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The underwater life off the coast of Southern California

Kathie Lyn Purkey

THE UNDERWATER LIFE OFF THE COAST OF SOUTHERN CALIFORNIA

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

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by

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ABSTRACT

This project reviews the basic chemical and geological features of the ocean, biological classification of marine life, background of the ocean's flora and fauna, and the ocean's environment. These facts are presented through an underwater documentary filmed at various sites along California's coast in San Diego County and Santa Catalina Island. The documentary was filmed and written by the author. This documentary is appropriate for grades K - 12 and complemented with lesson plans field-tested and designed for grades K - 4. These lessons are correlated to California Education Standards in areas of Science and Language Arts.

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DEDICATION

To my family, for giving me confidence, support and encouragement throughout my project.

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

> The beauty and genius of a work of art may be reconceived, though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again. (Beebe as cited in California Department of Education, 1993, p. 5)

Earth, the third planet from the sun, is our home. We must take care of it, for we have, in the foreseeable future, no other planet we can call home. All of Earth's living inhabitants and physical features are interconnected and play an important part to help sustain our planet.

There are many wonders and riches on Earth. Our oceans are but one, and their importance are immeasurable. Oceans cover 71% of our planet, and contain approximately 90% of Earth's inhabitants (Binney, 2001). Along with their beauty, they are a major source of food for much of the world's population. Our ocean's plants absorb a

significant amount of carbon dioxide, (Binney, 2001) and help heat and cool our atmosphere, thus significantly affecting our climate.

Though the oceans are of major importance to humankind, they have not been given the attention they deserve (Nybakken & Webster, 2002). Introducing young children to a multitude of environments and ecosystems is the beginning of environmental awareness and sensitivity. This underwater documentary introduces students to the ocean habitat, and will help increase accessibility to ocean content for teachers. It will also help teach ocean concepts in a way that will capture student's imagination, thus enhancing their learning.

General Statement of Problem

The goal of environmental education is to develop responsible environmental behaviors. These behaviors include environmental sensitivity, awareness, and values. There are many definitions for environmental education used today. Bill Stapp, professor at the University of Michigan wrote, "Environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware

of how to help solve these problems, and motivated to work toward their solution" (Stapp et al., 2001, p. 34).

Many influences are needed in order to develop solid environmentally sensitive attitudes in our citizenry. These attitudes are well established by early teens. In order to develop positive attitudes for the natural environment, students need positive influences beginning at an early age (Wilson, 1996). Thus, in order to encourage environmental sensitivity, awareness, and values about our oceans, students must learn about them first. This project allows students to learn about our oceans via an underwater documentary, filmed along Southern California's coast. Though this documentary is targeted for grades kindergarten through fourth, it could feasibly be used for other grade levels as well.

Significance of Project

The ocean habitat is one of the least explored areas in our planet. Many students have never, and may never, visit the ocean's immense world of underwater beauty. Documentary films can be used as effective tools with which to help educate students about our environment, and acquaint them with environmental issues. Films can visually convey people to places they may never see.

Viewing films along with informative class discussions can help promote environmental sensitivity, awareness and values (Norman, 2000). This film will help students to identify with the ocean environment and its many diverse life forms.

Statement of Needs

Earle stated, "There is no guarantee that people will care if they know what's happening, but it is certain that they cannot care if they do not know" (as cited in Cava, 2002, p. 49).

Unfortunately, our oceans are in peril from pollution and exploitation. They are plagued with varied and numerous problems (Cava, 2002). Some problems, such as over fishing, are the direct result of human activity. Other problems are disputable as to whether the cause is due to human involvement. Some researchers contend that the current global warming trend is the continuation of a natural cycle. However, others conclude that global warming has been intensified by human influence. Troubles that plague our oceans are not limited to over fishing and global warming. These topics will be discussed in this project along with background knowledge on the chemical and geological features of the ocean, biological

classification, and information about some of the oceans flora and fauna.

CHAPTER TWO

LITERATURE REVIEW

Chemical and Geological Features of the Ocean

Chemical Features

The characteristics of ocean waters are, in part, due to solids dissolved within it. These solids can come from weathering of rocks, materials released from deep-sea hydrothermal vents, or through atmospheric precipitation. Water is particularly good at dissolving salts. Approximately 85% of the ocean solutes come from sodium and chloride ions. These ions are the reason seawater tastes salty (Castro & Huber, 2003).

Due to the circulation of the ocean, seawater is thoroughly mixed. This mixing keeps ions in relatively constant proportions throughout the ocean. Marine organisms cannot control their environment. The salinity of the ocean water greatly affects organisms that live in it. They must adapt to their surroundings or move to a more suitable environment. Some organisms will be harmed even if there is a small variation in salinity. Most marine organisms will die in fresh water. Many, such as those that live where the degree of salinity may fluctuate, have mechanisms allowing them to cope with

changes in the salinity (Castro & Huber, 2003). "The types of organisms found at a given place in the ocean, and the way those organisms live, is controlled to a large extent by chemical and physical factors" (Castro & Huber, 2003, p. 43).

Geological Features

The main geological features of the ocean floor are very similar around the world. The ocean floor is divided into two regions, the continental margins and the deep sea floor (Castro & Huber, 2003). "The continental margins are the boundaries between continental crusts and the oceanic crust" (Castro & Huber, 2003, p. 35).

Continental margins commonly have a continental shelf, a continental slope, and a continental rise. The continental shelf is the shallowest part of the continental margin. Continental shelves extend toward the ocean with a gentle slope and may vary from a depth of 0.6 miles to more than 479 miles. The continental shelf makes up about 8% of the ocean surface area yet contains the most life and is the most biologically richest area of the ocean. The continental slope begins where the gentle slope abruptly gets steeper. This is usually at a depth of 400 to 600 feet but can occur as deep as 1,300 feet. This steeper slope continues toward the deep sea floor. The

continental rise forms at the base of the continental slope. This is where the sediments accumulate from canyons that run through the continental slope forming deep sea fans. These fans are similar to fans formed at the base of mountain canyons on land, or those that are formed in river deltas (Castro & Huber, 2003).

The deep sea floor, called the abyssal plain, ranges from 10,000 to 16,500 feet in depth. The deep sea floor is relatively flat. It does, however, have submarine volcanoes, plateaus, rises and other features. Deep sea floor trenches are the deepest part of the ocean. The deep sea floor trenches are where tectonic plates descend into the mantel. The Mariana Trench is the deepest place in the ocean with a depth of 36,163 feet (Castro & Huber, 2003).

Biological Classification

Not all biologists agree on the classification of biological taxonomy. Some consider the five-kingdom system. The kingdoms, Anamalia, Plantae, Fungi, and Protista, are all eukaryotes. The fifth kingdom Monera, is composed of prokaryotes. Due to recent studies in cellular chemistry some biologists have divided the prokaryotes into two kingdoms Bacteria and Archaea (Castro & Huber, 2003).

Other classifications recognize a new taxon, the domain. The domain system uses a classification that is more general than kingdoms. Some divide this new taxon into two domains, the Prokaryotes and the Eukaryotes. Others use a three-domain classification. In the three-domain classification Eukaryotes are still considered as one domain. Prokaryotes are divided into two domains, Bacteria (also called Eubacteria) and Archaea [also called Archaebacteria] (Castro & Huber, 2003). This project will use the three-domain classification.

Prokaryotes

"Prokaryotes are the smallest and structurally simplest organism, and the oldest forms of life on earth" (Castro & Huber, 2003, p. 92). Prokaryote organisms may contain one or more cells. What separates them from other organisms is that their cells do not have membrane bound organelles. Their DNA (deoxyribonucleic acid) is not organized in a membrane bound nucleus. Instead their DNA resides in a nucleoid. They have a cell wall, a plasma membrane just inside the cell wall, a capsule, and prokaryotic flagella (Purves, Orians, & Heller, 1992). Castro and Huber stated (2003) "In addition to lacking membrane-bound organelles, prokaryotes differ from eukaryotes in the circular shape of the DNA molecules that

encode their genetic information, in the size of their ribosome's, and in a number of other ways" (p. 92).

Eukaryotes

Eukaryotes are more complex than prokaryotes. Membranes enclose many structures and organelles. Most of the DNA resides in the nucleus (Purves et al., 1992). Eukaryotes include members of the Protista, Fungi, Plantae and Animalia kingdoms. They can be distinguished from the Prokaryotes in that their cells contain organelles and a nucleus (Castro & Huber, 2003).

Background of the Ocean: Flora and Fauna

All three domains, Eukaryote, Bacteria, and Archaea, include microorganisms. Microorganisms are the most abundant forms of marine life. The are the most important primary producers in many marine environments. Primary producers are organisms that manufacture organic material from carbon dioxide, usually by photosynthesis. Photosynthetic organisms are capable of using sunlight to make glucose, which is then used as a source of energy, or converted into other organic compounds. These organic materials contain a large amount of energy. In turn, other organisms use these organic compounds as sources of energy (Castro & Huber, 2003).

Domain - Archaea

Archaebacteria are prokaryotes. They are the most primitive and simplest life forms on earth. The prefix archae originated from a Greek word which means ancient (Holt, Rinehart, and Winston, 2001). Many Archaebacteria are found in environments were most organisms can not survive (Castro & Huber, 2003). Characteristic of the environments where Archaebacteria may be found include extremely acidic or alkaline environments, in or near hydrothermal vents, under high pressure in deep marine environments, in hot sulfur springs, areas of low oxygen concentrations, and in areas of extreme salinity (Purves et al., 1992). Archaebacteria were once thought to live exclusively in extreme environments. However, they are commonly found throughout the water column (Castro & Huber, 2003).

Archaebacteria are important decomposers, nitrogen fixers, and methane producers. Methane producing bacteria account for all the methane released into earth's atmosphere (Purves et al., 1992).

Domain - Bacteria

Bacteria are sometimes referred to as Eubacteria or true bacteria. There are many types of bacteria. Heterotrophic bacteria are crucial to the recycling of

nutrients. They not only recycle essential nutrients in all marine environments, they also play an important role in feeding bottom-dwelling animals. Decomposers obtain their energy from organic matter. They break down organic matter and release nutrients into the environment (Castro & Huber, 2003). "Other marine bacteria are beneficial because they are involved in degrading oil and other toxic pollutants that find their way into the environment" (Castro & Huber, 2003, p. 93). Autotrophic bacteria are the principal primary producers in many open ocean areas. There are bacteria that live in a variety of symbiotic relationships with other marine organisms. Some are parasitic, while others are beneficial. Certain bacteria are responsible for the bioluminescence of other organisms. Some bacteria produce deadly toxins that protect various marine organisms. For example, Pufferfish store a deadly toxin, which is produced by bacteria. This toxin makes the fish deadly to any predator that eats it, including humans (Castro & Huber, 2003).

Cyanobacteria, also referred to as bluegreen algae, is a photosynthetic bacteria. Cyanobacteria is a group of marine bacteria that contains blue and red pigments. The color of the bacteria will depend on the specific amount of these pigments. Some red tides are caused by

cyanobacteria that contain red pigments. Cyanobacteria can be found just about everywhere in the marine environment and can tolerate a wide range of temperatures and salinity. Some are responsible for skin rashes on swimmers, while others carry out nitrogen fixation. Cyanobacteria can be autotrophs, epiphytes, endophytes and others may lose their ability to photosynthesize and become heterotrophs (Castro & Huber, 2003).

Domain - Eukaryote

Kingdom - Protista. Members of the kingdom Protista are a diverse group. They include pathogens, decomposers, and major producers of the aquatic ecosystem. Their nutritional requirements vary. They may be autotrophs, absorptive heterotrophs, or ingestive heterotrophs. Some change readily between heterotroph to autotroph. Some are non-mobile, and others are mobile in diverse ways. Eukaryotic organisms that do not fit into the plant, animal or fugal kingdoms are in the kingdom Protista (Purves et al., 1992).

Protista include protozoa, algae, slime molds, and water molds (Holt, Rinehart, & Winston, 2001). Protista that are animal like are referred to as protozoa. Protista that display plant-like characteristics are referred to as algae. The slime molds and water molds appear fungus like.

Some Protista are multicellular, but most are unicellular (Purves et al., 1992).

Protozoan are a vary diverse group of single celled organisms. Most protozoans are animal like, and ingest food. However, others are plant like because they contain chlorophyll, and photosynthesize. Some protozoans contribute to material on coral reefs, while others are planktonic. Their shells supply calcium carbonate, an important material in the ocean sediments (Castro & Huber, 2003).

Unicellular algae are a very diverse group, and most are photosynthetic organisms (Castro & Huber, 2003). It is estimated that algae account of 50% to 60% of all photosynthesis on earth (Purves et al., 1992). Unicellular algae are referred to as plants, though many demonstrate animal like characteristics. Unicellular algae include Diatoms and Dinoflagellates (Castro & Huber, 2003).

Diatoms (phylum Bacillariophyta) are autotrophs. It is estimated that half the approximately 12,000 species inhabit the marine environment. They are important primary producers in polar and temperate regions, and account for a large portion of the oxygen and organic carbon produced on earth (Castro & Huber, 2003). Their cell walls resist decomposition because they are composed of silica. Many

sedimentary rocks are composed of their skeletons (Purves et al., 1992). The siliceous frustules of dead diatoms settle to the ocean floor and form thick deposits of diatomaceous ooze. Large fossil deposits of these sediments are found in various areas around the world. The fossil deposits, usually found inland, are of economic importance. These fossils are referred to as diatomaceous earth. Diatomaceous earth is used for swimming pool filters, beer clarifying, and mild abrasives (Castro & Huber, 2003).

Dinoflagellates (Phylum Dinoflagellata) are important primary photosynthetic producers of organic matter in tropical ocean waters. Most photosynthesize, and some can even ingest food particles (Castro & Huber, 2003). "A few have a light-sensitive pigment spot that acts as a crude eye" (Castro & Huber, 2003, p. 98). Dinoflagellates are also known to cause bioluminescence tides and red tides. At times, they may release a potent nerve toxin killing tons of fish (Purves et al., 1992). Seafood collected during these red tides can be poisonous (Castro & Huber, 2003). These toxins are not fatal to shellfish. However, the toxins may accumulate in amounts that are fatal to humans who eat these shellfish (Purves et al., 1992). Other Dinoflagellates, through their photosynthetic cycle,

are able to fix carbon dioxide and release organic matter used by coral, which aids in the formation of coral skeletons (Castro & Huber, 2003).

The most commonly known multicellular algae are the seaweeds. However, some seaweeds are unicellular. Seaweeds are also known as macroalgae, through the term seaweed helps to differentiate them from the unicellular algae previously discussed. Seaweeds are grouped with the kingdom Protista, mainly because they lack specialized tissues of plants (Castro & Huber, 2003). The giant kelp are multicellular marine protista and are some of the longest organisms that exist (Purves et al., 1992). There are three types of seaweeds: the red, green, and brown algae (Castro & Huber, 2003).

The largest group of seaweeds are the red algae (Phylum Rhodophyta). Red algae can be unicellular through most are multicellular (Purves et al., 1992). Chlorophyll of the red algae is hidden by red pigments. Most of the 4,000 species live in marine environments and are usually found in shallow waters (Castro & Huber, 2003). Some are found in the deep ocean to 558 feet when the water is clear (Purves et al., 1992).

Green algae (phylum Chlorophyta) may be unicellular or multicellular (Purves et al., 1992). Most of the green

algae are unicellular and microscopic. They are usually bright green because their chlorophyll is not hidden by other pigments. Of the 7,000 species of green algae, only about 10% live in the marine environment. They may live in environments that have a wide variation of salinity, such as isolated tide pools, bays and estuaries (Castro & Huber, 2003).

The brown algae (phylum Phaeophyta) are all multicellular (Purves et al., 1992). Yellow-brown pigments typically hide the chlorophyll of brown algae. This group includes one of the dominant primary producers on temperate and polar rocky coasts. The kelps are members of this group. They are found in temperate regions, and in the Arctic. They form the dense kelp forests along California's coast, which provide shelter and food for many marine organisms. They are also of economic importance and are harvested for many reasons. Some kelps are used as a food source and in food processing. They have many uses in the pharmaceutical, chemical, printing, and cosmetic industries. Kelps are also being examined in medical research and use in fertilizers, and pesticides (Castro & Huber, 2003).

Kingdom - Fungi. Fungi are very diverse and found in all environments. Fungi may be parasites, attacking

virtually all eukaryotes. Others are saprobes or mutualists (Purves et al., 1992). Most fungi are multicellular microscopic organisms. They appear plant like. However, they do not have chlorophyll, and do not photosynthesize. Instead, they are heterotrophs (Castro & Huber, 2003). Mushrooms and molds are examples of Fungi (Holt et al., 2001). There are over 500 species of marine fungi. Some are decomposers while others are parasitic on seagrasses, seaweeds, shellfish, sponges, and fish. Some marine fungi are being researched for use as antibiotics (Castro & Huber, 2003).

Kingdom - Plantae. Plants are complex multicellular photosynthetic eukaryotic organisms. They are immobile organism using the sun's energy to power their metabolic process (Purves et al., 1992). Members of the kingdom Plantae are different from other kingdoms because plant cells have organelles called chloroplasts. Chloroplasts contain chlorophyll, which absorb light energy from the sun. Plant cells also have a rigid cell wall that helps to protect and support the plant (Holt et al., 2001). Some botanists believed that terrestrial plants arose from the green algae because this member of the Protista kingdom shares many traits with the Plantae kingdom (Purves et al., 1992). The most common marine plants are seagrasses

that inhabit well protected shallow coastal waters of North America and the Pacific coast (Castro & Huber, 2003).

Kingdom - Animalia. Animals are eukaryotic multicellular organisms (Holt et al., 2001). Cells of animals have cell membranes. "At the microscopic level, animal cells differ from those of fungi, plants, most protists, and bacteria, because animal cells lack cell walls" (Holt et al., 2001, p. 239). There are millions of animal species living on Earth. They live in almost every type of environment (Purves et al., 1992).

Animals with a backbone and a skull are vertebrates. Vertebrates account for approximately 3% of the known animal species. Animals without a backbone are invertebrates and they account for about 97% of the animal species (Holt et al., 2001).

Animals can not photosynthesize and manufacture their own food. They need an assortment of complex organic molecules as sources of energy. Animals have adapted to acquiring energy in diverse ways. Much of the diversity in the shape and size of animals is a result of this adaptation (Purves et al., 1992). Most animals are mobile. They have nervous systems that help them sense and react to their surroundings. They are consumers and survive by

eating other organisms (Holt et al., 2001). The type of food animals eat varies greatly. They eat organisms from the Animalia kingdom as well as from all the other kingdoms (Purves et al., 1992).

Animals may have one of two types of body symmetry, or they may be asymmetrical. The two types of body symmetry are bilateral, or radial. A body with two similar halves is bilateral. If the body parts are arranged in a circle, they have radial symmetry (Holt et al., 2001). Radial symmetry is displayed as a pattern of similar body parts that are arranged, and repeated, around a central point (Purves et al., 1992). Thus, they look the same from all sides. Animals with no body symmetry are asymmetrical (Holt et al., 2001).

Phylum - Porifera. The phylum Porifera is comprised of sponges. Structurally, sponges are the simplest of the invertebrates. The name Porifera is derived from the tiny holes, or pores, on the sponges outside (Holt et al., 2001). Many scientists have placed sponges in a subkingdom of their own (Parazoa) because they are very distinct. Only species in the phylum Porifera are asymmetrical, and all species in this phylum are asymmetrical (Purves et al. 1992).

All sponges live in water (Holt et al., 2001). Most of the 10,000 species of sponges live in the marine environment (Purves et al., 1992). All sponges are sessile, living attached to a surface (Castro & Huber, 2003).

Sponges are an aggregation of specialized cells (Holt et al., 2001). The cells do not form organs or true tissues. Basically, the cells within a sponge are independent of one another (Castro & Huber, 2003). If the sponge's body is broken, cells can re-form. New sponges can form from the broken piece and they can regenerate new body parts. Sponges are filter feeders and eat food particles that are suspended in water. They have collar cells that digest their own food particles (Holt et al., 2001). Sponges have some commercial value.

Phylum - Cnidaria. Cnidarians (sometimes referred to as phylum Coelenterata) include jellyfish, coral, sea anemones and others. There are approximately 10,000 species and almost all live in the marine environment. They are more complex than sponges, and have tissues that perform specialized functions (Castro & Huber, 2003). Their bodies are arranged in a radial symmetrical pattern. Most cnidarians go through a change of body forms, and

reproductive types, during their life cycles (Purves et al., 1992).

"The word cnidaria comes from the Greek word for 'nettle'" (Holt et al., 2001, p. 330). Nettles are plants with stinging barbs (Holt et al., 2001). Most cnidarians are carnivores, and capture prey by discharging stinging structures called nematocysts which are located on their tentacles (Castro & Huber, 2003). When food is captured it is brought to the mouth with the tentacles (Purves et al., 1992). Due to the toxins that are released from their nematocysts, cnidarians are some of the most dangerous marine animals (Castro & Huber, 2003).

Many species of cnidarians have bodies that are made of mesoglea and they have a very low metabolic rate. Because of this, they can go weeks or months without food (Purves et al., 1992).

Phylum - Ctenophora. There are about 100 known species of ctenophores. Ctenophores are commonly known as comb jellies, sea walnuts or sea gooseberries. They have radial symmetry and a body made of mesoglea (Castro & Huber, 2003). Though they look similar to cnidarians there are many differences (Purves et al., 1992). The main difference is that comb jellies do not have nematocysts. Most capture their prey by using two long tentacles with

sticky cells called colloblasts (Castro & Huber, 2003). Once prey is caught, the tentacles are retracted and brought into contact with the mouth (Purves et al., 1992). They have eight rows of ciliary combs, short flagellum, which are used for movement and other functions. Swarms of comb jellies may be found in warm and cold waters. The swarms can consume vast amounts of plankton and fish larvae (Castro & Huber, 2003).

Worm Phyla. In the marine environment, worms come in many shapes and sizes. There are over 20,000 species of flatworms (phylum - Platyhelminthes), many of which are parasitic. Most of the approximately 900 species of ribbon worms (phylum - Nemertea) live in the marine environment. All are predators feeding on other worms and crustaceans. "Ribbon worms are incredibly elastic, and the proboscis may extend a meter or more beyond the body" (Castro & Huber, 2003, p. 125). One species has been measured up to 100 feet long making it the longest animal on earth. Nematodes, (phylum - Nematoda) which include round worms, are rarely seen. Many species are parasitic and infect most groups of marine animals. There is some controversy on the number of species of nematodes. There are estimates from 10,000 to 15,000. Some biologists believe there could be up to half a million species, many yet undiscovered.

The larvae of some species live in the flesh of many species of fish, and may infect humans if they eat raw or under cooked fish. There are about 15,000 species of segmented worms (phylum - Annelida) which include earthworms and leeches. Many species live in the marine environment. Some marine species are carnivores, other are deposit feeders and feed on organic material that settles on the bottom. Some are bloodsucking , living on marine fish and invertebrates. There are more than 250 species of peanut worms (phylum - Sipuncula) and 100 or more species of echiurans (phylum - Echiura). All are marine species and deposit feeders. Most of the approximately 135 species of beard worms (phylum - Pogonophora) live in deep water. Beard worms were not discovered until 1900. Beard worms absorb nutrients that are dissolved in the water. They have no mouth or gut. Instead Beard worms have a symbiotic bacteria that manufactures the nutrients into food, which is then used by the beard worm. Arrow worms (phyla - Chaetognatha) are one of the smallest animal phyla. There are only about 100 species, but are one of the most important members of the plankton. They are carnivores and eat just about anything that is small enough. They eat larvae and eggs of fishes, small crustaceans, other arrow worms and other animals (Castro & Huber, 2003).

Phylum - Mollusca. There are more than 200,000 species of molluscs. Molluscs live on land, in fresh water and in the marine environment (Holt et al., 2001). They are the second largest animal phylum and the most abundant animal phylum in the ocean. Molluscs inhabit all marine environments, from the shoreline to deep hydrothermal vents. Molluscs have a soft body and a muscular foot (Castro & Huber, 2003). Most have a shell and a radula (Holt et al., 2001). There are three main classes of mollusce: the gastropods (class Gastropoda), bivalves (class Bivalvia), and cephalopods (class Cephalopoda) (Castro & Huber, 2003).

Gastropods are the most common class of molluscs. It includes snails, sea slugs, nudibranchs, limpets, and abalones. Gastropods account for about 75,000 Mollusca species. Most inhabit the marine environment. Most can be described as having a creeping muscular foot with a soft body covered by a dorsal shell. Sea slugs and nudibranchs have lost their shell. "Colorful branches of the gut or exposed gills make sea slugs among the most beautiful of all marine animals" (Castro & Huber 2003, p. 131). Gastropods move by secreting mucus from their muscular foot. Most gastropods eat algae, though some are deposit feeders (Castro & Huber, 2003).

Bivalves include oysters, mussels, and clams. They have a two-valved shell, and no radula. Some are filter feeders, and use their gills to obtain oxygen and filter the water. Others, such as the shipworms, bore into wood using small valves to excavate the wood, and then they eat the wood. Some attach themselves to rocks and other hard surfaces, while others burrow in sand or mud. Some are of economic importance for food and pearls (Castro & Huber, 2003).

Cephalopods are more mobile than gastropods and bivalves. The class Cephalopods includes octopuses, squids and cuttlefishes. They are agile swimmers and voracious predators. Their shells are reduced or non-existent. The foot has been modified into tentacles or arms. These usually have suckers that help to catch its prey. Most can emit a cloud of dark fluid to distract potential predators (Castro & Huber, 2003). All 650 species of cephalopods live in the marine environment. Of all invertebrates, octopus and squid have the most advanced nervous system. Octopuses can build a cave in which to hide, and can navigate a maze. Giant squid are the largest of all invertebrates. They have been measured at 82 feet long and weighing up to 4,409 pounds (Holt et al., 2001).

Often seen along Southern California's coast is another class of molluscs, the Polyplacophora. These are commonly called chitons. All of the 800 species of chitons inhabit the marine environment. Most live along rocky shores. Chitons can be identified by their eight overlapping shell plates (Castro & Huber, 2003).

Other molluscs include approximately 350 species of scaphopods, and a few species of monoplacophorans. Scaphopods (class Scaphopoda) are most common in deep water. Empty shells occasionally can be found washed ashore. Monoplacophorans (class Monoplacophora) are limpet-like molluscs. They were thought to be extinct until a living fossil was discovered in 1952 (Castro & Huber, 2003).

Phylum - Arthropoda. Arthropods are the largest phylum of organisms, with more than one million known species (Castro & Huber, 2003). Arthropods account for 75% of animal species. They are characteristic of having an exoskeleton, a segmented body, a well develop nervous system, and jointed appendages. Arthropods are named for their jointed appendages. "Arthro means 'joint' and pod means 'foot'" (Holt et al., 2001, p. 339). Arthropods make a chitinous secretion to form an exoskeleton. The exoskeleton provides protection and support for the

filter feeders, parasitic, scavengers, feed on seaweed or organic matter (Castro & Huber, 2003).

Copepods are tiny crustaceans that are often planktonic. They typically account for up to 70% of any given zooplankton community. "This probably makes them the most numerous group of animals on earth" (Castro & Huber, 2003, p. 330). Adult barnacles (class Cirripedia) are similar in appearance to mollusks (Purves et al., 1992). The larvae of barnacles are typical crustacean larvae. They swim around then eventually attach to a surface before they metamorphous into adults. Barnacles are filter feeders and they are usually very particular on what type of surface to which they attach. Some barnacles live on whales or crabs. Others attach to rocky surfaces. Barnacles have a crustacean body beneath thick plates. "They lie on their backs and use their legs to filter feed" (Castro & Huber, 2003, p. 136).

Amphipods live among seaweeds, burrow in the skin of whales, or live as plankton. Their bodies are compressed from side to side and are usually under ¾ of an inch long. Beach hoppers are commonly found among debris that has washed ashore. They jump by curving their bodies, then quickly stretching out causing them to spring about (Castro & Huber, 2003).

There are many marine isopods. They are similar to terrestrial pill bugs. Many marine isopods are parasites of other crustaceans and fishes. Krill (euphausiids) are usually filter feeders. They are planktonic crustaceans feeding on diatoms and other plankton. They grow to about 2½ inches and look like miniature shrimp. They are the primary diet of many cold-water fishes, penguins, and whales (Castro & Huber, 2003).

The largest group of crustaceans are decapods, with as many as 10,000 species. The name decapod means ten legs. They are of great economic importance. This group includes lobsters, crabs, hermit crabs, and shrimps. Lobsters, hermit crabs, and shrimp are typically scavengers. Some shrimp remove parasites from fish, live on other invertebrates or in deep water. Lobsters may also catch live prey. Crabs are the largest group of decapods, with over 4,500 species. Most are scavengers, yet others may eat mollusks, coral mucus, organic matter, or seaweeds. Though hermit crabs are not true crabs, they too, are scavengers (Castro & Huber, 2003).

Phylum - Echinodermata. All of the approximately 7,000 species of echinoderms live in the marine environment. Echinoderms include sea cucumbers, sea urchins, sand dollars, and sea stars (Castro & Huber,

2003). The term echinoderm means spiny skinned. All adult echinoderms have radial symmetry. Some, such as the sea star, sea urchins, and sand dollars have bilateral symmetry in the larvae stage (Holt et al., 2001). Sea stars, more commonly known as starfish, (class Asteroidea) generally feed on slow moving animals such as snails, barnacles, or bivalves. Brittle stars (class Ophiuroidea) are similar to starfish, but have long flexible arms. They eat small animals or particulate organic matter. Sea urchins (class Echinoidea) eat seaweeds or small organic debris (Purves et al., 1992). Some, such as the sand dollars, are bottom deposit feeders. The radial symmetry is not so obvious in sea cucumbers (class Holothuroidea). Their bodies are more elongated than sea urchins. Some are deposit feeders, others are suspension feeders (Castro & Huber, 2003).

Phylum - Chordata. The phylum Chordata includes three subphyla. Two subphyla are invertebrates, Cephalochordata and Urochordata, collectively called protochordates. The third subphyla is the vertebrates, called vertebrata (Castro & Huber, 2003). All chordates share distinct characteristics and have similarities in at least part of their development. All chordates have a notochord, in some this will disappear and a backbone will grow in its place.

Second, they have a hollow nerve cord which is called the spinal cord. Third, chordates have a tail, some only in the embryo stage. Fourth, all chordates have a pharyngeal pouch. This develops into gills or other body parts (Holt et al., 2001).

Subphyla Invertebrates, Cephalochordata and Urochordata. Subphylum Cephalochordata is composed of about 29 species of lancelets. They are soft bottom filter feeders. Subphylum Urochordata is comprised of about 3,000 species. All Urochordata live in the marine environment (Castro & Huber, 2003).

Subphylum Vertebrata, Class Fishes. Over half the earth's vertebrates species are fishes. There are approximately 27,000 species of fishes. Approximately 60% of them live in the marine environment. There are three major groups of fishes: the jawless fishes, cartilaginous fishes, and bony fishes. Jawless fishes (class - Agnatha) feed by suction (Purves et al., 1992). This group includes slime eels and lampreys. The second group is cartilaginous fishes (class Chondrichthyes) (Castro & Huber, 2003). They are mainly marine, and are rarely found in fresh water (Purves et al., 1992). Their skeleton is made of cartilage (Castro & Huber, 2003). Their skin is flexible and leathery, giving them increased mobility (Purves et al.,

1992). This group includes sharks, rays, skates and ratfishes (Castro & Huber, 2003). The world's largest fish is the whale shark. Whale sharks are plankton feeders. However, most sharks are predators. Most rays and skates eat mollusks, and some invertebrates, which are buried in the ocean sediments (Purves et al., 1992). The third major group is the bony fishes (class Osteichthyes). Their skeleton is made, at least partially, of bone. This is by far the largest group, with 26,000 species. This is about 96% of all fishes. There are between 75 and 100 new species described each year. There are many varieties of shape, color, locomotion, diet, migration, and habitat (Castro & Huber, 2003).

Subphylum Vertebrata, Class Reptilea. There are about 7,000 species of marine reptiles. This group includes 9 species of sea turtles, about 55 species of sea snakes, the marine iguana, and saltwater crocodile. Reptilea lay eggs, have scales, and are ectotherms (Castro & Huber, 2003).

Subphylum Vertebrata, Class Mammalia. There is approximately 4,600 species of mammals. Mammals are endotherms, have hair, reproduce sexually, bear live young, have mammary glands, and are fed milk when young. Most mammals are born helpless. The smallest order of

water dwelling mammals is the Sirenia. They include dugongs, and manatees. Manatees are often referred to as sea cows. All Sirenia are herbivores. They eat seaweed and water plants. Members of the orders Cetacean and Pinniped are carnivores. The order Cetacean includes whales, dolphins and porpoises. The order Pinniped includes seals, sea lions and walruses. Pinnipeds use canine teeth for defense, digging for food and climbing on ice (Holt et al., 2001).

Subphylum Vertebrata, Class Aves. Aves comes from a Latin word meaning bird. There are approximately 9,700 species of birds. Birds have beaks, feathers, wings and other adaptations for flight. Characteristics of bird's bodies can vary greatly from one species to another. Through not inclusive of all birds, birds are often categorized into four groups, flightless, waterfowl, birds of prey, and perching birds (Holt et al., 2001).

Seabirds account for about 3% of the approximately 9,700 species of birds. Seabirds feed on marine organisms and spend most of their lives at sea. They have webbed feet, most live in large colonies and nest on land. Seabirds often found along the oceans coastal environment include gulls, pelicans, albatross, puffins, terns, and penguins (Castro & Huber, 2003).

The Ocean Environment

Maintaining a healthy environment is a tremendous responsibility. In recent years, the global warming trend and the problem of overfishing worldwide have been major causes for concern. Our oceans are vital to life on Earth. Thus, there is an urgent need to understand how human interaction affects them.

Global Warming

There has been life on Earth for four billion years. Throughout millennia, countless life forms have evolved, thrived, adapted, or perished. During this time, Earth's climate has varied drastically. There have been periods of mild climate, steamy heat, and ice ages. During the present century, the global climate has been showing a warming trend. This warming trend has been more rapid than any time in the last 1000 years (Suplee & Pinneo, 1998). Some researchers theorize that this global warming period is due to human influences. Others believe this warming is just a natural climatic cycle. Still, others believe there is no warming trend at all.

Earth's atmosphere is one of the many elements that effect our global climate. The benefits of Earth's atmosphere extend beyond the air we breath. Without our atmosphere, heat from the sun would bounce off earth and

radiate back into space. As it is, when the sun's rays bounce off the earth, some heat is trapped in the lower atmosphere by various gases, such as water vapor, carbon dioxide, and methane (Suplee & Pinneo, 1998). As these gases absorb the infrared radiation they are heated. Some of this heat is then radiated back to earth. As the atmosphere warms, water evaporates from the land and oceans. Warmer atmospheric temperatures can hold more water vapor. Thus, the warmer atmosphere is able to hold more infrared heat, and radiate more of this heat back to earth. This cyclic process is called the "greenhouse effect," because it is mostly caused by water vapor, the predominant greenhouse gas (Suplee & Pinneo, 1998). An increase in greenhouse gases is a major concern by experts (Suplee & Pinneo, 1998). In the last century, humans have produced excessive amounts of carbon dioxide. The concentration of carbon dioxide has been increasing 0.3% each year since the beginning of the industrial age. This is of some concern, because carbon dioxide has a lifetime of 100 years, whereas water vapor has a lifetime of only 8 days (Suplee & Pinneo, 1998). Carbon dioxide that is produced today will remain in the atmosphere for 100 years, thus contributing to the retention of larger and larger amounts of heat.

Our oceans and atmosphere are closely associated with each other. To understand one, we must understand the other. The oceans absorb vast amounts of the heat that is radiated down to earth from the atmosphere. The ocean currents then distribute this heat over thousands of miles (Ackerman, 2000). Even slight changes in the ocean temperature can affect air temperature worldwide. El Nino is a well known example of how warmer currents can affect our global climate ("Global warming," 2000). Altering the natural mixture of greenhouse gases can magnify the effect of global warming. The Intergovernmental Panel on Climate Change (IPCC) estimate about 60% of global warming since 1850 is due to an increase of carbon dioxide, a byproduct of burning fossil fuels (Suplee & Pinneo, 1998).

The ocean's surface temperature, off the Coast of Southern California, has risen approximately 2.7 F° in the last 40 years. This rise in temperature is a concern for a number of reasons. One reason is that an increase in temperature causes water to expand. This expansion has raised the sea level off Southern California by 4 centimeters ("Warming raises," 1992). Globally, the sea level seems to be rising at a rate of about 2mm/year (Roemmich, 1992). Various other factors, including changes in the shape of the ocean basin and more water mass due to

glacial melting, could contribute to the rise in sea levels. A second reason is an increase in water temperature along the Pacific coast has been linked to stress in certain temperature-sensitive species and ecosystems. There has been a decline in reproduction, and an increase in death rates, among birds, seals, and sea lions. California's kelp forests, which are home to a multitude of species, have also been devastated due to ocean warming ("Global warming," 2000). The increase in water temperature has also caused a 70% decline of zooplankton. Zooplankton, tiny sea creatures, are the primary food for all fish larvae, and many seabirds ("A rise," 1995).

Another connection between the oceans and the atmosphere is the absorption of organic carbon. The majority of organic carbon is consumed in the oceanic food chain. Some is returned to the atmosphere via respiration and the rest settles to the ocean floor. Most of earth's organic carbon is stored in marine sediments (McGinn, 2000). Besides carbon, other nutrients settle and concentrate on the ocean floor. Upwelling currents stir up these nutrients and carry them to various mobile and fixed aquatic ecosystems. They are also carried to the surface and used by phytoplankton. Phytoplankton, which are

microscopic plants, are considered to be the base of the food chain. When these nutrients reach the surface, phytoplankton begin to grow and bloom. These plants support an abundance of life. Without phytoplankton many areas in our oceans would be barren. Phytoplankton use sun light and carbon dioxide for photosynthesis, thus absorbing large quantities of carbon dioxide. Small plants and animals that feed on phytoplankton are in return eaten, or eventually die and sink to the ocean floor taking the carbon with them. This process is also a major climate regulator due to the massive amounts of carbon absorbed from the atmosphere. The concern is when there is less sea life more carbon dioxide remains in the atmosphere, adding to global warming (Cowen, 2001).

Overfishing

Current research indicates that approximately 70% of the world's fisheries are now operating beyond sustainable levels. Despite the richness and importance of marine ecosystems, they have been left out of most discussions involving saving Earth's biodiversity. Though our oceans seem endless and inexhaustible they are not infinitely resilient (Nybakken & Webster, 2002).

In 1996, 35% of the world's marine fish species were overexploited and an additional 25% were nearing full

exploitation. This is compared to almost 0% in 1950 (Hayden, 2001). Approximately 90% of the harvested fisheries occur within 200 miles of shore, though most occur within 5 miles of the coast. Ironically, these coastal waters are areas that sustain the most human abuse. In 1976, the United States developed regulations to protect some ocean fisheries. However, to allow fish populations to rebuild, stricter limits are needed (Lord, 2000). Of all the United States waters, currently less than 1% is protected from human exploitation (Hayden, 2001).

Overfishing has affected the ocean's chain of life. Overfishing does more than deplete fish - it affects entire ecosystems. Reducing the population of one species upsets the balance of nature. Each species play a roll, whether they are symbiotic, predator, prey, or scavenger. A survey of fishing data reveals a connection uniting just about every instance of marine ecosystem collapse to overfishing (Hayden, 2001).

Overfishing results in a reduction of genetic diversity, thus making it more difficult for the remaining population to adapt to future environmental changes (McGinn, 2000). The lack of large fish is one symptom of overfishing. There is evidence that suggests fish sizes

are shrinking. Much of this evidence is based on what we have seen in our lifetime. Many scientists believe that humans are contributing to an unnatural selection that favors smaller fish. Those who fish usually try to get the largest fish. Larger fish win trophies, are worth more money and are admired the most. Since we are catching the larger ones, the smaller ones are left and they provide the genes for the future generations (Gardner, 2002). Also, larger fish are usually the most fertile. For example, one 10-year old female red snapper can product 9,000,000 eggs. However, it takes 212 of the smaller 3 to 4 year old females to produce the same number of eggs (Gardner, 2002).

In the 1980s a new fish market developed that focused on catches of fish that were the size of a single serving. These fish were shipped live to restaurants and displayed in tanks for customers to select. This market is still popular today. The single serving fish market includes California's sheephead. Generally these smaller sheephead are females that have yet to reproduce. The California sheephead has an unusual life cycle. They start out as an asexual juvenile, then transform into a female, and eventually develop into a male. The males can grow to 40 pounds and are considered a spear fishing trophy. Analysis

of historical records indicate sheephead were once more plentiful. In 1989 the statewide catch of sheephead in California was 16,203 metric tons. In 1995 the catch was 194,942 metric tons. This was an increase of 178,739 metric tons within 6 years (Malcolm, 2000).

The live-fish market, of single serving size, is minimally regulated, with the resulting potential to disrupt the sheephead's roll in their community. Sheephead are an integral species in California's kelp forest habitats. Sheephead feed on sea urchins. Sea urchins in turn feed on kelp. When the sheephead population is reduced, sea urchins graze out of control creating barren areas in the kelp forests, thus affecting many other kelp dwelling species (Malcolm, 2000).

Another inhabitant of California's kelp forests is the white abalone. White abalone is desirable by diners and is the rarest of several shellfish in the area. This abalone has been managed by requiring minimum size limits. However, researchers have discovered that this limitation is not enough to protect the abalone. White abalone are broadcast spawners. Unless the male and female are within three feet of each other, the chances of fertilization are considerably reduced. In some areas of the kelp forest

there are only a few white abalone per hectare, too few to allow fertilization to take place (Malcolm, 2000).

Many species of California's rockfish are at critically low levels, despite previously imposed limits. On July 1, 2002, there was an emergency ban of commercial fishing for several of these rockfish. The ban included yelloweye, canary, bocaccio and dark blotched rockfish. Though this move by federal officials angered many fishermen, officials insist that the closing was necessary. Of these rockfish, the bocaccio is in the greatest danger. Experts estimate that it will take 90 years or more for this species to recover ("Commercial rockfishing," 2002).

There are approximately 15,000 different kinds of marine fish which have been described and cataloged. It is estimated that at least 5,000 more have yet to be found along with innumerable shellfish, crustaceans, and worms (Malakoff, 2000). An unknown author wrote, "Destroying a species before learning its worth is like burning a library before reading the books" (as cited in California Department of Education, 1993, p. 10).

CHAPTER THREE

DESIGN OF PROJECT

This project required considerable research in the areas of chemical and geological features of the ocean, classification of biological taxonomy of the marine environment and background of the ocean's flora and fauna. The ocean environment in the areas of global warming and over fishing was also researched.

I am an advanced open water certified SCUBA diver with specialties in the areas of, navigation, enriched air nitrox, deep diving, and night/limited visibility. I own my own equipment necessary for diving. Along with my dive experience, preparation for filming of this documentary involved purchasing a camera, an underwater housing, lights, videotapes, various computer equipment and programs.

After research, experimentation and practice in underwater filming I began my project. Some filming was done in La Jolla Cove and other sites in San Diego County California. Because of better underwater visibility most filming was done around Santa Catalina Island, located about 22 miles off the coast of Southern California.

This project required many trips to San Diego County, and two week-long trips to Santa Catalina Island. After nearly 40 dives I had enough footage to begin editing and creating a documentary. I worked with Tony Ruggieri to create music for my documentary. It took many hours of editing, cutting and splicing to complete this documentary.

Upon completion of the documentary, I designed lesson plans to complement the film. Lessons were designed and field-tested for kindergarten through fourth grades. These lessons are correlated to California Education Standards in areas of Science and Language Arts.

APPENDIX A

DEFINITION OF TERMS

Definition of Terms

Asymmetrical – An organism with no body symmetry.

Autotroph – Organisms that use energy from the sun, or other sources, to manufacture its own organic matter.

Bilateral symmetry – Body parts are arranged so that there are two identical halves, with different posterior and anterior ends.

Carnivore – An animal that consumes meat by eating other animals.

Cartilage – Tissue that is flexible and gives support.

Chitin – A complex organic component which makes up exoskeleton of Arthropods.

Chlorophyll – A green pigment used in the process of photosynthesis.

Chloroplast – An organelle that contains chlorophyll.

Collar cell – A cell in sponges which traps food.

Decomposer – An organism which breaks down dead organic material.

Ectotherms – Organisms who can not regulate their body temperatures. Their metabolic rate varies with the temperature. Also, referred to as cold-blooded.

Endophyte – A photosynthetic organism which lives within cell tissues of plants or algae.

Endotherms – an organism which can regulate its own body temperature by using its own body energy. Also known as warm-blooded.

Epiphyte – A non-parasitic photosynthetic organism that lives on the surface of other plants.

Flagellum – A whip-like organelle usually used for cell locomotion.

Herbivore – a plant eating animal.

Heterotroph – An organism that cannot make its own food and attains its energy from organic matter.

Mesoglea – A jelly-like layer under the epidermis which makes up the bulk of the bodies of many cnidarians.

Microorganisms – A microscopic organism.

Mutualism – A mutually beneficial relationship between symbiotic partners.

Nematocysts – Stinging structures of cnidarians which are used to paralyze prey.

Parasitic – An organism which attacks a host, generally much larger than its self. Parasitic organisms may attack internally or externally.

Photosynthesis – A chemical process using solar energy to manufacture glucose.

Plankton – Free floating plants and animals, usually microscopic.

Primary producer – An autotrophic organism. An organism which changes inorganic carbon into organic carbon.

Radial symmetry – Similar body parts that are arranged around a central point.

Radula – A toothed ribbon-like organ molluscs use for feeding.

Saprobes – Organisms which feed on dead organic material.

Silicerous frustules – Cell wall of diatoms made mostly of silica.

Symbiotic relationship – A prolonged relationship between two species. May be mutualistic, commensalistic or parasitic.

Zooplankton – Free floating protists, animal larvae and tiny animals.

APPENDIX B

SCRIPT

SCRIPT

INTRODUCTION

From the crashing waves to the quiet depths, the ocean is in constant motion. Winds sweep the surface, currents mix tropical and polar waters circulating nutrients throughout the sea.

Oceans cover 71% of our planet, and contain nearly 90% of Earth's inhabitants. Though the ocean habitat is extremely important, it is one of the least explored areas of our planet. Our oceans are vital to life on Earth. Thus, there is an urgent need to understand them and the life within.

The Underwater Life off the Coast of Southern California

Rocky shores, like these along Southern California's coast, are among the richest coastal habitats in the world. Battering waves wear down rocks, forming cracks and crevices. This endless carving creates a multitude of holes and homesteading sites for animals that are suited to these harsh conditions.

Imagine living in a world where twice a day, you must withstand the pounding waves of the incoming tide. In the meantime, you struggle to survive low tide when the sun warms the pools and begins to evaporate the water left behind.

A variety of plants and animals inhabit these brutal conditions. **Tide pool** residents must adjust to these extreme differences. They have evolved remarkable adaptations in order to survive.

Mussels and **barnacles** are often found clumped together, to protect themselves from drying out in the hot sun.

Barnacles are rock-clinging filter feeders. They cement themselves, headfirst, then secrete a volcano shaped shell, with four plates at the top. Inside, the four plates can close, retaining water when the tide goes out, protecting the animal. To feed, they push their feather like legs through the opening, and comb food particles from the water.

The **California Mussel** is one of the most abundant animals along the California Coast. The mussel produces strong sticky threads used to attach itself to a rock.

Among the barnacles and mussels, **crabs** can be found searching for food. Crabs feed in pools, or find shelter in moss, grass, or hide under damp rocks.

Chitons are algae eaters. They have a flattened body, with 8 shells running down their back.

You can find many creatures, such as sea **anemones**, in pools of water the tide has left behind. Though they look like plants they are in fact animals. The sea anemone eats by stinging passing food with its tentacles, and drawing the food into its mouth. When the water level drops in a tide pool, anemones tuck their tentacles inside their bodies and coat themselves with slime to keep moisture in.

Sharing this tide pool are small fish, sea anemones, and a **hermit crab**. Hermit crabs have soft bodies and live inside an empty snail shell for protection. They use two tail hooks to hold the shell in place.

Some **seaweeds** thrives in the mid-tidal zone. When the tide goes out, seaweeds droop over rocks, providing a moist refuge beneath the blades for many inter-tidal residents.

BELOW THE WAVES

Below the waves is the rich and fragile world of the ocean, an immense and diverse wilderness. Southern California's ocean is teaming with life from colorful seaweeds, grasses, and delicate corals, to a variety of fish and other sea life.

The **landscape** of the underwater world varies just as it does on land, from forests of seaweed, deserts of sand, to outcroppings of jagged or smooth rocks. All are important ecosystems that support a wide range of species.

Giant kelp forms magnificent submarine forests which nurture animal life as abundant and diverse as that in forests on land. Many exotic and beautiful creatures inhabit the vast kelp forests of Southern California.

Seaweed, also called kelp, is a multicellular algae, though it is often referred to as a plant. Even though it is an algae, Giant kelp is considered one of the fastest growing plants in the world. This species can grow over 12 inches a day, and may reach lengths of 200 feet.

This enormous plant, like all seaweeds, does not have true roots. The clump of root-like structures are called holdfast. Many individual fronds grow from each holdfast.

The stipe supports blades, the leaf-like structures, which are buoyed by air-filled bladders. These rise to the surface where they form a thick interwoven canopy.

A **giant kelp fish** slides past a swaying kelp blade. The color, shape, fins, and even the body movements of the kelp fish, imitate the waving fronds of the kelp.

Similar in appearance are the **Island kelp fish,** which are found in rocky areas among kelps and grasses.

Here, a **Norris Top Snail** is grazing among kelp fronds.

Opaleyes are dark olive green fish that generally have 2 yellowish-white spots below the dorsal fins. Opaleyes are unique in that they have homing behavior and can breath air when out of water.

Halfmoon fish are found in rocky kelp beds to depths of 40 meters.

Rock Wrasses feed on small crustaceans and gastropods and pick parasites from other fish. The female is able to change sex. Upon maturity some will change to male, and acquire a different color pattern.

The **Senorita** is also a wrasse. However, they are not able change sex.

Sargos have a black stripe running from the backbone down the side. They are found in coastal waters near kelp beds, sandy bottoms, and in rocky areas.

Kelp Serf Perch are usually found among the canopy of giant kelp. They feed on small crustaceans, particularly ones that live on kelp. They also clean parasites from other fish.

Kelp bass are common residents in Southern California's kelp forests and are a popular sport fish with an estimate of over one million fish taken each year. They are a slow growing fish reaching a length of 12 inches in six years. Kelp bass may take 20 years to reach the length of 24 inches.

The **Garibaldi** is California's state fish. Adult Garibaldis are easily recognized by their beautiful orange color. Once over-fished, they are now protected. Infants are reddish-orange with iridescent blue markings. These

curious but territorial fish abruptly charge intruders that venture too close to their nest. Once the female lays her eggs, the male will chase her away and fiercely protect the eggs until the young hatch.

The **Black Eyed Gobi** and **Blue Banded Catalina Gobi** are found in open rocky areas and feed mainly on small crustaceans.

This **Purple Sea Urchin** is a spiky animal, resembling a pincushion. Even with their many spines, sea urchins have numerous predators.

The **California Sheephead** are found in areas with rocky bottoms, particularly in kelp forests. Juveniles are reddish brown with a white stripe along each side. Adult males have a black head and posterior section, a white chin and a large red band in the mid-section.

Sheephead have an unusual life cycle. They start out as an asexual juvenile, then transform into a female. When they are around 30 centimeters long they change into a male. Males can grow to 40 pounds and can live more than 50 years. Their teeth can cause serious bite wounds.

Sheephead are an important species in California's kelp forest habitats. Sheephead commonly feed on sea urchins using their large, flat crushing teeth. Sea urchins in turn, feed on kelp. When the sheephead population is reduced, sea urchins graze out of control, creating barren areas in the kelp forests, thus affecting many other kelp dwelling species.

These **moon jellyfish**, filmed at night, float near the surface, just offshore. They move by gently opening and closing their translucent saucer-shaped bodies. They have many short tentacles that they use to sting and capture prey.

These **Corals** are animals that resemble members of the plant kingdom.

Some hunters, like the **moray eel**, are content to lie in ambush in cracks or caves, watching for unsuspecting victims to swim past.

Warty Sea Cucumbers are soft bodied, slug-like echinoderms.

Octopuses are shy animals, hiding in cracks and caves during the day, and hunt for food at night. An octopus usually crawls along the bottom using its arms. For swift escapes the octopus can only jet backwards, with its arms trailing behind.

This Two-spotted Octopus has narrowly escaped death, losing only a few arms from a fierce predator, possibly a leopard shark.

These **leopard sharks** are named for their stripes, and spotty markings. Though formidable and menacing, leopard sharks are not considered dangerous to humans.

Rays are graceful cousins of sharks. They tend to hide in the bottom sand and sediment, or glide along slowly as they search for shellfish and fishes. Most stingrays possess whip-like tails, with venomous stingers that they use for defense. This ray has lost it's tail, probably from human contact.

A **California spiny lobster**, also called California Rock Lobster, hides in the crevice of a rock. Spiny lobsters hide during the day and feed at night.

California Spiny Lobsters are reddish-brown with an exoskeleton that has a row of strong spines. The largest spines are above the eyes. They have no large pinchers, as other species do. Spiny lobsters are occasionally found in tide pools, though usually found below the low-tide line.

Turbots are found in flat areas. Young turbots are commonly found in shallow water. This C-O Turbot is camouflaged by its spotty coloration allowing it to blend into the ocean floor.

Almost invisible, a **scorpion fish** waits for prey. They have venomous spines in the dorsal, anal, and pelvic fins.

Tree fish are related to the scorpion fish and have the characteristic venomous spines.

In deeper waters a **sheep crab** searches for food within a kelp forest. Sheep crabs can have a body width of over 8 inches with legs spanning over 18 inches. There are over 4,500 species of **crabs.** Most are scavengers, yet others may eat mollusks, coral mucus, organic matter, or seaweeds.

Abalones are snails with flattened shells. The holes along the shells are used to drain water from the gills. Abalone is a highly sought after delicacy for its meat. The shells are collected for the beautiful iridescent interior.

Sea stars, commonly known as starfish, are not fish they are echinoderms. The top part of the body is spiny and rough as you can see on this **Fragile Rainbow Star**. The arms have rows of little tubular feet, with suckers on each one.

When an arm is injured, it is shed, and a new arm is regenerated. In some species, such as **the Pacific Comet Star,** the shed arm may regenerate a new sea star.

Sea stars, like this **Giant Sea Star**, usually feed on mussels and clams.

Bat stars are the most abundant sea star along California's Coast. As seen here, color can vary dramatically.

Leather stars are named for their smooth and slick "leathery" exterior. They have a unique garlic odor when out of water.

There are many species of **Spiny brittle stars** along Southern California's coasts. As with all sea stars and brittle stars they have no organ specifically for excreting waste. Waste is diffused through the skin or water vascular system.

Egg cases vary according to the type of animal that lays them. Swell sharks have a flattened egg case. The horned shark has a distinctive corkscrew-shaped case, and the kellet whelk lays groups of soft oval shaped eggs.

Many fish swim closely together in large groups called **schools**. They move simultaneously in the same direction. Small fish in a tightly packed school may also discourage a predator by appearing as a single, much bigger creature.

Many schooling species have distinct marks on their bodies, fins, and tails. These markings are used as visual markers, helping fish achieve harmony in movement. They also have a vibration detecting lateral line running down their back, which helps to provide information about a neighbors' movement.

Fish **swim** by a sequence of S-shaped curves, which move along the body. Each curve begins with a slight sideways motion of the head. The S-shaped curve is made by muscle contractions along the backbone.

MAMMALS

Some animals are thought of as fish because they live in water, but they are not true fish. If you are lucky you may catch a glimpse of a **dolphin**, or a **California sea lion**. These are in fact mammals and must come to the surface to breath. California sea lions are commonly seen in harbors and

bays. This California sea lion is dinning on a fish while sea gulls and pelicans wait for tasty treats.

CONCLUSION

For hundreds of years, humans have used the ocean as a source of food, minerals, transportation, and for sport. Seaweeds are used for foods, fertilizers, and other products. Rocks, shells, and sand are used for cement and building. For over 4,000 years salt has been extracted form seawater.

Today, much of our oceans remain untouched, seemingly unaffected, by humankind. Inevitably, change has come. The sea is now tainted, as the land and air are tainted, with the imprint of human ways.

As the human population continues to grow, the demand for food, shipping, and recreation often competes with the needs of ocean habitats. The future of our species is closely bound to the future of the ocean, and the life it supports.

Earth, the third planet from the sun, is our home. We must take care of it, for we have, in the foreseeable future, no other plant we can call home.

APPENDIX C

TEACHER RESOURCE

TEACHER RESOURCE

INTRODUCTION

From the crashing waves to the quiet depths, the ocean is in constant motion. Winds sweep the surface, currents mix tropical and polar waters circulating nutrients throughout the sea.

Oceans cover 71% of our planet, and contain nearly 90% of Earth's inhabitants. Though the ocean habitat is extremely important, it is one of the least explored areas of our planet. Our oceans are vital to life on Earth. Thus, there is an urgent need to understand them and the life within.

The Underwater Life off the Coast of Southern California

Rocky shores, such as those along Southern California's coast, are among the richest coastal habitats in the world. Battering waves wear down rocks, forming cracks and crevices. This endless carving creates a multitude of holes and homesteading sites for animals that are suited to these harsh conditions.

Imagine living in a world where twice a day, you must withstand the pounding waves of the incoming tide. In the meantime, you struggle to survive low tide when the sun warms the pools and begins to evaporate the water left behind. The temperature may jump from hot to cold or cold to hot within minutes. A variety of plants and animals inhabit these brutal conditions. Tide pool residents must adjust to these extreme differences. They have evolved remarkable adaptations in order to survive.

Tide pools are formed when tides bring waves higher ashore, filling in holes along the rocky shore. A variety of organisms compete for the limited space in this region.

Mussels and barnacles are often found clumped together, to protect themselves from drying out in the hot sun. **Barnacles**, like mussels, are rock-clinging filter feeders that spread open their shells during high tide. The similarity ends there. Barnacles are not mollusks, but crustaceans, relatives of crabs, shrimps and lobsters. When barnacles are young, they use sensitive antennae to select a spot, usually a rock or shell, to settle down permanently. They cement themselves, headfirst, in a place, which will be their home for life. Barnacles then secrete a volcano shaped shell, with four plates at the top that controls an opening. Inside, four movable plates can close, retaining water when the tide goes out, protecting the animal. The part of the barnacle

inside the shell looks like a tiny shrimp. To feed, barnacles push their feather like legs through the opening, and comb food particles from the water. Barnacles mature in five years and can live to be twenty years old.

When young, the **California Mussel,** one of the most abundant animals along the California Coast, produces a mesh of strong, sticky threads. These threads are used to attach itself to a rock to avoid being washed out to sea. At high tide, mussels open their shells so they can filter out tiny bits of food from the seawater. When the tide retreats, they shut their shells, trapping in moisture. California mussels are preyed upon by crabs, birds, sea otters, sea stars, predatory snails, and by humans.

Among the barnacles and mussels, **crabs** can be found searching for food. **Crabs** feed in pools or find shelter in moss, grass, or hide under damp rocks.

During high tide, **limpets** roam the rocks nibbling on algae. When the tide retreats, each limpet returns to its own home spot, a hollow on a rock that the limpet has carved to fit its shell. To hold itself in place, the limpet creates a powerful suction with its muscular foot.

Another group of algae eaters are **chitons.** They are unique they have a flattened body, with 8 shells running down their back.

You can find many creatures, such as **sea anemones, in** pools of water the tide has left behind. Though they look like plants they are in fact animals. Their flowery tentacle easily identifies sea anemones. These tentacles surround the mouth at the top of a tubular form. The sea anemone eats by stinging passing food with its tentacles, and drawing the food into its mouth. Anemones may attach bits of shell to themselves for protection from the sun's penetrating rays. Sea anemones and jellyfish are very closely related. The sea anemone is like an upside-down jellyfish that spends its life attached to rocks. When the water level drops in a tide pool, anemones tuck their tentacles inside their bodies and coat themselves with slime to keep moisture in.

Hermit crabs have soft bodies and live inside an empty mollusk shell for protection. They use two tail hooks to hold the shell in place. When the crab retreats inside, crusher claws fit together to block the entrance. As they grow, the hermit crabs move into larger shells, sometimes dislodging another crab. Occasionally, they put other animals, such as sponges or sea anemones, onto their shells for camouflage.

Some **seaweed** thrives in the mid-tidal zone. Root like holdfast clamp seaweed securely to rocks. When the tide goes out, seaweeds droop over

rocks, providing a moist refuge beneath the blades for many inter-tidal residents.

Below the waves

Below the waves is the rich and fragile world of the ocean, an immense and diverse wilderness. Southern California's ocean is teaming with life from colorful seaweeds, grasses, and delicate corals, to a variety of fish and other sea life.

The **landscape** of the underwater world varies just as it does on land, from forests of seaweed, deserts of sand, to outcroppings of jagged or smooth rocks. All are important ecosystems that support a wide range of species. Each habitat offers opportunities for hiding places, which are useful for both predators and prey.

Seaweeds vary tremendously in size, shape, texture and color. They may be round and flat, stick like, clumped, ruffled, delicate, or long and leafy. They come in shades of green, brown, pink, red, yellow or purple.

Kelp forest

Giant kelp (Macro cystistus) forms magnificent submarine forests, which nurture animal life as abundant and diverse as that in forests on land. Many exotic and beautiful creatures inhabit the vast submarine kelp forests of Southern California.

The most commonly know multicellular algae are the seaweeds. However, some seaweeds are unicellular. Seaweeds are also known as macroalgae, thorough the term seaweed helps to differentiate them from unicellular algae. Seaweeds are grouped with the kingdom Protista, mainly because they lack specialized tissues of plants. Seaweed, also called kelp, is a multicellular algae though often referred to as a plant. However, it is not a plant, but in fact, an algae. Even though it is an algae, Giant kelp is considered one of the fastest growing plants in the world. This species can grow over 12 inches a day, and may reach lengths of 200 feet. This enormous plant, like all seaweeds, does not have true roots. The clumps of rootlike structures are called holdfast. They anchor the kelp to rocks or other solid places on the bottom of the ocean. Many individual fronds grow from each holdfast. Each frond has a slender stipe, or stalk. The stipe supports blades, the leaf-like structure, which is buoyed by air-filled bladders. These rise to the surface where they form a thick interwoven canopy. The blades in this canopy collect the sunlight needed for photosynthesis. Seaweeds are often seasonal,

growing in great abundance in the spring and summer, and dying off in the winter.

Kelp is also of economic importance and is harvested for many reasons. Some kelps are used as a food source and in food processing. The have many uses in the pharmaceutical, chemical, printing and cosmetic industries. Kelps are also being examined in medical research and use in fertilizers, and pesticides.

Kelp holdfasts, the root like structures, which hold the kelp plant in place, are occasionally torn loose due to strong currents or storms. Most such uprooted kelp soon wash ashore, and die making home to a multitude of crabs, snails and insects. Other uprooted kelp may sink to the ocean depth transporting organic matter to the ocean floor.

California's kelp forest species

Giant Kelp Fish (Heterostichus rostratus) are found in rocky areas with large seaweeds to a depth of 40 meters. They can reach a length of 24 inches. They vary in color from brownish-green to purplish-red, which help them blend in with their surroundings. When young, giant kelp fish congregate in schools but are solitary when adults. They feed on small fish, mollusks and small crustaceans. Kelp fish resemble kelp in many ways. The color, shape, fins, and even the body movements of kelp fish, imitate the waving fronds of the kelp. The combination of colors, and their long slender body, helps aid with camouflage.

Island kelp fish (Alloclinus holderi) are found in rocky areas to depths of 49 meters. They are harmless to humans.

Norris Top Snails graze among kelp fronds. **Snails** are mollusks and are known for their spiral shell. They can retract into the shell when not moving around. The shape, size, and color of snail's shells vary widely. Most snail's shells spiral to the right. This can be seen by holding the tip of the shell, pointing towards you and observing the coils.

Some common residents of Southern California's kelp forests are the opaleye, halfmoon fish, rock wrasse, senorita, sargo, kelp Serf perch, kelp bass, garibaldi, Gobi, and Sheephead.

Opaleye (Girrella nigricans) are generally around 9 inches long but can reach a length of up to 26 inches. They are dark olive green and generally have 2 yellowish-white spots below the dorsal fins. They are an inter-tidal species. They are usually found swimming over rocks in kelp beds, but can be

found from 2 to 30 metes in depth. They feed mainly on seaweeds and occasionally on invertebrates. They are harmless to humans. Opaleyes are unique in that they have homing behavior and can breath air when out of water.

Halfmoon fish (Medialuna californiensis) are found in rocky kelp beds to depth of 40 meters. They are harmless to human and feed on seaweeds and small invertebrates.

Rock Wrasses (Halichoeres semicinctus) are found close to rocks, near sandy patches, and in tide pools. When threatened they dart into bottom sediments. They sleep in the sand with their heads protruding, and are found to depths of 24 meters. They feed on small crustaceans and gastropods. They have been observed picking parasites from other fish and are harmless to humans. The female is able to change sex. Upon maturity some will change to male, and acquire a different color pattern.

The **Senorita** fish (Oxyjulis californica) is also a wrasse. However, they do not change sex. They live in kelp beds, seaweeds, and over rocky areas. The are usually found in waters shallower than 23 meters but have been seen in depths to 73 meters. They are often found in small groups, swimming well above the bottom. Senoritas feed on small invertebrates, they clean parasites from other fish, and are harmless to humans. When disturbed, they will dart away and bury themselves in bottom sediments. Like the rock wrasse, they too sleep in the sand with their heads protruding.

Sargos (Anisotremus davidsonii) are found in coastal waters near kelp beds, sandy bottoms and in rocky areas. They are found to depths down to 40 meters. Juveniles are usually found in schools. Sargos feed on mollusks, crustaceans, and bryozoans. They are harmless to humans.

Kelp Serf Perch (Brachyistius frenatus) are usually found among the canopy of giant kelp, forming large groups in summer. They feed on small crustaceans, particularly ones that live on kelp and are harmless to humans. They also clean parasites from other fish.

Kelp bass (Paralabrax clathratus) are common residents in Southern California's kelp forests, and are a popular sport fish with an estimate of over one million fish taken each year. Kelp bass feed on crustaceans, octopus, and other fish. They are a slow growing fish reaching a length of 12 inches in six years. Kelp bass may take 20 years to reach the length of 24 inches.

The **Garibaldi** is California's state fish. Adult Garibaldis (Hypsypops rubicundus) are easily recognized by their orange color. Juveniles are reddish orange with iridescent blue markings. These beautiful fish can be seen darting

in and around the kelp forest. Once over-fished, they are now protected. These curious but territorial fish abruptly charge intruders that venture too close to their nests. The male garibaldi prepares the nest by removing rocks and large plant material from around the nesting site. Once this is completed, he will allow certain kinds of small red algae to grow back. Once the female lays her eggs on the soft algae, the male will chase her away and fiercely protect the eggs until the young hatch.

The **Blackeye Goby** (Rhinogobiops nicholsii) is tan to olive, and blends in with bottom sediments. They have an iridescent blue spot under each eye and the first dorsal fin is edge in black. They are found in bays, in sandy areas and rocky reef to depths of 420 feet. Spawning occurs between April to October. Males lure females into caves where the female lays her egg. The male then chases her away and guards the eggs

The **Blue Banded Catalina Gobi** (Lythrypnus dalli) once was considered rare until the increased popularity of SCUBA diving. They are found on open rocky areas, usually sitting on an exposed rock. They grow to around 6.4 centimeters and can be found from 0 to 76 meters in depth. The Catalina Gobi is shy and will dart into holes, crevice or among the spines of sea anemones when disturbed. They feed mainly on small crustaceans and are harmless to humans.

This **Purple Sea Urchin** is a spiky animal, resembling a pincushion, and vary in color from browns, white to purple. They are related to the starfish. They have a hard outer covering with many spines, which cover the entire body, except the base. The mouth is on the base along with little suckers, which the sea urchin uses to move around. Sea urchins can be found in tide pools, or in deeper waters to 525 feet. Some sea urchins are nocturnal and feed at night. Others feed during the day. Sea urchins eat algae or seaweed. Even with their many spines, sea urchins have numerous predators including sheephead, lobsters, crabs, mollusks, and fish.

The California **sheephead** (Semicossyphus pulcher) is a popular game fish. They are found in areas with rocky bottoms, particularly in kelp forests to depths of 55 meters. Juveniles are reddish brown with a white stripe along each side. Adult females are reddish brown with a white chin and males have a black head and posterior section, white chin and a large red band in the mid section. The sheephead has an unusual life cycle. They start our as an asexual juvenile, then transform into a female. When they are around 30 centimeters long they change into a male. They can live more than 50 years. The males can grow to 40 pounds, and are considered a spearfishing trophy. Sheephead are an integral species in California's kelp forest habitats. They feed on mollusks, crabs, corals, or tough plant matter using their large, flat

crushing teeth. They are curious fish so swimmers and divers should be wary. Their large teeth can cause serious bite wounds.

Sheephead commonly feed on sea urchins. Sea urchins in turn, feed on kelp. When the sheephead population is reduced, sea urchins graze out of control, creating barren areas in the kelp forests, thus affecting many other kelp dwelling species.

Jellyfish are not fish they are a cnidarians. **Moon jellyfish** (Aurelia aurita) float near the surface, just offshore. Jellyfish are subject to winds, tides, and currents. They move by gently opening and closing their translucent saucer-shaped bodies. They have many tentacles that they use to sting and capture prey. Jellyfish can sting humans causing a rash. Some jellyfish have deadly stings.

Bottom dwelling creatures

Corals are animals that resemble members of the plant kingdom. Some corals are soft and fuzzy; others are hard and rock-like.

Hunters, like the **California moray eel** (Gymnothorax mordax), are content to lie in ambush in cracks or caves, watching for unsuspecting victims to swim past. An eel's body is adapted for lurking deep within cracks. Moray eels do not have pectoral fins like other fish, and are often confused as being a snake. In fact eels resemble a snake, more than a fish. They glide through the water like snakes slither across land. Using its well-developed sense of smell, eels hunt at night, seizing prey with a quick strike and a snap of its strong sharp toothed jaws. During the day they withdraw into a hole. Here they spend the day with their heads near the opening and mouths open during breathing. California moray eels eat molluscs, crustaceans, and small fishes.

Warty Sea Cucumbers (Parastichopus parvimensis californicus) are soft bodied, slug-like echinoderms. The body is cylindrical with a mouth at one end and tube feet on the underside. They have no arms and are usually flexible. The body has many small "warts" and 5 to 6 large "warts." Sea cucumbers have small skeletons, which are calcareous bone-like plates. They feed on organic detritus and small organisms, which are found in soft sediments. They have no known predators and are found from the low tidal zone to 64 meters deep.

Two-spotted Octopuses (Octopus bimaculatus) are mollusks, and are related to mussels, though they do not have a shell. Octopuses are shy animals, hiding in cracks and caves during the day, and hunt for food at night. Their body is soft, and they have 8 arms covered with suckers. The arms

surround the mouth, where there is a parrot shaped beak, which is used for killing and tearing apart prey. Octopuses usually crawl along the bottom using its arms. When threatened, the octopus squirts out a cloud of ink, confusing the predator, allowing the octopus to escape. For swift escapes the octopus can only jet backwards, with its arms trailing behind. The octopus has a large capacity for learning, and the most complex brain of all invertebrates. They move small rocks, can build their own home, and have been observed navigating a maze.

This **leopard shark** (Triakis semifasciata) is named for its stripes, and spotty markings. Leopard sharks feed on bottom dwelling animals such as octopus, clams, crabs, shrimp, and small fish. They are usually found in shallow waters and are not considered dangerous to humans. Males can grow to a length of 5 feet while females can reach 7 feet.

Sharks are cartilaginous fishes. Their skeletons are not made of bone, they are made of cartilage. The cartilaginous skeleton is not soft, but extremely hard.

There are more than 100 species of **stingrays** around the world. Rays are graceful cousins of sharks. They are found in depths from 37 to 238 meters. Rays, like sharks, have skeletons made of cartilage. They tend to hide in the bottom sand and sediment or glide along slowly as they search for shellfish and fishes. Their gills are on the underside, so rays have evolved an opening above the eyes where clean water flows into the gill chambers. Stingrays feed on worms, shellfish, fishes, and other bottom-dwelling animals, which they crush with their blunt teeth. Most stingrays possess whip-like tails, with venomous stingers that they use for defense.

Spiny lobsters hide during the day and feed at night, eating mainly mollusks. **California Spiny Lobsters** (Panulirus interruptus), also called California Rock Lobster, are reddish-brown with an exoskeleton, which has a row of strong spines. The largest spine is above the eyes. They have no large pinchers, as other species do. Spiny lobsters are occasionally found in tide pools, though usually found below the low-tide line.

The California Spiny Lobster, also know as California Rock Lobster, is an arthropod. Arthropods have a characteristic exoskeleton. The exoskeleton gives rigidity to the animal, and protects the soft insides. In order to grow arthropods molt. Molting is when they form a new exoskeleton and shed the old. The new exoskeleton is soft, leaving the animal vulnerable to predators. They stay hidden for a few days relying on their two long whip-like antennae to avoid predators. Once the exoskeleton hardens, the arthropod resumes its normal behavior.

Spiny lobsters are related to New England lobsters. However, the spiny lobster lacks the large claws. They begin life as small transparent plankton, and drift in the ocean for the first year. The larvae then settle into grassy areas. As they mature, spiny lobsters molt around 10 to 12 times. In the summer, they begin to mix with adult lobsters that migrate into shallow grassy areas. In the fall, they follow the adults into deeper waters.

Extensive fishing of spiny lobsters appears to have caused a change in the ecological balance. One of the sea urchin's natural predators is the spiny lobster. Marine biologists are finding bare areas in kelp forests, with an over abundance of sea urchins nearby. The sea urchins have overgrazed the kelp forest, destroying an important habitat for many species.

Most flat fish live on, or near, the ocean floor. Flatfish, such as flounders, halibut, and turbots often bury themselves in the sand, in shallow water. **Turbots** (Pleuronichtys coenosus) are found in flat, somewhat rocky, areas. They are found in waters 18 to 450 meters. Young turbots are common in shallow water. This **Turbot** is camouflaged by its spotty coloration allowing it to blend into the ocean floor. Turbots swim by flapping their fins in a wave like motion, then glide to the ocean floor, where they flutter their fins to stir up sand. The particles settle back over the fish, partially covering them. This breaks up their outlines, making them even more difficult to see. They are harmless to humans.

Scorpion fish (Scorpaena guttata) are usually found in rocky bays and along shore near cracks and crevices. They are a common commercial game fish. Many members of this species are difficult to distinguish from one another. Venomous spines in the dorsal, anal, and pelvic fins are used for protection, making this one of the Southern California's most feared species.

Tree fish (Sebastes serriceps) are related to the scorpion fish and have the characteristic venomous spines. Tree fish are very territorial and are found in rocky areas, usually in and around crevices.

Crabs are members of the largest phylum, arthropods, with more than one million known species. Arthropods account for 75% of animal species. They are characteristic as having an exoskeleton, a segmented body, a well develop nervous system, and jointed appendages. Arthropods are named for their jointed appendages. Arthro means 'joint' and pod means 'foot'. Insects (class Insecta) are the most dominant arthropod living in all environments except the ocean. In the marine environment, crustaceans are the most abundant arthropod. Crustaceans (subphylum – Crustacea) include crabs, lobsters, krill and shrimps. Crabs are decapods. Decapods are characteristic as having 10 legs. Most are scavengers, yet others may eat mollusks, coral

mucus, organic matter, or seaweeds. The **Sheep crab** (loxorhynchus grandis) can have a body width of over 6 inches with legs spanning over twelve inches. The southern kelp crabs body can grow to four inches in width.

Abalones are snails with flattened shells. The holes along the shells are used to drain water from the gills. Abalone are a highly sought after delicacy for its meat. The shells are collected for the beautiful iridescent interior. Abalones are found on rocks and in crevices, usually overgrown with algae and animal life.

Sea stars, commonly known as starfish, are not fish they are echinoderms. The top part of the body is spiny and rough. The underside has a mouth, which is in the middle of the central disk. The colors and number of arms on sea stars vary between individuals and between species. The arms have rows of little tubular feet, with suckers on each one. The suckers reach ahead, and attach to objects, and pull the sea star forward. Sea stars pump the tubes full of water, and attach the suckers onto something solid. When the sea star lets the water out its feet recoil, pulling the animal along.

When an arm is injured, it is shed, and a new arm is regenerated. In some species, such as **the Pacific Comet Star** (Linckia columbiae), the shed arm may regenerate a new sea star. Sea stars usually feed on mussels and clams.

They pry open the shell of its prey then the sea star inserts its stomach inside the crack of the prey's shell and digests the meat inside. When done feeding the sea star sucks its stomach back into its body. As with all sea stars and brittle stars they have no organ specifically for excreting waste. Waste is diffused through the skin or water vascular system.

The **Giant Sea Star** (Pisaster giganteus) is commonly seen along Southern California's coast. The are found on rocky shores and in shallow water.

Bat stars (Patiria miniata) are usually reddish-orange, but can vary in color. They usually have 5 short arms. They are found on sandy bottoms, and rocks, usually within kelp beds. Bat stars are the most abundant sea star along the California's West Coast. They can be found to depths of 960 feet.

Leather stars (Dermasterias imbricata) are named for their smooth and slick "leathery" exterior. They feed on sea urchins, sea cucumbers and anemones. They have a unique garlic odor when out of water.

Many species of **Spiny brittle stars** live under rocks, and feed on pieces of dead plants and animals along Southern California's coast. Their flexible arms are covered with spines.

Egg laying and caring

Egg cases vary according to the type of animal that lays them. Swell sharks have a flattened egg case, horned sharks have a distinctive corkscrew-shaped case, and the kellet whelk lays groups of soft, opalescent, oval shaped eggs.

Fishes have a wide range of behaviors for laying, and caring for, eggs. **S**pecies, such as the turbot, release millions of tiny eggs, scattering them in the water, to become fertilized, and develop unaided. All but a handful of the millions will soon end up as food for other water creatures. The garibaldi female lays many eggs, and the male guards them fiercely. The giant kelp fish females lay eggs on seaweed, and the male guards them. The Blue Banded Catalina Gobi female deposits eggs and the male guards them.

Schooling

Many fish swim closely together in large groups called **schools**, or shoals. Looser groups are called aggregates. Schooling is associated with feeding, or with breeding. Protection from predators is another way fishes benefit from swimming in schools. They move simultaneously in the same direction. The number, and actions, of the school often confuse predators. The predator finds it difficult to select out a single individual to attack. Small fishes in a tightly packed school may also discourage a predator by appearing as a single, much bigger creature.

Many schooling species have distinct marks on their bodies, fins, and tails. These markings are used as visual markers, helping fishes achieve harmony in movement. They also have a vibration detecting lateral line running down their back, which helps to provide information about its neighbors' movement.

Protection

Another way fish **avoid hungry predators** is by using a burst of speed to escape. Most small fish, like these wrasses, must feed out in the open. This can be dangerous, but within an instant they can dart out of danger, hiding within kelp blades, or diving into a narrow crevice, in the rocks. Some fish use size or shape to discourage prey, others take refuge in cracks and crevices.

Some have evolved tactics in the use of poison, camouflage, or weapons, to defend themselves against predators. Others have spines on their backs, or tail, which can inflict painful injuries.

Colors can be used as **camouflage** from both predator and prey. Greens, blues, and browns may camouflage some species in open water. Fish that swim near the surface may have a darker back and lighter underside, allowing it to "disappear" into the surrounding waters. A darker back camouflages fish from above, allowing it to blend in with the darker depths. A lighter underside when viewed from below which blends it in with the bright surface waters. Spotty coloration, or stripes, breaks up a fish's outline. Shape, like color, helps to camouflage a fish. Thin bodies may look like plant leaves, or the entire fish's body may resemble a plant, or another animal. Most fishes are covered with **scales.** Scales are thin transparent overlapping plates. The transparency allows the layers of skin to show through also assisting with camouflage.

Mammals

Some animals are thought of as fishes because they live in water, but they are not true fishes. If you are lucky you may catch a glimpse of a **dolphin** or **California sea lion** (Zalophus californianus). These are in fact mammals and must come to the surface to breath.

California Sea lions are frequently seen in bays and harbors. They have sharp teeth designed for gripping and tearing their food. Males reach lengths of 6.5 to 8 feet and can weigh up to 440 to 880 pounds. Females reach 5 to 6.5 feet and weigh 110 to 240 pounds.

General fish information

Fish are large group of fascinating animals designed for life underwater. Though there are many differences, there are some similarities, thus we can make a few generalizations. Most fishes live in water, use gills to breath, swim using tails and fins, are covered with scales, and all are vertebrates.

All animals need **oxygen** in order to survive. Land animals obtain oxygen from the air. Water contains oxygen too, and fish are able to get this oxygen by using their gills. Water flows past the blood supply in the gills, and then oxygen passes from the water, through the thin gill membranes, into the fish's blood. Oxygen is then transported throughout the fish's body.

Fish have two main types of **fins**, paired and median. Paired fins are the pelvic and pectoral fins. They help with steering, maneuvering, and stopping. Median fins are the dorsal fin (some species have up to three), the anal, and the tail fin. The dorsal and anal fins help with stability and the tail provides power for moving.

Fish **swim** by a sequence of S-shaped curves, which move along the body. Each curve begins with a slight sideways motion of the head. The curve becomes larger as it moves down the body. The movement of the body and tail pushes the neighboring water sideways and backwards. This moves the fish forward. The S-shaped curve is made by muscle contractions along the backbone. Most fishes use their tails for forward motion but some species move their pectoral fins in a rowing motion instead.

Fish can **feel** water movements caused by other creatures and by currents. Water is an exceptionally good conductor of sound. Fish mainly sense sound vibrations with their lateral line. The lateral is a fluid-filled canal that runs along each side of the fish's body. Sound vibrations pass into the canal, through small pores in the skin, shaking clumps of gelatinous material, which in turn stimulates nerve endings.

The most common fish **shape** is designed for slipping smoothly through the water. Long, slim, straight fish are designed for quickly darting around. Thin flexible fish can glide between plants, rocks, and coral. Others are built more for a surprise attack than for speed.

Food

Life is based on the food chain. At the bottom of the food chain are plants. Most plants in the ocean are microscopic. The microscopic, usually floating, plants are called the phytoplankton. Microscopic animals are called zooplankton and they eat phytoplankton. Small creatures, such as shrimp, eat zooplankton. Larger creature eats smaller creatures. These are in turn eaten by even larger creatures, and so the chain of life continues.

Looking at the head of a fish will give clues to what they eat. Fish with large flat teeth may eat shellfish, corals, or tough plant material. Fish with sharp, pointy teeth are most likely hunters. Those with large gaping mouth are probably strain small zooplankton or phytoplankton from the water.

CONCLUSION

All of Earth's living inhabitants and physical features are interconnected and play an important part to help sustain our planet.

For hundreds of years, humans have used the ocean as a source of food, products, minerals, transportation, and for sport. Seaweeds are used for foods, fertilizers, and other products. Rocks, shells, and sand are used for cement and building. For over 4,000 years salt has been extracted form seawater.

Today, much of our oceans remain untouched, seemingly unaffected, by humankind. Inevitably, change has come. The sea is now tainted, as the land and air are tainted, with the imprint of human ways. The health of the ocean has been affected by overfishing, dumping, and oil spills. Many species are harvested before they are mature enough to reproduce. Not enough is being done to protect marine animal populations. Less than 1% of the ocean habitat's protected where the fishing or gathering of sea animals is prohibited. As the human population continues to grow, the demand for food, shipping, and recreation often competes with the needs of ocean habitats. Nevertheless, the future of our species is closely bound to the future of the ocean, and the life it supports.

Earth, the third planet from the sun, is our home. We must take care of it, for we have, in the foreseeable future, no other plant we can call home.

"Destroying a species before learning its worth is like
burning a library before reading the books."

Author Unknown

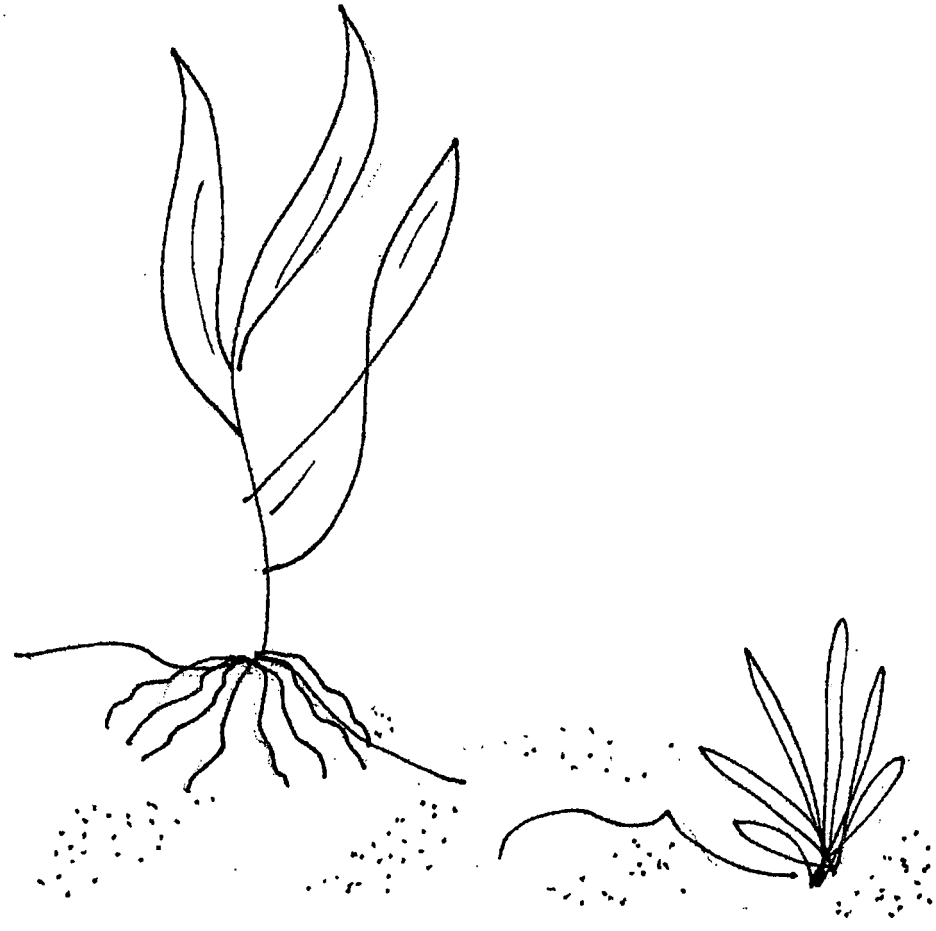
APPENDIX D

STUDENT LESSONS

Living in California's Coastal Waters

Draw picture

There is an abundance of life in California's coastal waters. There is life in tide pools, kelp forests, and on the ocean floor. Animals, plants and algae must be adapted to the place they live. Draw as many life forms as you can in their appropriate habitats.



Octopus	Jellyfish	Stingray	Turbot
Gobi	Crab	Lobster	Mussel
Sea cucumber	Kelp Bass	Fan Coral	Sea Urchin
Sheephead	Seastar	Anemone	Scorpion Fish

Extra Credit: Draw 5 more things that live in the ocean.

Ocean Diorama

Description:

This is an art project reviewing students acquired knowledge about the ocean's habitat.

Objective:

Assess students, knowledge about ocean habitat.

Time:

½ to ¾ hour

Material:

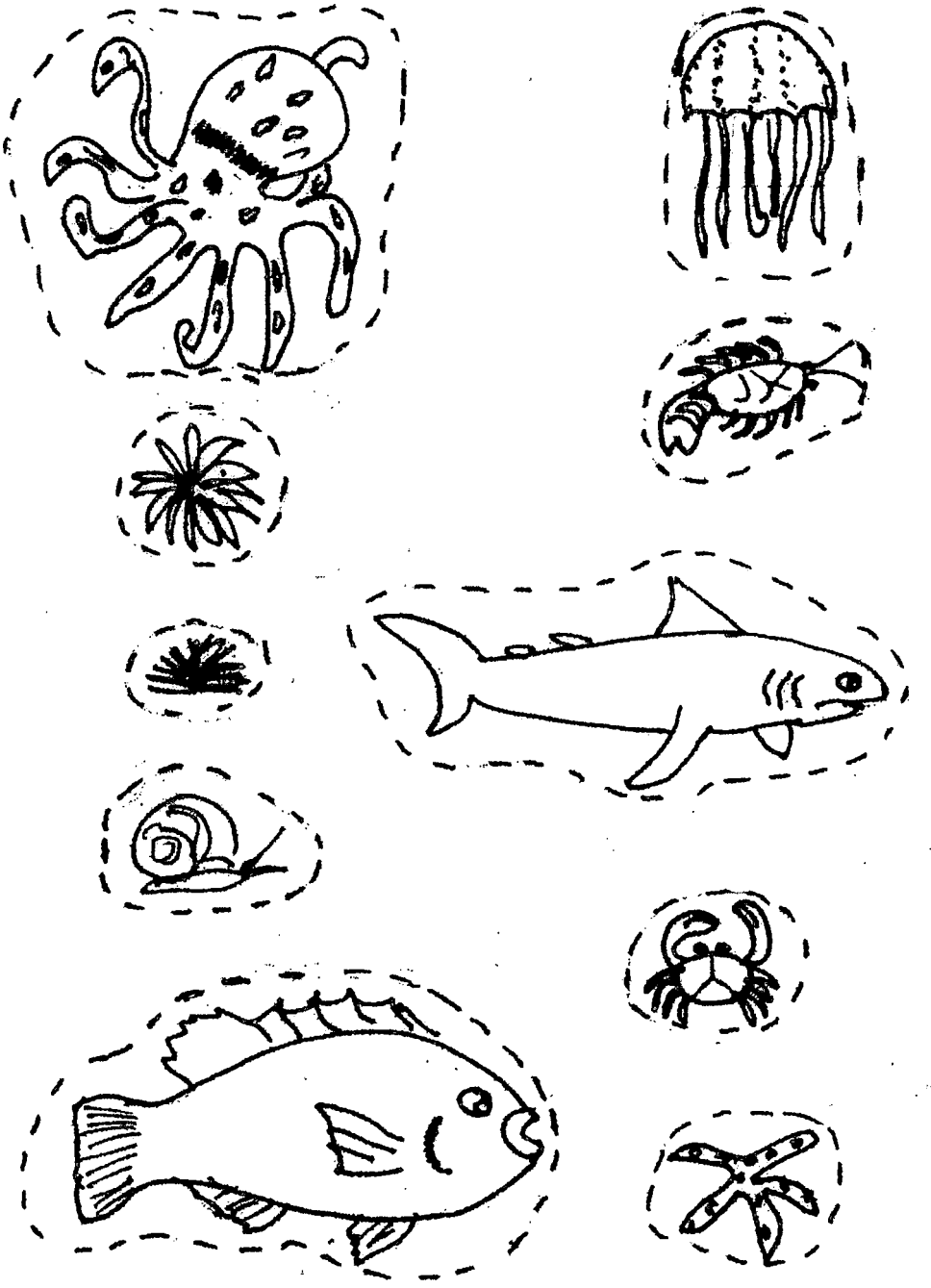
Crayons, colored pencils or markers
Glue
White paper plates
Scissors
Handouts with ocean drawings
Plastic wrap
Silver spray glitter

Procedure:

Color the ocean sand, kelp, and rocks on the inside of a paper plate. Color and cut out ocean pictures. Glue pictures on the plate. Lightly spray with glitter. Cover plate with clear plastic wrap. Encourage discussion and questions during activity.

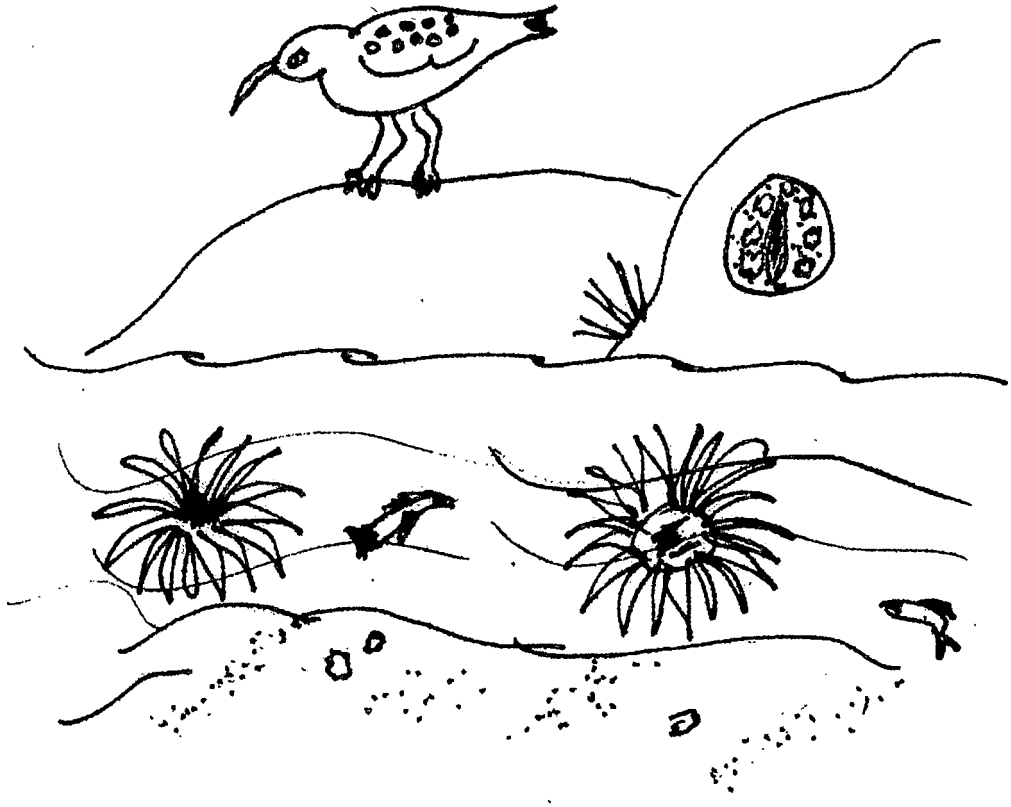
Ocean Diorama

Ocean Pictures

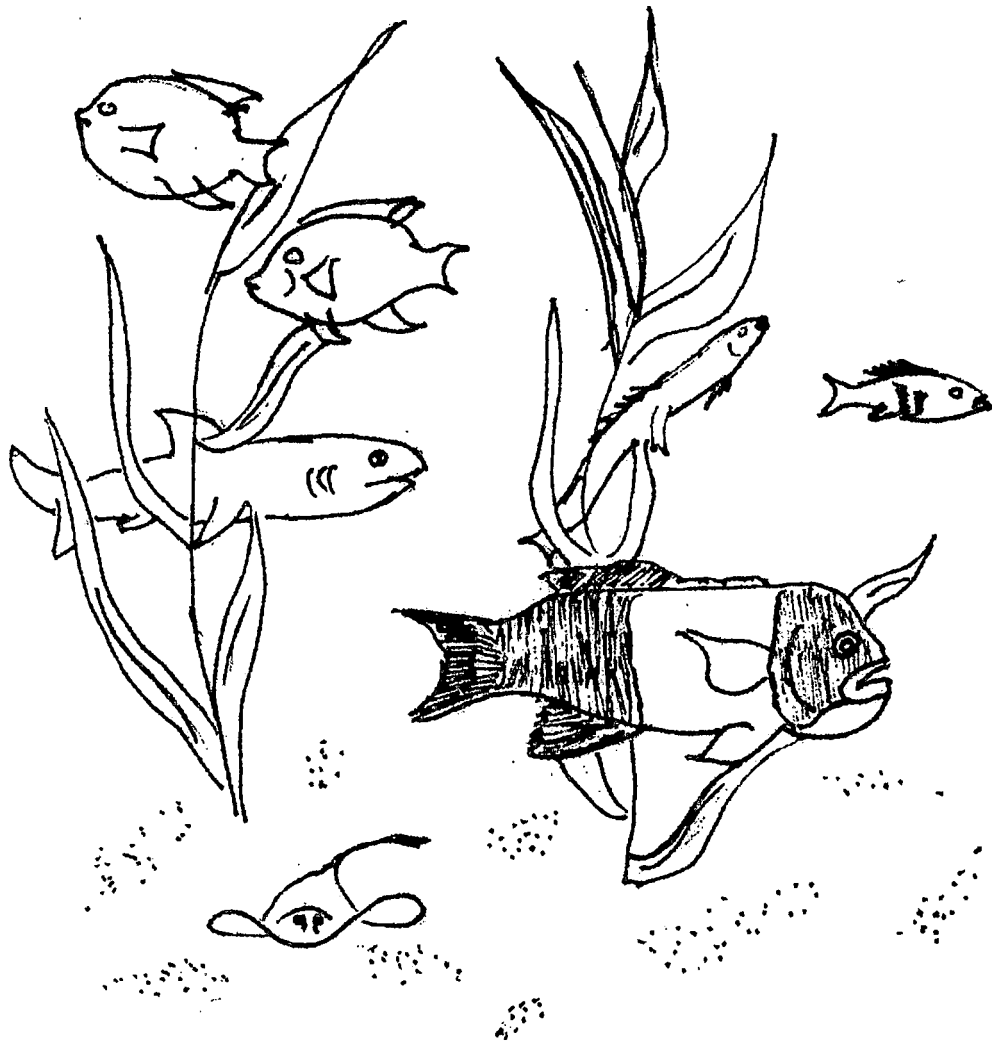


Life and Survival in Ocean Habitats
Book 1

A variety of plants and animals inhabit tide pools. Many of the animals, such as mussels and barnacles, clump together for protection from the sun so their bodies do not dry before the returning tide. Others, such as hermit crabs and crabs, seek shelter under damp moss, grass, or hide under rocks.



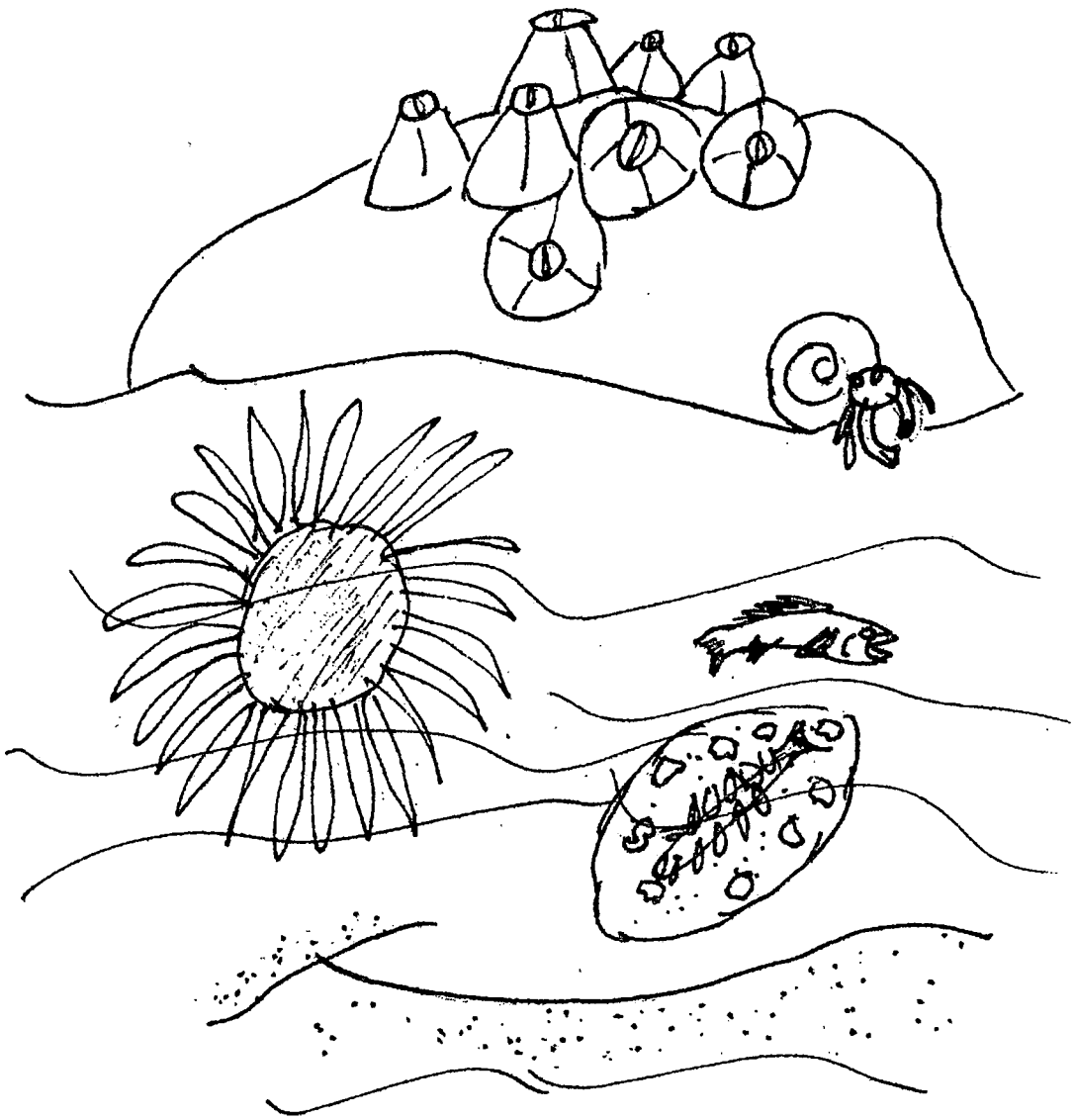
Some of the most appealing tide pool residents are the sea anemones. Though sea anemones look like plants they are in fact animals. Sea anemones may cover themselves with bits of shells to protect them from the sun's drying rays.



Just off shore, in rocky habitats, you can find forests of kelp. Within these kelp forests you may see brightly colored fish like the garibaldi or sheephead. If you look closer you may see the illusive giant kelp fish. The giant kelp fish resembles the leaves on kelp effectively blending into its surroundings for protection. Many other fish inhabit the kelp forest such as the rock wrasse, rays and sharks.

You may need to search in cracks and crevices of rocks to find some of the unique bottom dwelling species, such as the California spiny lobster, octopus, eel and turbot. As the turbot glides to settle on the bottom, particles of sand or gravel swish up then settle back over the fish's body partially covering its outline. This and its spotty coloration, make an effective camouflage hiding the turbot from predators and prey.

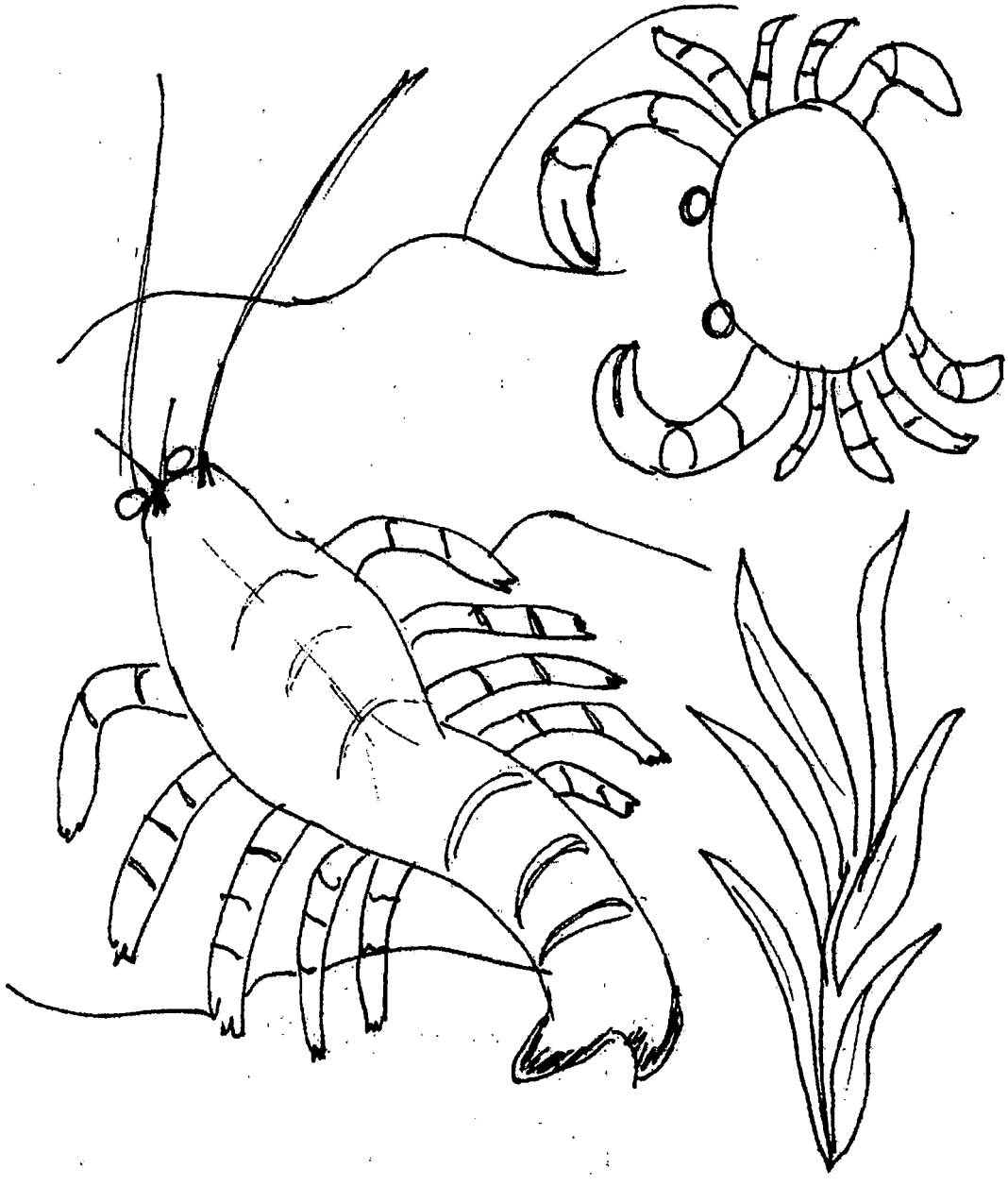
Ocean Inhabitants, What They Eat
Book 2



Many tide pool residents feed on algae that grow on rocks. Some species, such as barnacles, filter feed fine particles that each new tide brings in. Sea anemones use their tentacles to sting and capture prey. Hermit crabs are typically scavengers.

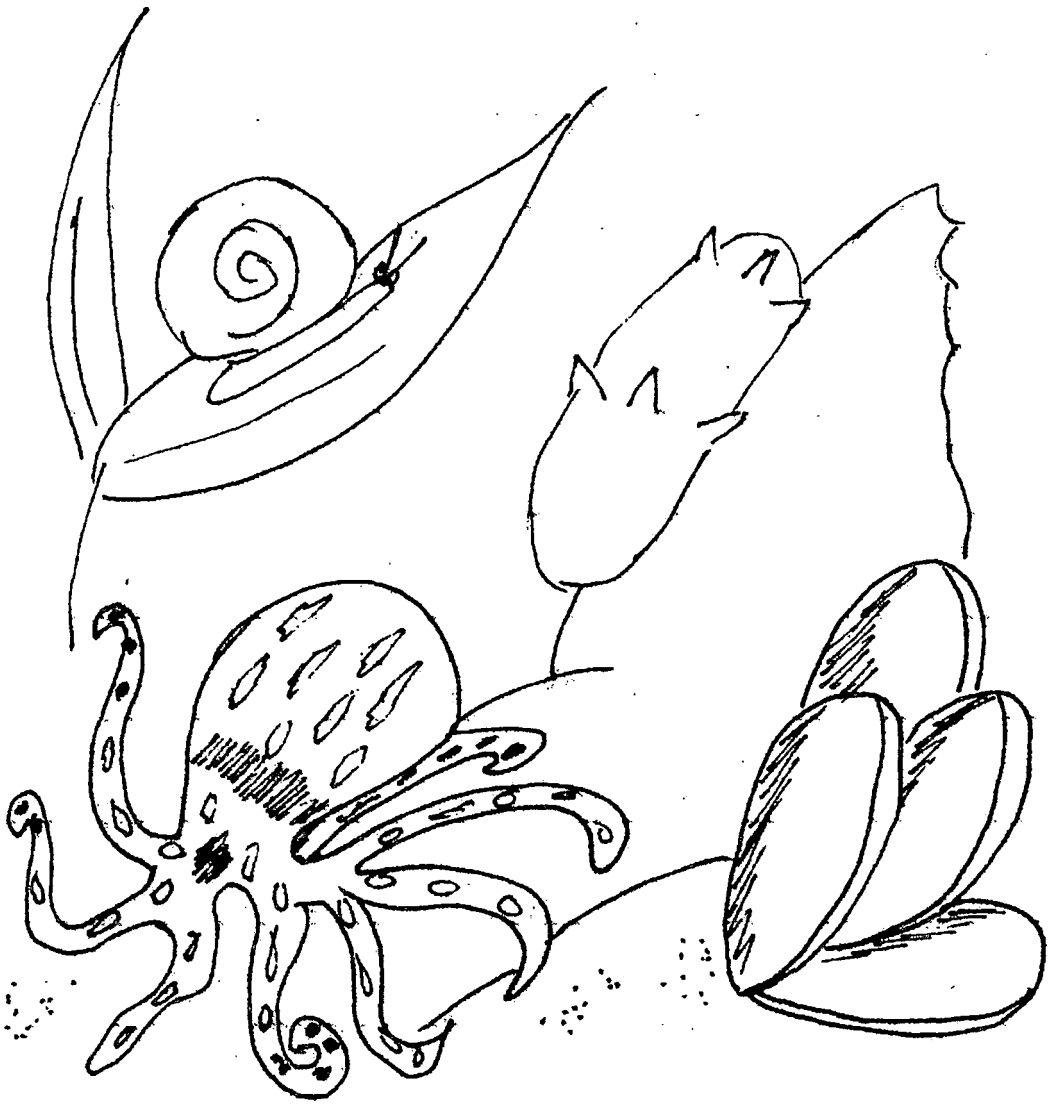
Some fish that inhabit kelp forests feed on plants, kelp and other algae. Some are predators and eat other fish. Others, such as sheephead, may feed on sea urchins, snails or sea stars.

Bottom dwellers have a variety of diets. Sea urchins feed on algae, such as kelp, or small organic debris. Sea stars usually feed on slow moving animals, barnacles, mussels and other shellfish. Predatory snails may eat mussels, while other types of snails feed on algae. Sea urchins and snails feed on kelp. This, in turn, keeps the kelp forest from growing rampantly. However, if there is an overpopulation of kelp eating animals the kelp forest can be destroyed.

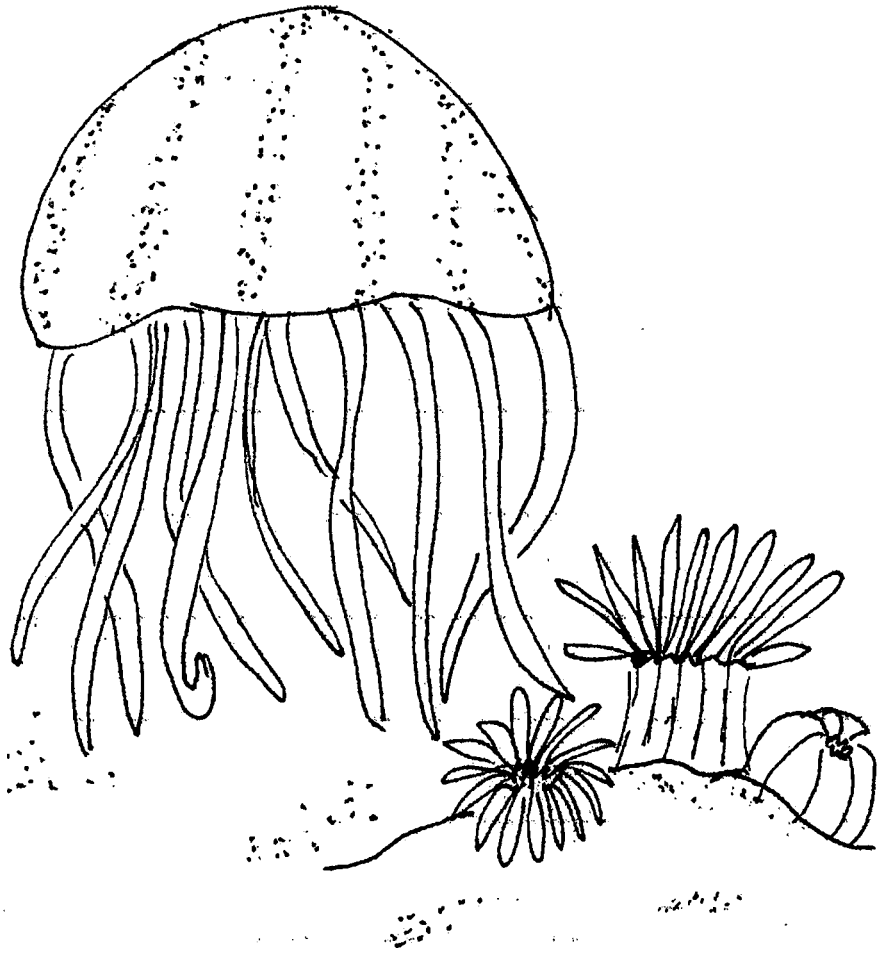


Lobsters are generally scavengers. However, they may also catch live prey. Crabs too are scavengers, although they may eat mussels, organic matter, seaweed, fish or shellfish.

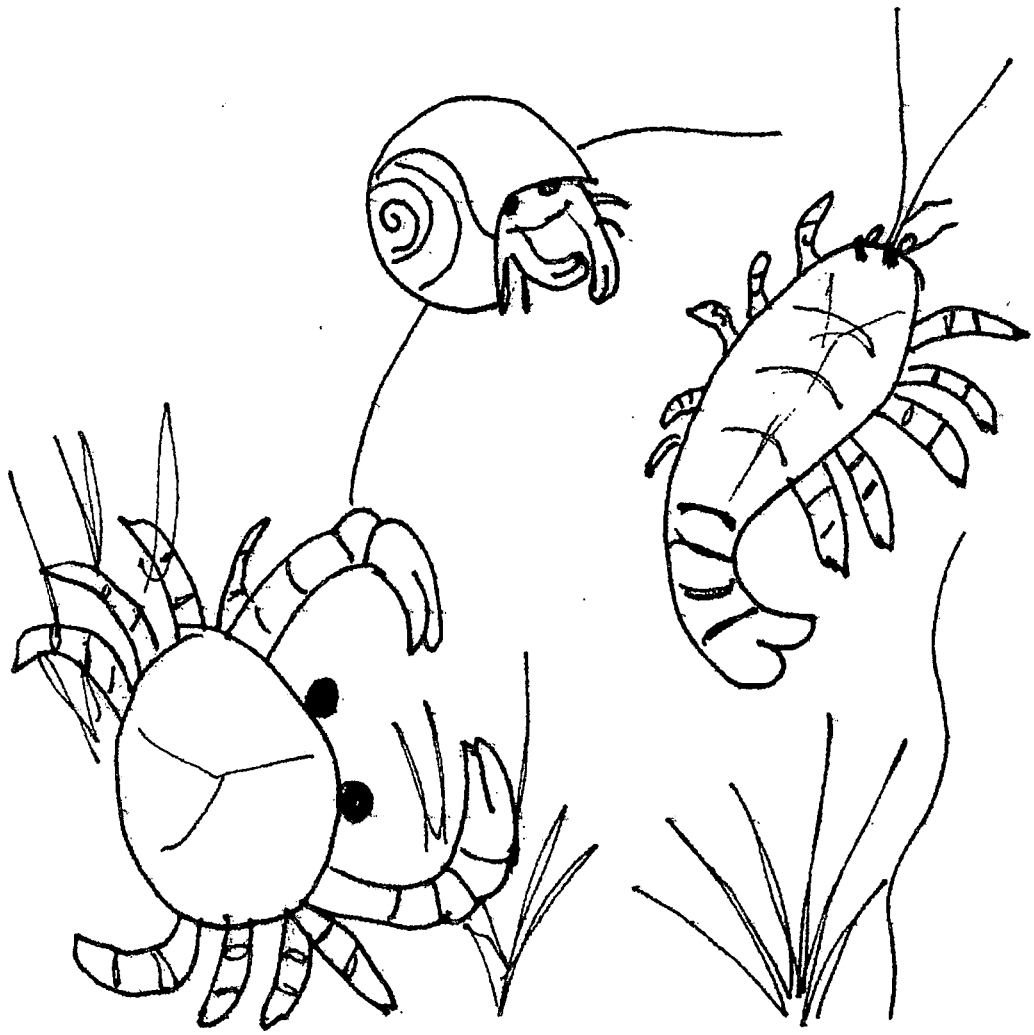
Ocean Inhabitants, What Are They?
Book 3



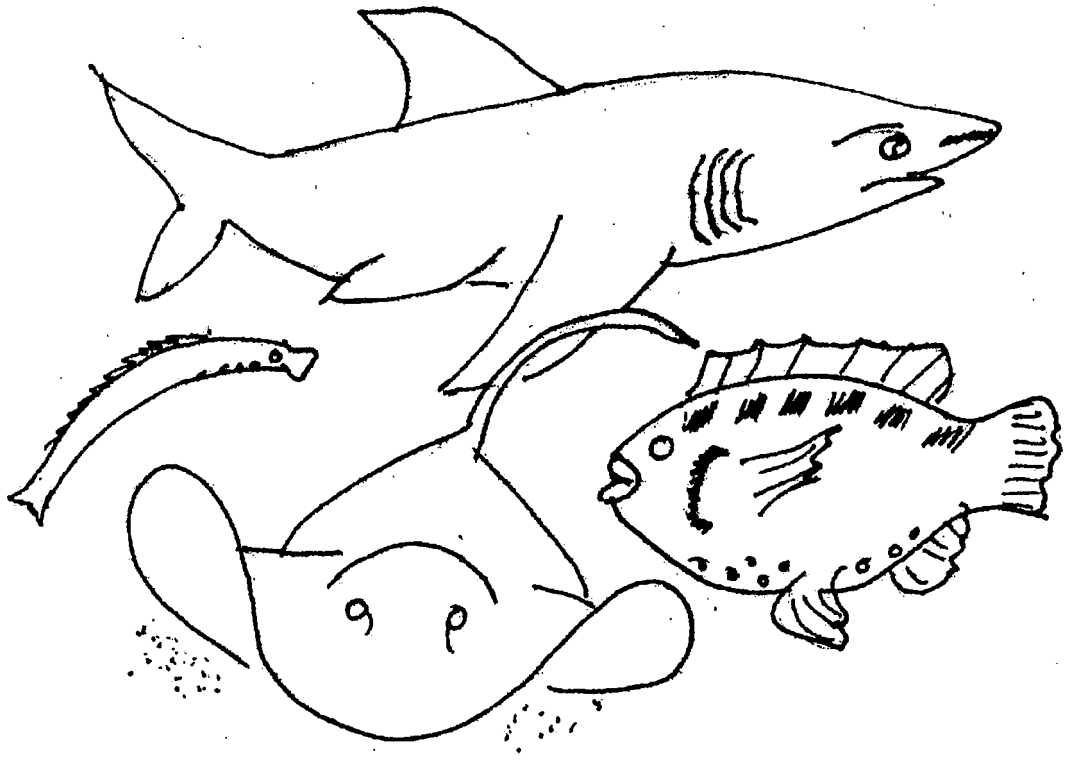
The phylum mollusca includes gastropods, bivalves and cephalopods. All are types of molluscs. Most molluscs have a muscular foot and a hard protective shell. Snails, sea slugs, limpets and abalone are gastropods. Oysters, mussels and clams are bivalves. Cephalopods include octopuses and squids. Their shells are reduced or non-existent.



The phylum cnidaria includes jellyfishes, corals, and sea anemones. Most cnidarians are carnivores. They capture prey by discharging stinging structures on their tentacles. The tentacles bring the captured food to the mouth. Due to the toxins that are released by their sting, cnidarians are some of the most dangerous ocean animals.

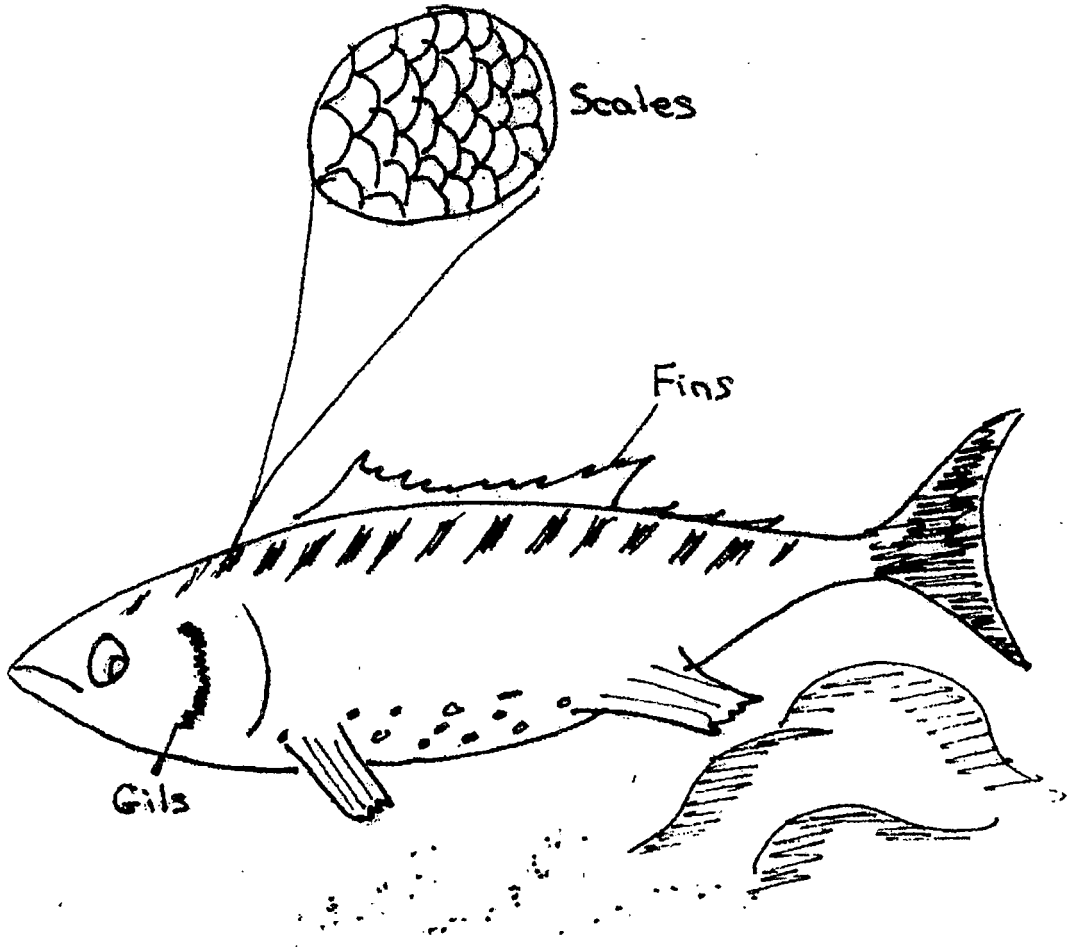


The phylum arthropoda has the characteristic of having an exoskeleton, a segmented body, and jointed appendages. In order to grow arthropods must shed their exoskeleton, or molt. Crustaceans are the most abundant arthropod in the marine environment. Crustaceans include lobsters, crabs, hermit crabs, krill and shrimp.

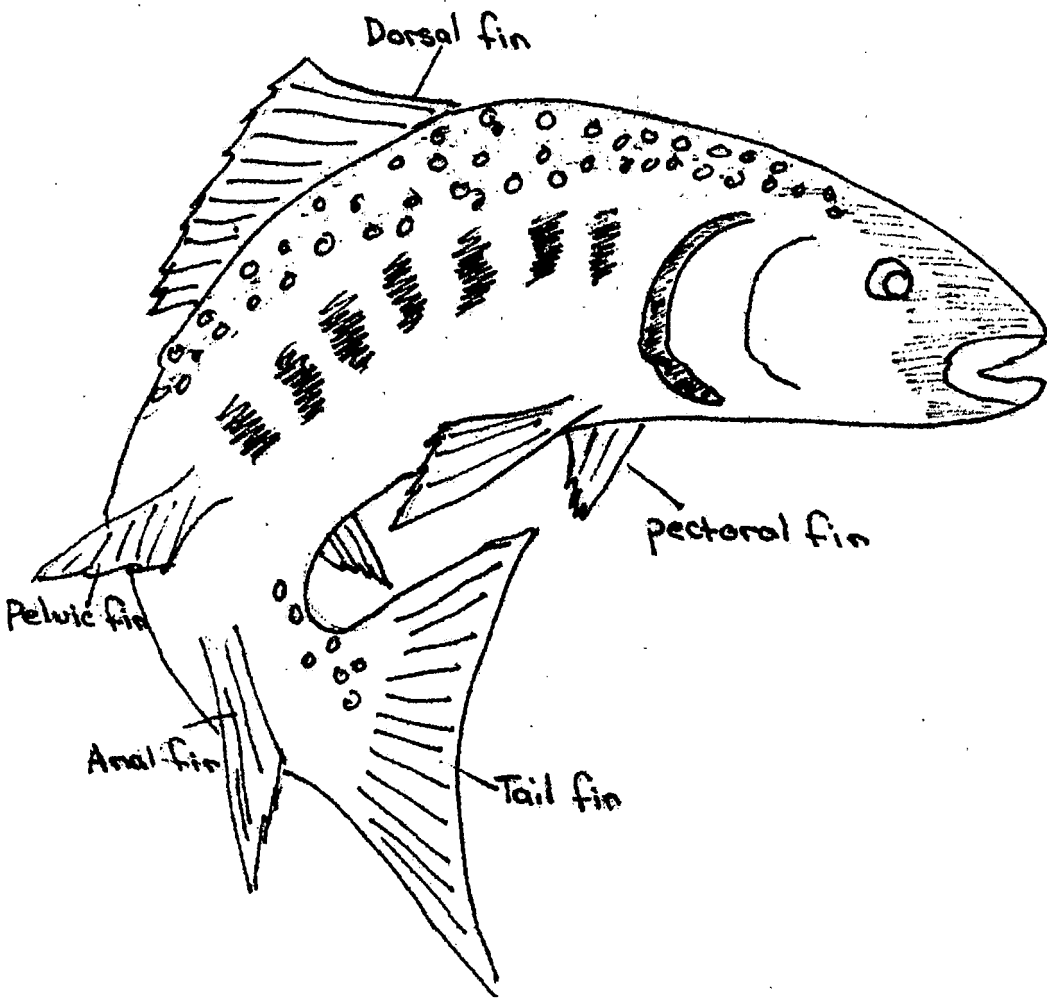


The phylum chordata includes vertebrates and invertebrates. Over half the earth's vertebrates species are fish. About 60% of them live in the marine environment. There are three major groups of fishes: the jawless fishes, cartilaginous fishes, and bony fishes. Jawless fish feed by suction and include slime eels and lampreys. The cartilaginous fish have a skeleton made of cartilage and includes sharks, rays and skates. Bony fish have skeleton made, at least partially, of bone. This is the largest group of fish and includes about 96% of all fish.

How Do Fish Move?
Book 4

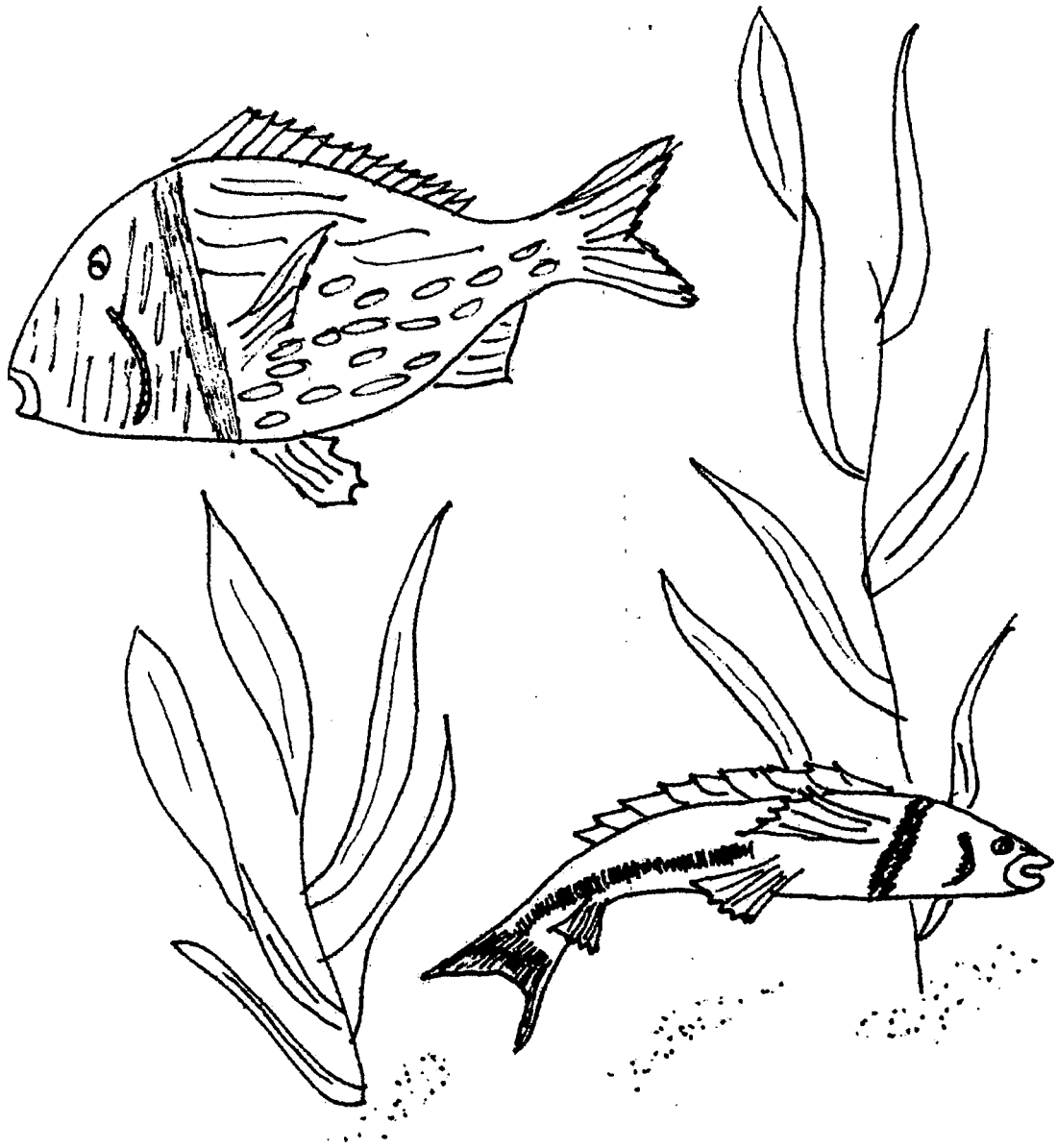


Fish are uniquely designed for underwater life. Though they are a varied group, some generalizations can be made. Fish are vertebrates, live in water, have gills, fins, and scales. Their basic shape is streamlined for swimming smoothly through the water.



Most fish have paired fins. The paired fins, one on each side of the body, include the pectoral fins and pelvic fins. The unpaired fins are the dorsal fin, the anal fin, and the tail.

How Do Fish Move?
Page 3

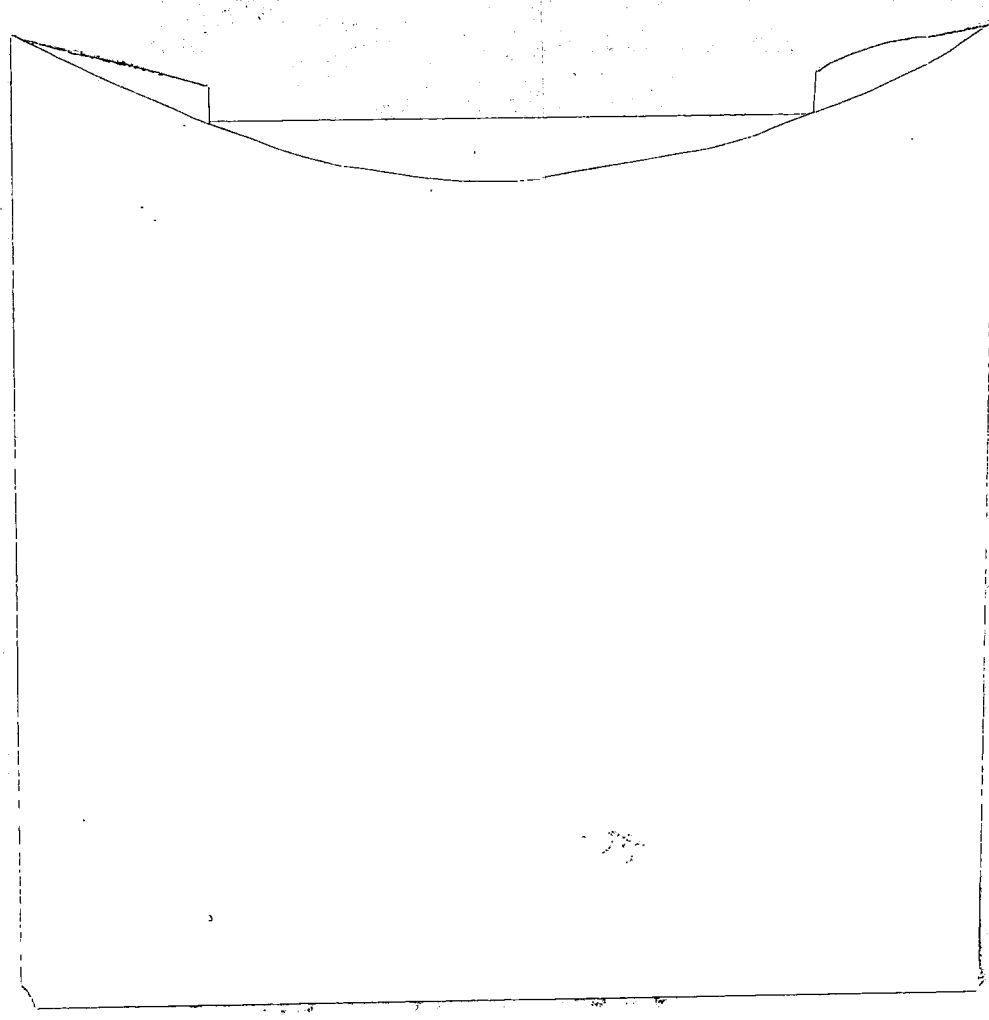


The pectoral and pelvic fins are used to help with steering and maneuvering. The dorsal and anal fins are used for stability. The tail is used for forward movement. Fins are not only used to swim forward and turn, but also to stop and hold still. Most fishes move forward with their tail.

Fish swim by a series of "S" shaped curves, which ripple along the entire length of the body. To begin, the fish makes a small sideways movement of the head. Each "S" curve is produced by muscle contractions on either side of the backbone. As this movement ripples along the body it becomes bigger and more pronounced. The tail moves much further side to side than the head. The tail and body move the surrounding water sideways and backwards propelling the fish forward.

APPENDIX E

DVD OCEAN DOCUMENTARY



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