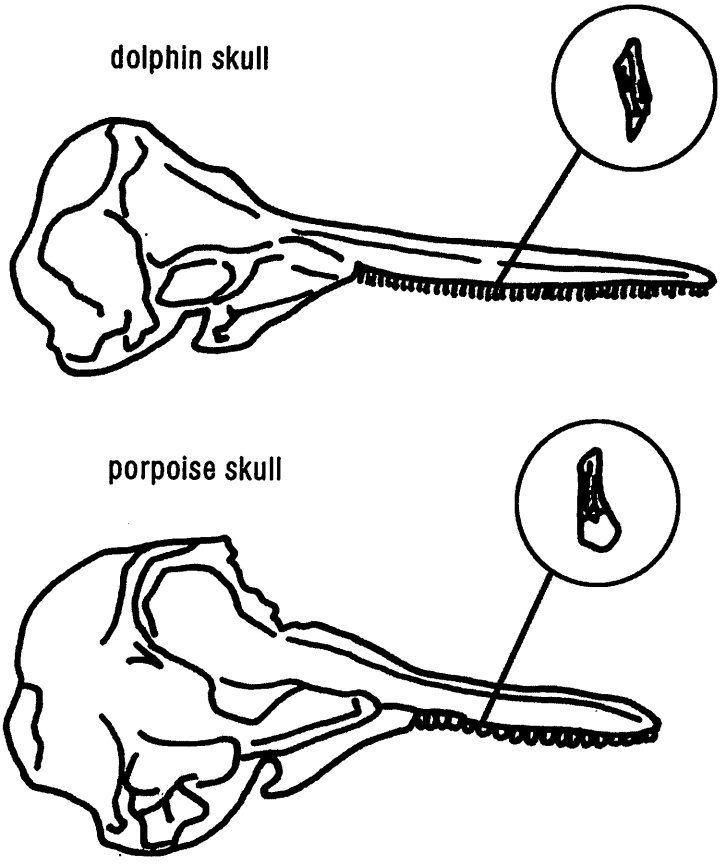


Fig. 3. Using teeth to distinguish between a dolphin and a porpoise.

27. How Are dolphins trained?

Animal Trainer _____ **Team** _____

Even in humans, "intelligence" is a loaded term. What is intelligence? How do we measure intelligence? It can mean many things—the ability to know, to analyze using reason and judgement, to think fast and to understand. How can we identify intelligence in other species? Intelligence of dolphins has been a subject of controversy for several decades. Studies on a few captive species show that they can quickly learn complex physical routines. Captives learn to respond to different human gestures or sounds and modify their behavior in response to instructions. You are going to participate in teaching a human an artificial sign language, based on dolphin conditioning techniques, to explore the concept of intelligence and how it relates to language and learning.

Materials: One ball, stick and towel for each group; a different whistle for each group; one package of candy or crackers.

Procedure:

1. Your team will work with another team. Elect a trainer and two "dolphins." The "dolphins" should be separated from the group at this time. (Your instructor will send the "dolphins" to another location.)

2. The trainer and remaining group members will develop the language symbols and construct the sentences that the trainer will use in the experiment.

3. The sign language should consist of three nouns, which will correspond to the three objects (ball, stick and towel) and three verbs. Hand signals must be used for each noun and verb. Once the signals are determined, the group will devise two and three-word sentences using the six signals. For example:

WORD	HAND SIGNAL
Ball (noun)	closed fist
Stick (noun)	opened hand, palm down
Towel (noun)	open hand, palm up
Fetch (verb)	one finger up
Toss (verb)	two fingers up
Cover (verb)	three fingers up

SENTENCE	HAND SIGNAL
Cover ball	three fingers up, closed fist
Fetch ball	one finger up, closed fist
Toss stick	two fingers up, open hand, palm down
Towel cover ball	open hand, palm up, three fingers up, closed fist
Toss ball	two fingers up, closed fist
Stick fetch towel	opened hand, palm down, one finger up, open hand, palm down

4. The above example may be used or you may develop your own language. The signals you use should NOT describe the object or verb; otherwise they will serve as hints instead of challenges. Since each group has two trainees, or "dolphins," the group should have a hand signal or sound signal to summon each "dolphin." The trainer needs to be familiar with the new language before the training starts.

5. Mark off the section of the room that will be the pool for the "dolphins." When the group is ready to begin the training, they should direct the "dolphins" into their "pool." The three objects should also be put in the pool. ***NO SPOKEN WORDS SHOULD BE HEARD ONCE THE "DOLPHINS" HAVE BEEN PLACED IN THE POOL.***

6. The trainers will first condition the "dolphins." This involves getting them acquainted with their personal hand signals or sounds. For example the trainer may begin with one whistle or hand signal, then immediately point to the dolphin he or she is calling. Repeat this technique with the other dolphin. Repeat with both to be sure that they know what the signal means.

7. Next, the trainer must instruct the dolphins in the language, using the hand signal and immediately showing them what it means. Now work with each dolphin and test his response to these new signals.

8. Positive reinforcement should be given for every correct response. A "treat" such as a candy, or cracker, etc. can be used for reinforcement. No treat is given if the response is incorrect.

9. The trainer should progress to the two- and three word sentences. Throw in one or two sentences that do not make sense and note the "dolphin's" response.

10. The remaining group members should act as observers, taking notes to record the dolphin's responses and the trainer's techniques.

11. When the training session is complete, review what happened. Allow the "dolphins" and trainer to discuss their reactions and feelings.

12. Discuss the activity and use it to respond to the following:
    a. What is intelligence?
    b. What is learning?
    c. What is language?
    d. What is behavior?
    e. What is memory?
    f. What is conditioning?

13. Whales, dolphins and porpoises are the stars of aquariums, marine parks and zoos around the world. Every year millions of people flock to see them. Animal welfare and conservation groups have been campaigning for a total ban on the capture of wild whales, dolphins and porpoises. They would also like to see captive animals released where possible. The people who keep the whales, dolphins and porpoises argue that captivity is a simple trade-off. The animals lose their freedom and natural companions in return for escaping hunger and being eaten. Welfare groups argue that these animals are completely unsuited to life in captivity and keeping them in small tanks and pools is cruel. What is your opinion? Discuss this in your group and develop a plan as to what should do be done.

28. Can the Sea Be a Medicine Chest?

Pharmacologist _____ **Team** _____

We need new medicines. Bacterium after bacterium is becoming resistant to our drugs. Disease resistance is going up and drug discovery is going down. Doctors want medicines to attack cancer, Alzheimer's, AIDS and a long list of other diseases for which there are limited treatments and no cures. The ocean is the one place left to look for and find the next medicines. Not only is the sea a source of medicines but scientists are studying marine organisms to better understand how cells in our bodies grow and divide. You are going to learn about the sea as a medicine chest.

Procedure:

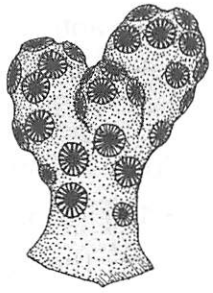
Part II: How are the medicines found and tested?

1. In 1928 Alexander Fleming first noticed that a common mold that had blown in from an open window had stopped the growth of staphylococcus bacteria growing in a Petri dish. His discovery led others to look in the soil for antibiotics. This led to finding the microorganisms that produce streptomycin, actinomycin, amoxicillin or vancomycin. Today no new antibiotic producing organisms are being found in the soil. Researchers are now beginning to scoop up ocean sediments, rotting driftwood, weeds, coral sponges and grasses to be grown in Petri dishes. The growths will be screened for ability to fight infection. Why are the ocean sediments a possible source of future antibiotics?

2. One of the problems is where to look. The ocean is over 70 percent of the Earth's surface. Finding new compounds that could be medicines is not easy. It is a process of trial and error. Organisms are collected, ground up and tested. One strategy is to go to a place where life is diverse and concentrated, such as reefs. Why is this area more likely to yield organisms that may be the source of potential medicines?

3. Scientist are paying attention to ecology. They are observing the organism and its surrounding environment. Scientists are more interested in an animal that looks delicate and appears to be a good source of food for fish, yet it is not being eaten. They are also interested in organisms that have no bacteria or algae growing on them or no other organism settling on it. Why are scientists more interested in these organisms than others for medicines?

4. Scientists do not consider hard corals as good potential sources of medicine. What is the reason?



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5. Scientists are examining organisms that use chemicals to defend themselves. Why would these organisms be more favorable candidates for future drugs?

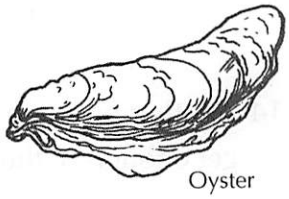
6. Many coral reef invertebrate animals contain biologically active chemicals that can be used to develop drugs. Scientist suspect that organisms loaded with biologically active molecules that they would need to defend themselves chemically could be the richest source of drugs. Sponges are an example; they have chemicals that have evolved as defense mechanisms to make them unpalatable to predators. Others such as cone shells have complex toxins that are used to catch and immobilize prey. Why are these invertebrates' better candidates as a source of future medicines?

7. While the venoms of several species have caused human deaths, toxins of some other species show potential as drugs for use in pain management, epilepsy and the prevention of stroke. The venoms of cone shells have been studied and the toxins have been isolated and purified. Now the toxins are being synthesized to provide quantities of the toxins for research and eliminating the need for further collection of cone shells. Why is it important that researchers be able to synthesize the chemicals from the organisms instead of just collecting more of the animal?

8. Not only are marine organisms a source of potential medicines but also the chemicals can be used to study the diseases. Researchers have found that toxins from different species of cone shells react either on muscle or brain receptors but not both. They are useful tools for examining the molecular natures of diseases in which the function of receptors in the brain is impaired, such as Alzheimer's disease, Parkinson's disease and epilepsy. Why is it important to learn how the disease is affecting the nerve cells?

9. So far only a few species of the cone shells have been analyzed for their toxins. Each species has over 20 different toxins. There are over 80 species on the Great Barrier Reef of Australia and over 500 species worldwide. Could these be a treasure chest of potentially beneficial compounds? What evidence is there to support your answer?

10. Sea water is filled with bacteria and viruses. Some phytoplankton show antibacterial activity and some seaweed show antibacterial action. Abalone, clams, oysters, sea snails, squid and conchs all



Oyster

have antibacterial and antiviral substances. Why would these filter feeders have these substances?

11. Some chemicals have unpredictable uses too. One such example is a feathery sea fan. Scientists put out a piece of tuna on the reef and fish came from everywhere and it was gone. They ground up a sea fan and mixed some of its extract with the tuna. The fish would come up, but they would not eat it. Pharmacologists have found that the sea fan's chemicals include a family of molecules called pseudopterosins. They soothe swelling caused by sunburn or chemical irritants. They stop an enzyme involved in inflammation and are stronger than hydrocortisone. Psoriasis, sunburn and arthritis all involve inflammation, so one day compounds from sea fans may be the drugs to treat these problems. The sea fan extract may be added to tooth paste for soothing inflamed gums. The extract is already being added to some cosmetics. Exposure to the sun triggers an inflammatory reaction in the skin. If the extract limits the inflammation, it could also limit sun damage. Do you agree or disagree with the statement? What evidence is there to support your answer?

12. To screen for medicinal potential is a long process. First, the scientists prepare liters of extract from the organism to be tested. Petri dishes of a disease causing yeast are prepared. The extract is added to a row of Petri dishes. Into the next seven rows of dishes, more diluted samples of the extract are added. The dishes are incubated overnight. The dishes are examined to see if any killed off the yeast in a diluted concentration. This same method is used to screen for compounds that might work on cancer cells or herpes. Why must each be tested with the extract from the organism?

13. If an extract shows that it kills yeast, bacteria or cancer cells, there are many more steps in the process. In the case of a potential cancer killer, researchers test the extract against a set of different cell lines developed by the National Cancer Institute and derived from colon cancers, breast cancers, leukemia and others. The trick is to find drugs that kill a range of cancer cells but leave healthy cells unharmed. Next, the compound must be purified and its molecular structure must be determined. Then either a drug company or the National Cancer Institute has to decide to fund testing on animals. Finally, the drug must be tested on people. At any stage, the testing may be stopped. The reasons may be as simple as the drug's being either too toxic or too weak. Why must it be tested on animals before being tested on people?

14. Another problem of experimenting with sea drugs is supply. Researchers must be able to get enough of the material to use in testing and then in producing it. For example, they

had to collect a metric ton of sponges to get 300 milligrams of the drug amount needed to begin preliminary trials. Most of the time it is too hard to make the chemical synthetically. The chemistry is too complicated. This means that scientist must learn how to grown the organisms. To grow or farm a marine organism, what all would you need to know?

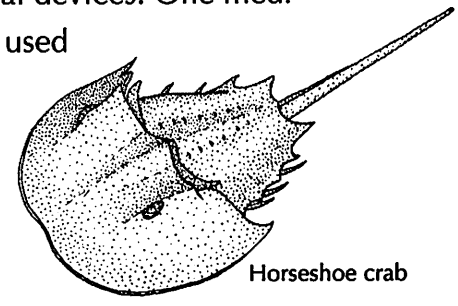
15. Bugula, a marine organism found on the bottom of boats, is under cultivation. The organism grows in shallow water almost anywhere. However, only three known populations of Bugula actually make bryostatin 1, a potent drug that is involved in dozens of chemical trials as a treatment for everything from leukemia to kidney cancer. Bugula can grow in vats on land and in the ocean on wire mesh. Despite the recent progress, no marine drug has reached the pharmacy shelf. It took two decades, from gathering crunched-up Pacific yew bark, to Food and Drug Administration approval for treating breast and ovarian cancer, for taxol to make it to the pharmacy shelf. Should this keep researchers from searching for medicines in the sea?

16. Marine organisms are also a source of knowledge. Atlantic squid nerves are 100 times larger than those of humans, making them easy to study. Squid have a giant axon, a nerve the size of pencil lead, which connects nerve cells. Much of what is known about the human nervous system comes from studies of the squid nerves. Octopi have advanced eyes and brains so they have been used in the studies of short and long term memory and learning mechanisms. Serotonin, a chemical compound that contributes to violent behavior is found in lobsters. The simple nervous system of lobsters is helping to explain and maybe eventually treat excessive aggression in humans. Sea urchins release 20 million eggs each time they reproduce. Why were they used to learn about embryo development?

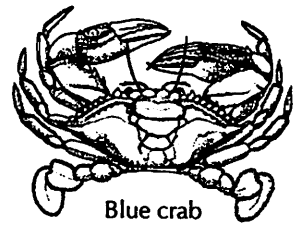

Squid

Part II: What are some potential medicines from the sea?

1. Sea-based medical products are still rare, but experts say the world's oceans and waterways may harbor the next generation of drugs and other medical devices. One medical device is the LAL (limulus amebocyte lysate) test; it is used to determine the presence of endotoxins. Endotoxins are produced when E. Coli and other gram-negative bacteria break down. The effect on humans exposed to the toxins ranges from fever to hemorrhagic stroke. This test enables doctors to test for and find these toxins before they can do damage. The test was developed from horseshoe crabs. Scientists found that the blood of these crabs could be used to detect dangerous endotox-


Horseshoe crab

ins in drugs, medical devices and even water. Drawing the blood from horseshoe crabs does not harm the animals and they can be returned to their habitat in 48 hours. Today, major pharmaceutical companies use it to detect endotoxins. Medical device firms also use it to test catheters, pacemakers and other invasive devices to make sure that they are endotoxin free. Why is it important that these devices be free of endotoxins and that there is a way to test for it?


Blue crab

2. Read the following report on potential medical help from the sea.

Medical Help from the Sea

Based on the finding that penicillin was derived from ordinary bread, marine fungi were investigated. Marine fungi that occur inside marine organisms and on the surfaces of most marine plants and animals are now being tested for new drugs. In preliminary testing, at least eight very different marine fungi produce compounds that inhibit cancer growth. Although these compounds have not been identified, these findings indicate that the fungi will be a possible source for new drugs.

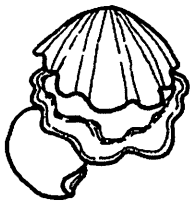
Osteoporosis, a crippling disease in which the bone mass wastes away, affects as many as 25 million Americans. It may be responsible for 1.5 million fractures of the hip, wrist and spine in people over 50 and may cause 50,000 deaths. The disease costs over $10 billion a year. A hormone from salmon called calcitonin helps regulate calcium and decrease bone loss. A synthetic version has been made and it has been approved for use.

Divers have marveled at the intricate patterns of coral reefs. Now these patterns are benefiting people with certain kinds of bone injuries. A product made from the rigid exoskeletons of marine coral can fill spaces caused by fractures or other trauma in the bones. This includes bone loss around the root of a tooth or in certain areas of the skull.

Researchers have created what may be a cancer treatment from blue-green algae. Using compounds called cryptophycins extracted from the algae, researchers treated mice implanted with cells that cause prostate and breast cancer. The compounds appear to affect the cancer cells' internal structure. This might keep the disease from spreading. One company is interested in developing the compounds as an anti-cancer therapy. The National Cancer Institute is sponsoring clinical trials on substances from marine invertebrates such as sea hares and bryozoans that may have use in the future as cancer treatments. One drug company is testing a neurotoxin obtained from a seagoing snail common in the Pacific as a potent painkiller. Clinical trials show that it relieves some of the worst kind of chronic pain. It could someday be an alternative to morphine.

In May 2000, researchers succeeded in synthesizing a complex anti-tumor drug from sea squirts. The compound is being tested on patients suffering with cancers of the blood vessels,

tendons and other soft tissues for which there are no effective chemotherapy.



Methopterosin is derived from natural pseudopterosins from soft corals and has been approved for clinical trials. It has properties that make it suitable for application to a number of conditions, including arthritis, psoriasis and inflammatory bowel disease among others. It also has the ability to speed up healing by over 400 percent. This property is of interest in the treatment of burn victims, in post-surgical treatment and in drug therapies for the many disorders involved in the healing process. It is also being used in reducing skin inflammation from sunburn or irritation and reduces the degeneration of the skin.

Microorganisms have been discovered that produce potent new anti-inflammatory agents. One estuarine bacterium produces a molecule that has been found to be a powerful inhibitor of skin inflammation both when applied directly to the skin and when taken orally.

Studies of a sponge metabolite have shown that it can inhibit cell division. It has the potential to provide an entirely new class of substances for the treatment of cancer.

A culturing system is being developed to grow an adequate supply of organisms that show anti-tumor properties. Some metabolites from dinoflagellates have shown cancer fighting potential.

Seaweeds are used in medicine. Carrageenans from red algae are used to treat peptic ulcers. Algae is used to make agar to culture bacteria. It is also used as a gel in numerous applications including DNA testing. Wound dressings contain calcium alginate from seaweed. When the fibers absorb fluid from the wound, they form a soft gel and make a warm moist condition for natural healing.

Chitin, from the exoskeleton of blue crabs, is used in absorbable, non-allergenic sutures that remain stable in the environment of the human intestine and urinary tracts.

3. Base on the reading, do you agree or disagree with the statement that the sea is our medicine chest of the future. What evidence is there to support your answer?

4. To understand why marine organisms such as sponges, corals, tunicates and others produce chemicals of use in human disease, we must first develop an appreciation for chemical ecology of the oceans. What evidence is there to support this statement?

5. Today the list of potential anticancer drugs at the National Cancer Institute's Natural Products Branch includes more candidates from the ocean than from the land. Chemicals produced by marine organisms are sensitive to changes in temperature and pollution. When the environment changes, so does the chemical makeup of a marine organism. Why must the marine environment be protected if there are to be more medicines from the sea?