CHAPTER III

MARINE ECOLOGY

Previous chapters have introduced physical and chemical properties of the ocean environment–salinity, temperature, buoyancy, density, and tidal effect, to name a few. These physical and chemical properties are delicately and intricately interwoven to produce a wonderful variety of places in the ocean that are capable of supporting life. As you will see in this chapter, each organism has its own particular place in the ocean in which it obtains food, finds shelter, protects itself from potential predators, and successfully reproduces, thereby ensuring continuation of the species.

Because there are so many unique areas in the ocean that are capable of supporting life, amazingly diverse assemblages of marine organisms have become uniquely adapted to life in these areas. These organisms have done so by developing some of the most bizarre shapes, feeding structures, means of locomotion, defense mechanisms, and methods of reproduction known to humans. In this chapter you will be introduced to several unique places in the ocean, and to the strange and wonderful organisms living there.

A. Environment

A population is a group of organisms of the same species living in a defined area. A community is all of the organisms, or all of the species, found inhabiting a defined area or environment. An environment is, in turn, defined as the external surroundings and conditions that affect the growth and development of an organism. The marine environment includes the properties of ocean water such as clarity, buoyancy, concentrations of nutrients, salinity, temperature, and density. Currents, waves, tides, availability of food, interactions among individuals, populations, and communities, and the type of ocean floor are also components of the marine environment. The environments in a defined area, as well as the communities found living in that area, are called an ecosystem.

The environment on land changes daily. One day may be sunny and pleasantly warm while the next day may be cold and rainy. Seasonal and interannual changes also occur. Marine environments are continuously changing too. For example, the salinity changes slightly from day to day, depending on the rate of evaporation and/or the amount of precipitation. The amount of cloud cover affects the depth to which sunlight penetrates. The amount of sunlight affects the rate at which tiny plants photosynthesize, produce oxygen (O_2), and grow. The amount of sunlight, and hence, the rate at which photosynthesis occurs in the ocean, ultimately affects the availability of food to other organisms. Additionally, currents may vary in their speed and position in the water column and tides on any one day may be extremely high or low, depending on the alignment of the earth, moon, and sun. A calm ocean surface may become a frightening sea within a very short time, depending on the speed, duration, and fetch of the wind.

Although the marine environment is always changing, the ocean is a very delicately balanced and fragile environment. We are continually altering this delicate balance by the activities of our daily lives. Pollution from stormwater runoff, heavy use of pesticides, automobile exhausts, coastal development, marine debris, oil spills, and over-utilization of ocean resources are all factors that tip the ocean environment's delicate balance to the "minus" side. Only recently have we recognized that our actions have affected the ocean environment–and in many cases, this effect has been negative. We have yet to determine and understand the full impact of our actions. We will discuss how we have altered the delicate balance of the ocean environment in more detail in Chapter 6.

B. Habitat

A habitat is the physical place where an organism or group of organisms lives. Oceanic habitats can be divided into two categories:

- pelagic habitats, and
- benthic habitats.

These habitats can each be further subdivided into smaller categories based on distance from shore, tidal exposure, and clarity, much like the zones of the ocean defined in Chapter 1.

1. Pelagic Habitats

The pelagic habitat is the water column that extends from the surface to the bottom. Pelagic habitats located far from coastlines do not receive large amounts of nutrients from coastal areas and rivers and their productivity is, therefore, not as high as that of coastal habitats. Nevertheless, pelagic habitats everywhere support a wonderful diversity of organisms. Organisms living in pelagic habitats can be classified into one of two categories: plankton or nekton.

Planktonic organisms are those organisms found at or near the ocean's surface. The word plankton is derived form the Greek word, planktos, which means "to wander." Many planktonic organisms are transparent, which makes it easier for these organisms to survive in the brightly-lit surface waters. Perhaps this explains why plankton, as an entire group of organisms, was only recently discovered in the early 1800s, even though scientists had been using the microscope for over 100 years. Additionally, many planktonic organisms have bizarre structures that help them remain afloat at the surface. These structures include extremely elongate antennae and spines that retard the rate of sinking in the water.

Organisms living in planktonic habitats are generally divided into two groups: phytoplankton and zooplankton. Phytoplankton are tiny plants that float, or wander, at the mercy of currents. Zooplankton are tiny animals that cannot significantly alter their position in the water column and thus, like phytoplankton, they are primarily transported by ocean currents.

Phytoplankton are primarily unicellular plants such as diatoms and dinoflagellates. Phytoplankton are sources of food for many marine organisms. Many organisms are thus dependent on phytoplankton for survival. Phytoplankton photosynthesize and, in doing so, produce over 80% of the oxygen on earth. All life in the ocean is, therefore, dependent on phytoplankton through a complex linking of feeding levels. We will discuss how phytoplankton form the basis of the food web in Section D.

Phytoplankton will, in many cases, give a body of water its characteristic color. Areas of the ocean may appear various shades of blue-green to green from the chlorophyll and other pigments present in the phytoplankton living there. "Red tides" get their name from dinoflagellates that may impart a reddish color to the water whenever there is a bloom, or rapid increase in abundance, of these organisms. In the absence of large amounts of phytoplankton, as is often the case in tropical seas, the water is crystal clear.

Zooplankton consist primarily of single-celled protozoans (Fig. 3-1) and the multicellular

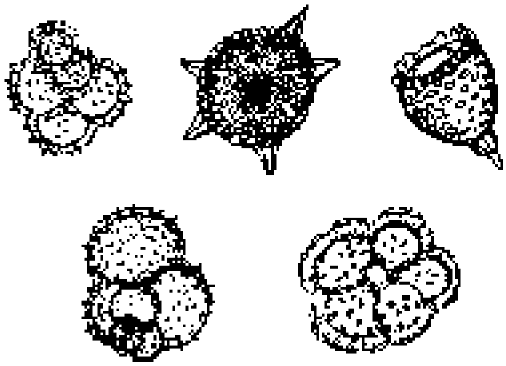

Figure 3-1.
Plankton forms of Foraminifera and Radiolaria. These single-celled zooplankton are <0.5 mm in size and live in pelagic habitats.

larval stages of many marine organisms. A larval stage is the form an organism takes when it hatches from the egg. Shrimp, crabs, and fish, as well as fish eggs, copepods, and arrow worms all have planktonic larval stages and are major components of zooplankton. Although most members of zooplankton have some means of movement, they cannot significantly alter their horizontal position at the surface, and thus, are transported with the currents. Many members of the zooplankton are transitory, as they only exist as zooplankton for a short period of their lives. These organisms are called meroplankton. As they continue to grow and metamorphose , or change in form, they develop into juvenile stages. As juveniles they settle out of the plankton and take up existence in the water column or on the ocean floor. They then continue their transformation into the adult stage. Still other forms of zooplankton spend their entire lives in the planktonic environment, such as copepods and euphausids, and make up a group of organisms known as holoplankton.

There are other planktonic marine animals and plants that, although they may be relatively large, cannot significantly alter their physical place in the water column and remain at the mercy of surface currents. Examples of these organisms are the Portuguese Man-o-War, comb jellies, jellyfish, and Sargassum, the floating brown alga found off the Southeastern U.S. coast (Fig. 2-6). Even the giant ocean sunfish, *Mola mola*, which can reach 3 meters (10 feet) in length, was once considered a planktonic organism, as it spends much of its time splashing around at the surface.

Nektonic organisms are generally fast, strong swimmers. Bullet-shaped bodies enable them to move rapidly with the least amount of resistance to the water which surrounds them. Tunas, some sharks, dolphins, swordfish, and mackerel are very rapid swimmers. Squid jet-propel themselves through the pelagic habitat. Additionally, many nektonic organisms have developed unique ways by which they remain suspended in the water column. Swim bladders and oily livers enable some fishes to remain afloat.

Some nektonic organisms migrate with seasonal changes. Some sharks off the Southeastern U.S. coast, for example, move farther south during winter and move back along the coast during the warmer months. Swordfish and tuna that occur off the Southeastern U.S. have extensive migratory routes, spending large amounts of time in the Gulf of Mexico. Whales also have extensive migration patterns, moving in the Pacific from Alaska to Hawaii and in the Atlantic from the Caribbean Sea to Canada.

2. Benthic Habitats

Organisms living in benthic habitats are divided into two categories: 1) epifaunal organisms, which are animals living on the surface of the ocean floor; and 2) infaunal organisms, which are organisms living within the sediment of the ocean floor (Fig. 3-2).

Figure 3-2. *Live bottom community with infaunal/epifaunal organisims.*

Epifaunal organisms can be mobile, either crawling on or swimming just above the ocean floor, or they may be sessile, or permanently attached to the ocean floor. Sea stars, crabs, whelks, and octopuses are examples of epifaunal marine organisms. Clams and worms are examples of infaunal organisms.

Organisms that live most of their lives attached to the ocean floor need a hard substrate to which they can affix themselves. Off the Southeastern U.S. coast, rocky outcrops that are exposed on a sandy bottom provide the perfect hard substrate to which marine organisms can attach. These sessile marine plants, called epibenthic flora, are limited in their distribution to those areas of the ocean floor that are shallow enough to receive sunlight from above. Although we primarily think of marine plants when discussing benthic marine organisms, there are many animals that attach to the ocean floor during certain life cycle stages. These animals include sponges, soft and hard corals, and the asexual stage of jellyfish. Although some organisms swim above the ocean floor, they spend most of their time at the bottom and are defined as benthic organisms. These organisms include many bottom fishes, such as snappers, flounders, groupers, and porgies.

As mentioned above, infaunal organisms are those organisms that live within the ocean sediments, such as worms and clams. Infaunal organisms generally live in tubes or burrows that they create. These tubes can be quite elaborate, constructed of different types and sizes of sand grains and shell material. Some of these tube-building organisms use mucous to “cement” grains of sand together. Burrows also may be very extensive, with multiple chambers branching off from the main burrow.

Discovery of hydrothermal vents located in the benthic zone of the deep ocean has revealed that quite bizarre organisms have adapted to survival in these abyssal areas where no light exists. Giant red tube worms, some of which reach a height of 2 meters (8 feet) thrive in these heated deep benthic habitats. Blind shrimp also occur near these hydrothermal vents. Bacteria carry out chemosynthesis, a process that uses hydrogen sulfide (H_2S) released from hydrothermal vents as a source of energy for the production of food. Bacteria use hydrothermal gases to produce their food much like plants use energy from the sun to produce food through photosynthesis. Bacteria are thus, the primary producers in areas where hydrothermal vents occur. They serve as a food source for other organisms in these areas of the deep sea.

Hydrothermal vents were first discovered in 1977 in the Pacific Ocean near the Galapagos Islands. Scientists now believe that these vents are located in all of the major ocean basins along the mid-oceanic ridges, where they form large geyser fields. These geyser fields have recently been discovered in the Atlantic Ocean, along the Mid-Atlantic Ridge approximately 2,896 kilometers (1,800 miles) off the coast of Miami at depths of 4 kilometers (2.5 miles).

Benthic organisms that cannot actively catch or make their own food are dependent on plant or animal material that is produced in the surface waters and falls to the sea floor. This decaying organic fall-out rains down through the water column to the ocean floor and supplies an abundance of food to many benthic marine organisms. Many of these benthic organisms are filter feeders, filtering their food out of the water column with specialized body parts. Some benthic organisms living in the deep ocean have developed interesting features that allow them to feed, grow, locate mates, and successfully reproduce in total darkness.

There are a variety of other marine habitats found along coastlines. These include rocky shorelines and their associated tidal pools, eel grass and turtle grass habitats, mangroves, and coral reefs. Habitats found along the Southeastern U.S. coast include estuaries, bays, sounds, salt marshes, beaches, dunes, maritime forests, inlets, tidal creeks, fouling communities on piers and docks, rocky intertidal habitats, grass beds, and mangroves.

C. Niche

A niche is defined as all of the physical and chemical factors affecting an organism's habitat, as well as the role that the organism plays in its habitat. The diversity and abundance of marine niches is always changing, as organisms continue to adapt and evolve to very specialized niches to ensure survival of their species. Those that cannot adapt vacate the niche. Subsequently, their space in the niche which will be taken up by a better adapted and thus, more successful, organism. This process by which one organism excludes another from a niche is known as competitive exclusion, as two organisms cannot successfully occupy the same niche.

Examine for a moment the niche of a larval fish. This niche consists of the temperature, salinity, amount of sunlight and nutrients, and the speed of the current in which the larval fish is being transported, as well as many other physical and chemical factors that come into play to affect its planktonic habitat. The larval fish's niche also consists of its prey as well as the potential predators that may feed upon the larval fish itself. The role that the larval fish plays in the plankton includes the amount of food it eats, the by-products of its metabolism, the physical space that it requires, the amount of oxygen it uses, and the impact it may have on the abundance and diversity of a certain copepod upon which it feeds. All of these complex interactions among physical and biological factors, as well as the role that the larval fish plays in its habitat, makes up its niche.

D. Trophic Level

Marine organisms are dependent upon their environment for food. Marine plants make their own food through photosynthesis. Photosynthesis is the process by which plants use energy from the sun to transform carbon dioxide (CO_2), water (H_2O), and nutrients, such as nitrate (NO_3^-) and phosphate (PO_4^{2-}), into a form of food and energy (i.e., sugars) that they can use. They also produce oxygen (O_2) as a by-product of photosynthesis. The basic equation for photosynthesis follows :

In the presence of sunlight and chlorophyll:

$CO_2 + H_2O = \text{Sugar} + O_2$

Plants are called producers, since they produce their own food. Areas of the ocean that have large amounts of phytoplankton are referred to as areas of high primary productivity, or areas where the rate of photosynthesis is relatively high. Although other marine plants, such as algae, contribute to an area's primary productivity, phytoplankton carry out most of the primary productivity that takes place in the ocean.

Other marine animals cannot make their own food and are dependent upon plants and/or other animals as a food source. These animals are called consumers. Consumers must either actively catch their prey or scavenge on the dead, decaying plant and animal matter as it slowly drifts down and comes to rest on the ocean floor. Primary consumers, such as zooplankton, feed directly upon phytoplankton. Secondary consumers are those organisms that feed on zooplankton, such as the filter-feeding soft corals and bivalves. Organisms that feed on filter-feeders, as well as other organisms in the ocean, are also secondary consumers. Organisms at the top "level" of feeding, or those organisms upon which few, if any, other organisms prey, are called top-level consumers. They are the ultimate predators.

Consumers can be further divided into three categories: herbivores, carnivores, and detritivores. Consumers feeding only on plant material are called herbivores. Consumers feeding only on animal material are called carnivores.

As plants and animals die, they are broken down by bacteria into a material known as detritus. Bacteria and other organisms that feed on dead and decaying plant and animal matter are called detritivores.

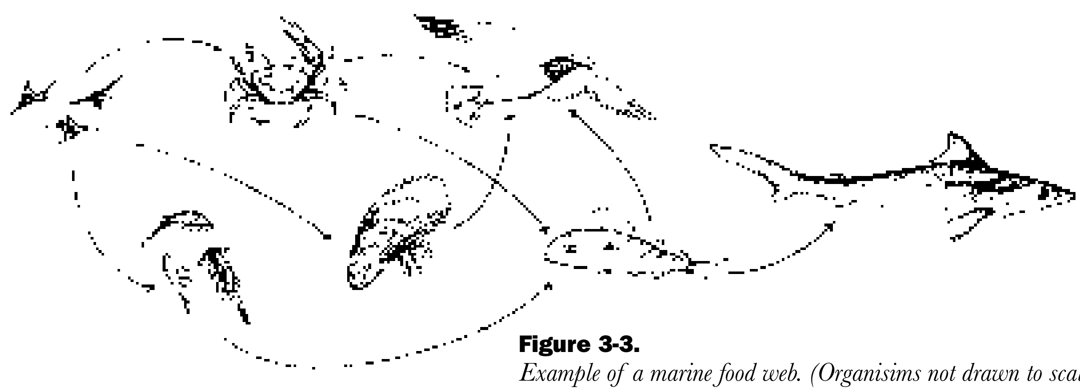

Figure 3-3.
Example of a marine food web. (Organisims not drawn to scale).

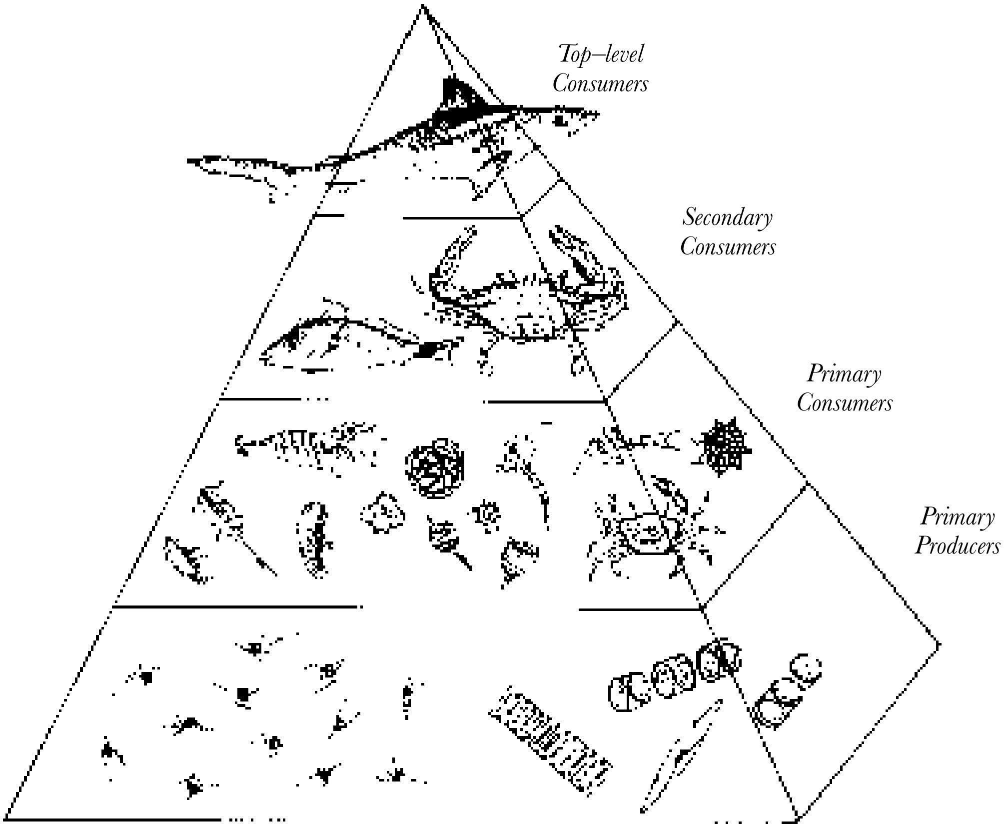

Figure 3-4.
Example of a marine trophic pyramid. (Organisms not drawn to scale).

As consumers eat producers, energy is obtained from the food as it passes up the different "levels" of feeding, or trophic levels. This transfer of food and energy from one level to another is defined as a food web (Fig. 3-3). The intricate feeding relationships that exist among marine producers, primary consumers, secondary consumers, and detritivores make up the marine food web, sometimes referred to as a "food chain." The word "chain" indicates a straight linking of trophic levels where, for example a diatom is eaten by a copepod that is then eaten by a small fish. Most marine food webs overlap in a complicated network, hence the more appropriate term, "food web."

Bacteria aid in the decomposition of top level predators and recycle nutrients that once again become available to phytoplankton. Perhaps a more appropriate term to describe transfer of food and energy among the different trophic levels would be "trophic cycle."

Trophic levels are often depicted as pyramids, with producers located at the bottom of the pyramid and high level consumers located at the top (Fig. 3-4). The amount of food energy passed up the pyramid decreases with each higher level. There are, therefore, considerably more producers at the bottom of the pyramid than there are consumers, since more food energy is available at the lower levels. Alternatively, since higher trophic levels are limited in the number of organisms supported, fewer consumers are located at the top of the pyramid. The pyramid structure is thus used to illustrate trophic levels because it represents the relative number of organisms that can be supported at each level.

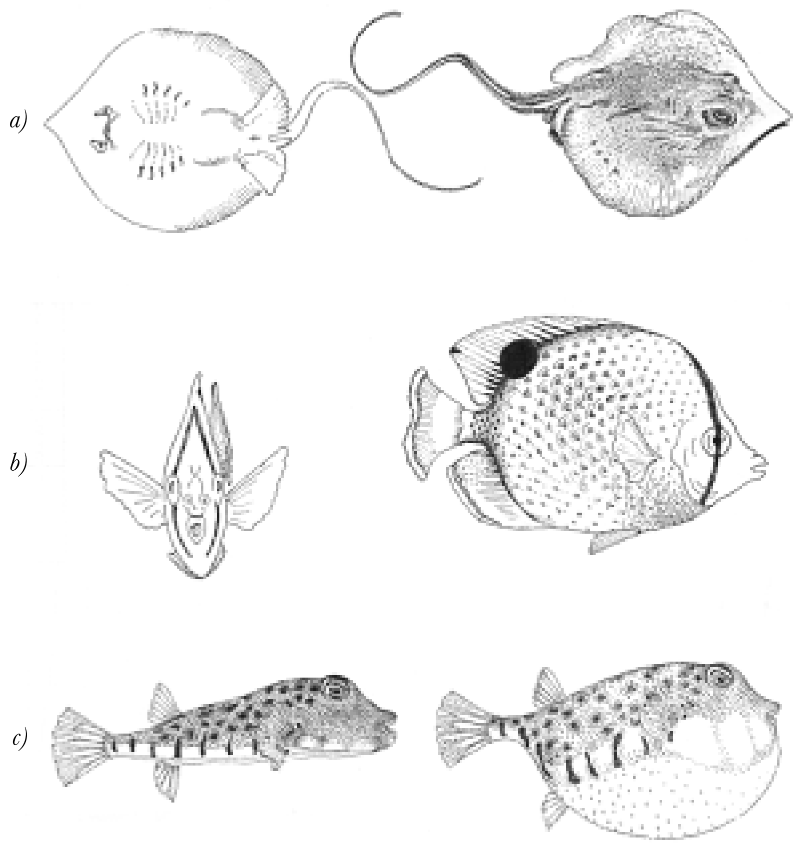

Figure 3-5.
Examples of different fish body forms among a) a stingray; b) a butterfly fish; and c) a puffer fish.

E. Adaptations

An adaptation is a genetically-controlled characteristic that aids an organism in surviving and reproducing in its environment. All marine organisms have special structures, or adaptations, that enable them to survive in their environments. For example, fishes have many body shapes and sizes and move in many different ways. Some are rapid swimmers, while others walk, burrow, leap, or even fly for short distances.

Because of the wide diversity of habitats in the ocean, we see amazing degrees of adaptations in body form and function among marine organisms. A wide range in body forms and swimming behaviors can be seen among fishes when one compares body shapes of puffers, butterfly fishes, stingrays (Fig. 3-5), eels, and flounders. Sizes, shapes, and locations of mouth parts of marine organisms are also adaptations that have enabled these organisms to expand into a wide diversity of oceanic habitats. In fact, the location, shape, and size of mouth parts can tell you quite a bit about where a particular organism lives and what it eats.

Some fishes have air bladders, or swim bladders, that function like internal balloons that can either "blow up" or reduce in size to enable the fish to move correspondingly up and down in its pelagic habitat. Some sharks have very large, oily livers that help them remain suspended in the water. Still other organisms, like the whales, dolphins, and porpoises, have large amounts of body fat, or blubber, that help prevent them from sinking.

Many pelagic organisms have developed fusiform bodies–torpedo-shaped and streamlined–that enable them to move rapidly with the least amount of resistance to the water which surrounds them. Tunas, some sharks, dolphins, swordfish, and mackerel are all very rapid swimmers. Squids can jet-propel their streamlined bodies through their pelagic habitats.

Marine organisms have developed very interesting ways to protect themselves from predators. Some pelagic organisms have developed special coloration, known as counter-shading, that affords them protection from potential predators. Counter-shading is discussed in more detail in Section 4-d. Other marine organisms have specialized body coverings, such as spines or poisonous mucous, that help them avoid predators. The puffer fish can rapidly change from a small round shape to a very large round ball to avoid being eaten by predators. Squids and octopuses produce ink to startle a predator as they escape to safer waters. Protective coloration, spines, the ability to change body shape, and ink production are just a few of the ways that these organisms successfully protect themselves.

We also see a fantastic diversity in modes of reproduction, degrees of parental care, and development of young. Some marine organisms simply release eggs and sperm into the water, also known as spawning, without exhibiting any means of parental care. Others lay eggs in nests and may even carry their eggs and young in their mouths. Still other marine organisms exhibit internal fertilization and bear their young alive.

There is also a wide range of developmental stages seen among the young of many marine organisms. Most marine animals that hatch from eggs go through various developmental stages, or changes in body form, called metamorphosis, as discussed in Section B-1. Most early metamorphic stages of marine animals not only look amazingly different from the adults, but they may also look quite bizarre. The young of the marine animals that bear live young have offspring that look very similar to the adults.

Let's look at how different marine animals have adapted to their environments in their own ways. To do this, we'll look specifically at how four different animals–a sea star, a clam, a crab, and a fish–have developed unique adaptations in body form, feeding, locomotion, protection, reproduction, development of young, and parental care.

1. The Sea Star

a. Body Form

The sea star is a benthic organism that crawls on the ocean floor (Fig. 3-6). The body of the sea star exhibits pentamerous symmetry in the form of a flattened, central disk from which

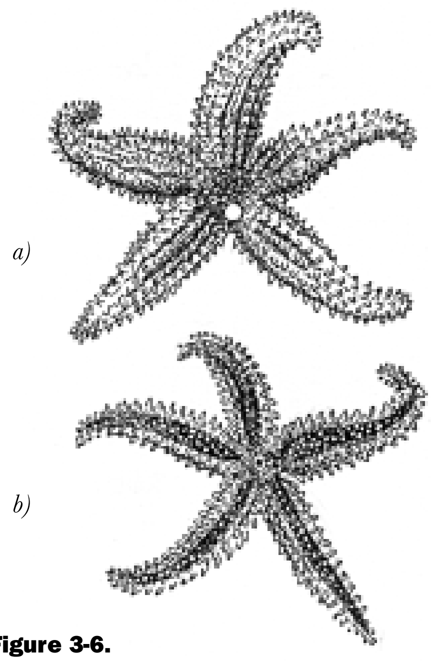

Figure 3-6.
Sea stars: a) dorsal view; b) ventral view.

five or more arms radiate. The sea star's arms are used in feeding and locomotion. One eye spot is located at the tip of each arm. These eye spots can only detect light and dark and do not function as true "eyes." The sea star's mouth is located in the center of its undersurface, or ventral surface.

b. Locomotion

A single large pore, called the madreporite is located on the top or dorsal surface of the central disk and allows ocean water to enter a specialized system that aids the sea star in locomotion and obtaining its food. This system is called the water vascular system. Water is drawn in through the madreporite and is channeled through the body via a series of canals. As water is pumped into the water vascular system, the tube feet are extended outward. As water moves back into channels from the tube feet, each tube foot is retracted, creating a suction against the ocean floor. The sea star pulls itself along the ocean floor by continually extending and contracting its hundreds of tiny tube feet. The water vascular system is also used in feeding, as it creates the suction that pulls the shells of bivalves apart.

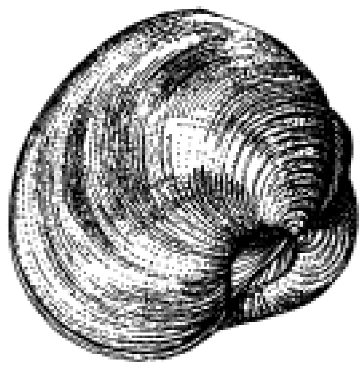

Figure 3-7.
Clam, showing hinge.

c. Feeding

The sea star feeds primarily on clams, scallops, and mussels and has a most unusual way of obtaining its food. The sea star crawls on top of a clam, with its mouth positioned above the point where the shell opens, just opposite the clam's hinge. Special suction cup feet, or tube feet, line its ventral surface. The sea star uses its tube feet to exert a continuous force that eventually pulls the two shells of the clam apart. When the clam's muscles tire from the constant force exerted by the sea star's tube feet, its shell opens. The sea star extends its stomach out of its mouth and into the partially opened shell of the clam. It then digests the clam while the clam remains in its own shell!

d. Protection

Although the sea star does not have very obvious ways to protect itself from predators, its exoskeleton, or "outside skeleton", is firm and covered with tiny spines, which afford some degree of protection to the sea star.

e. Reproduction, Development of Young, and Parental Care

The sea star releases either eggs or sperm into the surrounding waters. Fertilization occurs in the water and sea star larvae go through various metamorphic stages as they float in the plankton. A few species of sea stars brood, or incubate, their young. The young sea stars, whether planktonic or brooded, transform into small adult sea stars and take residence on the ocean floor.

2. The Clam

a. Body Form

The clam is an infaunal organism, as it burrows in soft mud or sand. The clam has a soft body that is attached to two shells, or valves, hence the name bivalve (Fig. 3-7). The valves are hinged together, and two very strong muscles enable the clam to open and close its shell. Clams have incurrent and excurrent siphons that protrude to the surface of the sediment. The incurrent siphon brings water into the clam's shell. The water, once filtered, exits the clam's body through the excurrent siphon.

b. Locomotion

The clam has a large muscular foot inside of its shell. The clam enlarges its foot by engorging it with blood. The muscular foot extends out of the animal's shell and "anchors" itself in the mud or sand. As the foot remains anchored, the clam pulls itself toward its anchored foot. This action is repeated over and over as the clam moves through the sediment.

c. Feeding

The clam is a filter feeder. It has gills that are not only used for respiration, but also function in feeding. As water is filtered in through the incurrent siphon, it passes over the clam's gills. Food particles present in the water are selected out of the water by the clam's gills and are then passed to the clam's mouth.

d. Protection

The clam's hard shell protects its soft body from most predators. As we have seen, the clam's hard shell is no contest for the sea star or for that matter, other animals that feed on whole clams, such as large fishes.

e. Reproduction, Development of Young, and Parental Care

The female and male clams release, or spawn, either eggs or sperm into the water column. Fertilization occurs and the small clam larva goes through various metamorphic stages as it floats in the plankton. The clam larva then develops a very thin shell and looks very much like a small clam. It then settles to the bottom of the ocean. Clams do not exhibit parental care.

3. The Crab

a. Body Form

Crabs are epifaunal benthic organisms that walk along the bottom of the ocean (Fig. 3-8). Many crabs live in burrows. The crab has a hard exoskeleton underneath which its soft body parts lie. Its body is somewhat flattened with five paired legs located on either side of the crab's body. Each of the paired legs functions in a different way and may actually look quite different from other pairs of legs, enabling the crab to walk, swim, or obtain its food. Some crabs walk, while others primarily swim. A crab's mouth is located in front of its face and is surrounded by many paired feeding structures. Two stalked eyes rest on either side of paired antennae. Most crabs must molt, or shed their exoskeleton, to grow.

b. Locomotion

Crabs have specialized legs for walking and/or swimming. A crab's walking legs are usually pointed, and narrow. Its swimming legs are flattened, paddle-shaped structures that gracefully propel the crab through the water. The scientific name of the blue crab that commonly occurs off the Mid-Atlantic and Southeastern U.S. coast is *Callinectes sapidus*, which is Latin for "beautiful swimmer." Most species of crabs, however, are not capable of swimming.

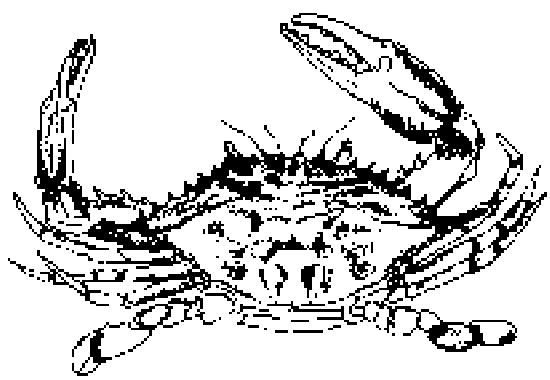

Figure 3-8. *A blue crab, dorsal view.*

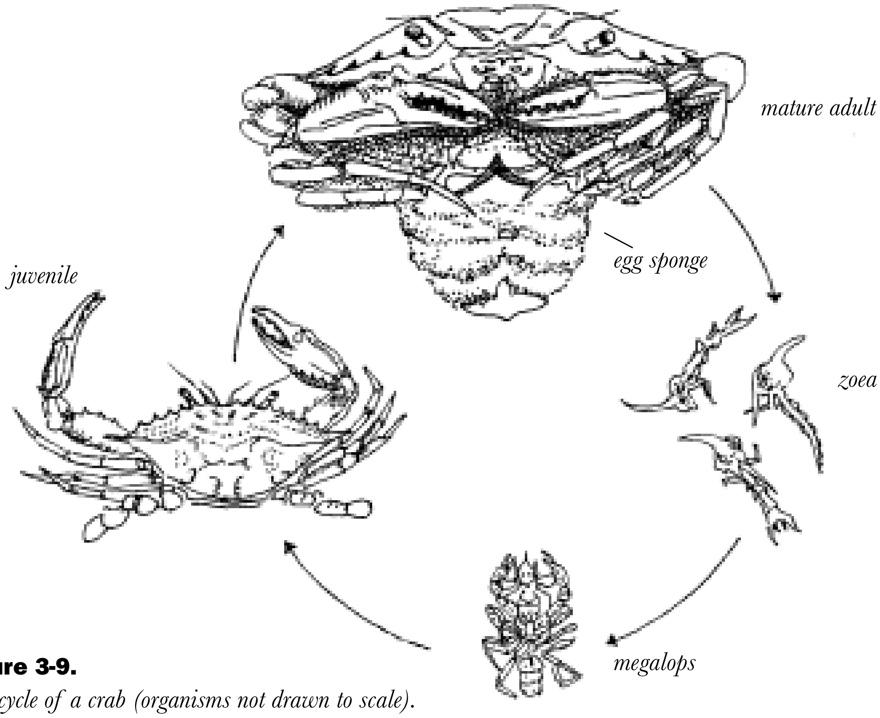

Figure 3-9.
Life cycle of a crab (organisms not drawn to scale).

c. Feeding

A crab uses its first pair of legs, which are modified as pincers, to capture food items or scavenge upon dead matter. Food is torn or picked apart and brought to the mouth where it is macerated by the many paired feeding structures that surround the crab's mouth. The next time you eat boiled crabs for dinner, check out the many paired feeding structures. You will certainly be amazed!

d. Protection

A crab's most anterior paired legs are large pincers that help keep predators at bay. Additionally, there may be sharp spines along the top and/or sides of the crab's body. A crab's hard exoskeleton also protects it from potential predators. Some crabs exhibit protective coloration and blend in with their surroundings. The decorator crab will actually decorate its body with sponges or seaweed to camouflage itself. Hermit crabs use abandoned shells as a means of protection.

e. Reproduction, Development of Young, and Parental Care

The female crab produces eggs. The male crab produces packets of sperm which are transferred to the female during mating, which in many species, only occurs when the female molts, or sheds, its shell (soft shell). A fertilized egg mass, or sponge as it is sometimes called, forms on the ventral surface of the female (Fig. 3-9). The eggs break off and small crab larvae (zoea) hatch from within and go through a variety of metamorphic stages, including the megalops stage, as they float in their planktonic habitat. As the crab larvae settle out of the plankton, looking like very small adult crabs, they begin to take up existence in the adult habitat. Crabs do not exhibit parental care.

4. The Fish

a. Body Form

Fishes are by far the most numerous of all vertebrates, with an estimated 20,000 species known to mankind. Fishes have adapted to a wide variety of habitats, occurring in both freshwater and saltwater environments. They range in distribution from shallow lagoons to the deep ocean, and from near-freezing Arctic waters to the warmth of tropical seas.

Because fishes have been so successful in a wide range of habitats, they also exhibit a wide range of body shapes (Fig. 3-10). Some are fusiform, which enables them to move through the water at rapid speeds. Others, like flounders and stingrays, live on the ocean floor and have "flattened" body shapes. Eels live in crevices among rocks and corals and have body shapes that allow them to twist and wriggle into small spaces.

b. Locomotion

A variety of fin types and shapes and therefore, modes of swimming, can be found among the fishes. Some fishes are very rapid swimmers, like the tunas, mackerels, and sharks. Sea horses, on the other hand, are very weak swimmers that live among coral and seaweed. Their tails are adapted to help them hold onto structures like soft corals and seaweed in swift currents. Other fishes have developed fins that serve as support structures, enabling them to "walk" along the ocean floor. Still others have developed fins that function as wings, much like the wings of a bird. These winged fish leap out of the water and briefly "fly" just above the ocean's surface. Anyone who has been out to the Gulf Stream has surely seen flying fish leaping out of the water as they gracefully glide a short distance along the ocean's surface.

There are many different types of fins on fishes. These include dorsal, pectoral, pelvic, anal, and caudal fins. Some fishes have very small modified fins called finlets.

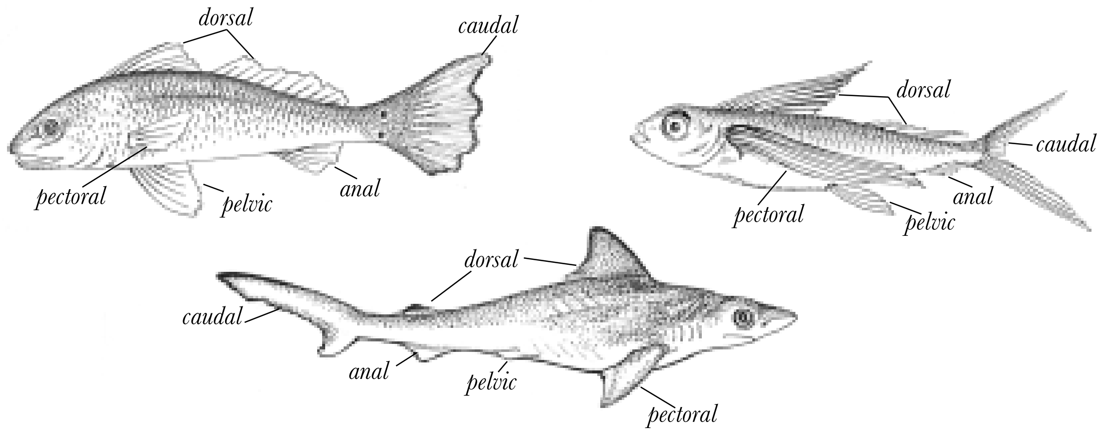

Figure 3-10.
Variety of fish forms. Fin types are indicated on each.

c. Feeding

Fishes that feed near the surface may have mouths that are directed upward, while those fishes feeding along the bottom may have mouths that are directed downward with barbels that are used as feelers covered with taste buds on their "chins." Catfish are good examples of bottom feeders. These barbels help them locate food. Fishes that spend most of their lives in the water column have mouths that are located in the center of their "face." Teeth may be very sharp and well-developed, minute, or even absent in some species.

d. Protection

Many marine fishes exhibit protective coloration. Types of protective coloration may be horizontal or vertical bars or lines, that assist fishes in hiding among algae or grasses. Some fishes have dark spots that look similar to eyes located on various areas of their bodies. These "eye spots," which are nothing more than circular areas of dark pigment, serve to confuse a predator. The predator may not be able to tell in which direction its prey's head is located, and may thus, miscalculate its predatory move.

Additionally, many pelagic fishes have developed counter-shading (Fig. 3-10 a,b). Fishes that exhibit counter-shading have a dark dorsal surface and a light ventral, or underside, surface. Counter-shading enables an organism to appear lighter to a predator swimming below it. The light underside effectively blends more easily with the lighter surface waters and sky above. Alternatively, countershading enables the fish to appear darker to a potential predator swimming above it, thereby blending in with the darker waters and ocean floor below. Counter-shading is a fantastic way for an organism to be camouflaged to potential predators from above and below!

e. Reproduction, Development of Young, and Parental Care

Fishes exhibit many different modes of reproduction, development of young, and parental care. Because fishes have adapted to a wide variety of habitats, it is not surprising that one of the most fascinating aspects of the life histories of these remarkably diverse animals is their mode of reproduction. Each is interesting in its own way and it is difficult to decide which to discuss here. Some fishes release eggs and sperm and do not exhibit parental care. Others bear their young alive. And in some species, the males brood developing eggs in their mouths or in the case of male sea horses, in special pouches.

The sexes are separate in most species of fishes, with an individual maturing as a male or a female and remaining as that sex throughout its entire life. However, in some species, both male and female sex organs are present in the same individual and may actually produce eggs and sperm at the same time. This condition is referred to as simultaneous hermaphroditism. Although it is a common mode of reproduction in fishes, self-fertilization seldom occurs. Some simultaneous hermaphrodites may even spawn for a few moments as a female, displaying the behavior pattern and coloration unique to females, only to spawn several moments later as a male– displaying the coloration and behavior patterns unique to males!

Many deep sea fishes have specialized light organs that flash on and off in species-specific patterns. These "flashing lights" in many cases serve to locate mates in the dark abyss of the ocean. Nevertheless, to ensure that reproduction successfully occurs, some of the deep sea fishes are simultaneous hermaphrodites and self-fertilize, probably because of the difficulty involved in mate location in the deep sea environment.

Some fishes exhibit synchronous hermaphroditism, in which they spawn for several years as one sex, undergo sexual transition, actually "turning into" the opposite sex, and live the rest of their lives as the sex that they transformed into. Groupers and some of the sea basses are synchronous hermaphrodites and are referred to as protogynous, meaning "first female." These fishes mature first as a female, spawn for several years as a female, undergo transition, and turn into a male. Once a male, they always spawn as a male and never function as females again. In these fishes, the ovaries actually turn into testes.

Other fishes exhibit protandry, meaning "first male," and spawn first as males, undergo sexual transition, and change into females. Once they have transformed into females, they always spawn as females and never function as males again. In protandrous fishes, the testes become ovaries.

Let's look, for example, at how flounder reproduce and how their young develop. Male flounders release sperm into the water while female flounders release eggs into the water. There is no parental care, as the flounder eggs and larvae float in the plankton. Once a planktonic flounder larva hatches out of an egg, its eyes are located on either side of its head, just as in other fishes. This arrangement is beneficial since it swims upright near the surface, and it can see potential predators on either side of its body.

But something amazing begins to happen when the flounder larva begins to settle to the bottom and takes up the adult existence. As the planktonic larval flounder begins to settle to the bottom, one of its eyes migrates to join the other eye on one side of its head! Adult flounder live on their "side" on the ocean floor, with both eyes facing upward to help the flounder locate food and avoid potential predators. The larval flounder was not only able to successfully avoid being eaten while it lived in the plankton, but it can now continue to avoid being eaten as it takes up existence in the adult benthic habitat.