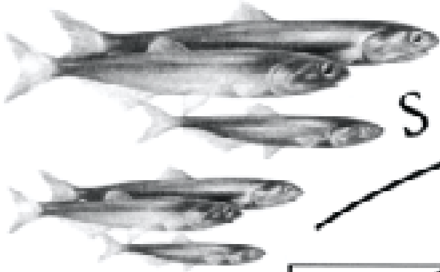
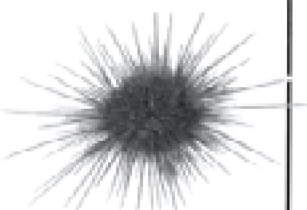
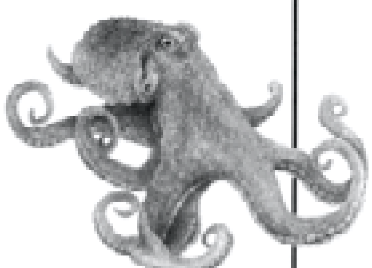


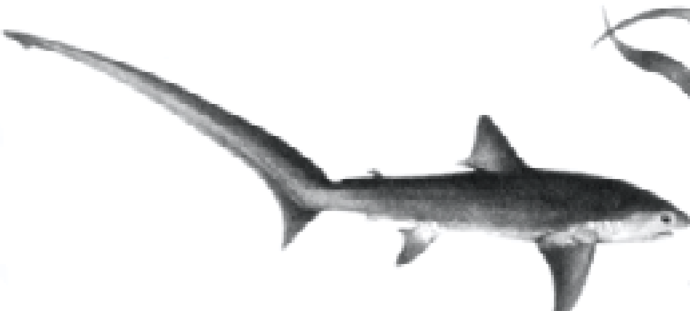
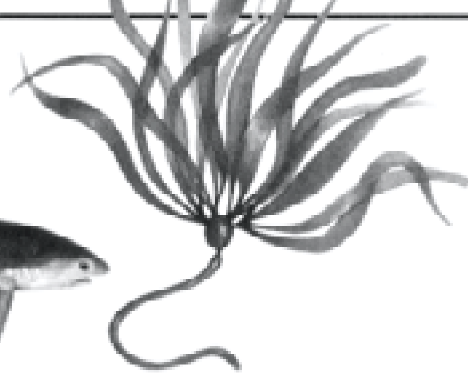

SEARCHING SEA HABITATS

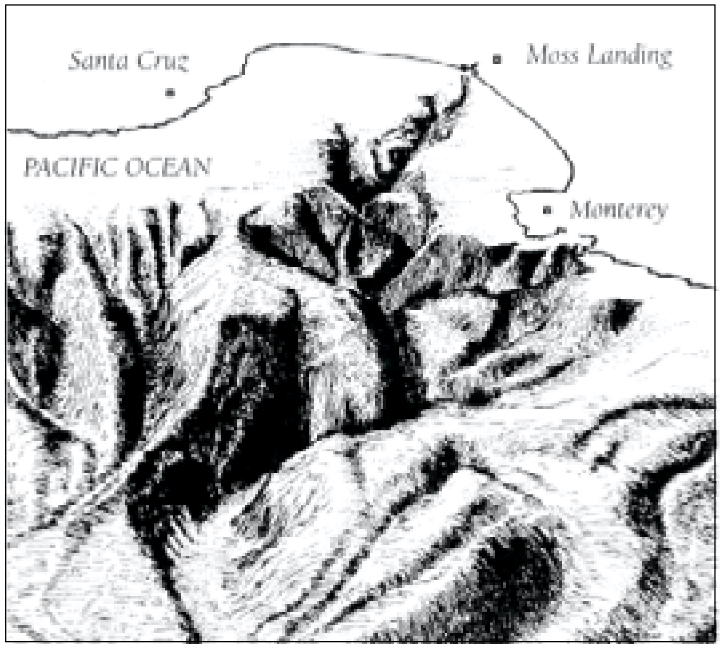



The Deep Sea Canyon





Monterey Bay submarine canyon off the California coast

What is the Deep Sea?

Cold and dark, the deep sea is the largest, but least known, region on earth. The deep-seafloor extends under water from the edge of the continental shelf, across broad plains and down into trenches seven miles deep. The deep sea covers about 60 percent of the earth's surface, but we know more about the moon than we know about the ocean depths.

Why do we know so little? It's difficult and expensive to sample miles below the surface. Oceanographers go to sea aboard huge research vessels equipped with echo-sounders, expensive deep-water dredges, traps and submersible vehicles.

Some scientists study the midwater fishes and invertebrates that swim or hover in the water, others focus on the benthic animals living on the ocean bottom. Midwater or bottom, only small areas of the ocean can be sampled at a time. Sampling lets us know about where different animals live and how they have adapted to the low temperatures, high pressure and darkness of the deep sea.

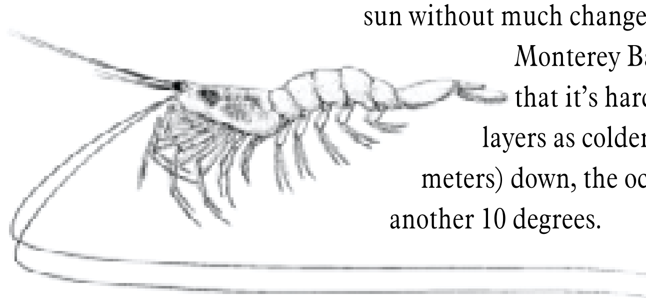
Monterey Canyon

Just offshore in Monterey Bay lies a canyon that's twice as deep and one-third the length of the Grand Canyon. The huge chasm cuts the bay nearly in half, sloping down from a depth of about 60 feet (18 meters) at Moss Landing to nearly 12,000 feet (3,656 meters) at its end 60 miles (97 kilometers) out to sea. Because of the Monterey Canyon, we have deep sea habitats close to shore.

Temperature

Try a quick dip in Monterey Bay on a sunny day. The water temperatures here range from 50° to 60° F (10° to 15° C), shocking to the hardiest of swimmers. Even on the warmest day, the bay can absorb a lot of radiant energy and hear from the sun without much change in temperature.

Monterey Bay is so cold at the surface that it's hard to imagine the deep layers as colder yet. But 300 feet (91 meters) down, the ocean has cooled down another 10 degrees.



Deep sea shrimp

Below 3,000 feet (914 meters), the water cools gradually to just above freezing and remains bitterly cold throughout the year without any seasonal change.

Pressure

Scientists who use submersible vehicles sometimes attach Styrofoam cups to the vehicle's exterior to demonstrate how pressure increases with depth in the ocean. On the surface, at an atmospheric pressure of 14.7 pounds per square inch, a Styrofoam cup stands about four inches tall. As the submersible sinks down into the ocean depths, the scientist can watch the coffee cup gradually shrink as the pressure permanently compresses the Styrofoam. Below 3,000 feet (914 meters), under pressure 100 times greater than that at the surface, the Styrofoam cup has shriveled to about one half of its original size. In the deepest ocean trenches, pressure is a crushing 1,000 times surface atmospheric pressure.

Pressure probably limits where many ocean animals can survive. Fishes with slow adjusting gas bladders would explode if they migrated upward into reduced pressure. Changes in pressure may also affect deep sea animals by speeding up or slowing down their metabolism.

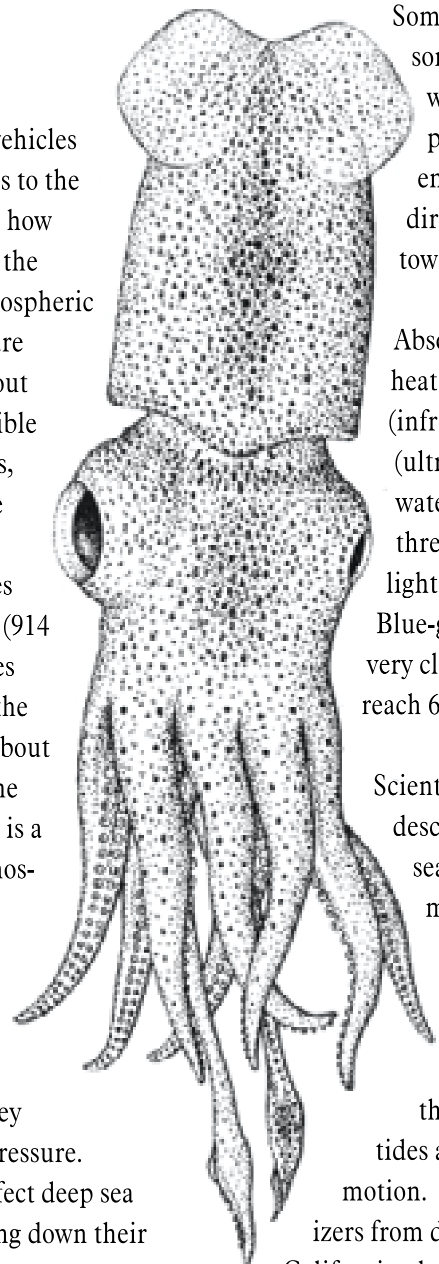
Light

For all the sunlight pouring down on the ocean's surface, none reaches the deep ocean bottom. Some light reflects off the surface; some is scattered or absorbed in sea water. Tiny bits of soil or other particles in sea water scatter light energy, changing its downward direction and sending light back toward the surface or off at an angle.

Absorption converts light energy into heat. The longest wavelengths of light (infrared) and the shortest wavelengths (ultraviolet) disappear in shallow sea water: they're absorbed in the first three feet of water. Red and purple light vanish 30 feet (9 meters) down. Blue-green light penetrates deepest; in very clear water, blue-green light may reach 600 feet (183 meters) deep.

Scientists use light penetration to describe different habitats in the open sea: the upper sunlit zone, the middle twilight zone and the deepest zone of darkness.

The photic or sunlit zone is the most active layer of the ocean. In this shallow region, storm waves, tides and currents keep the water in motion. Upwelling mixes in natural fertilizers from deeper waters. In central California, the photic zone can reach 300 feet



Deep sea squid

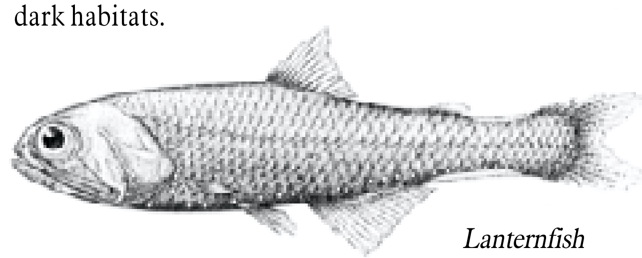
(91 meters) down. These waters are rich with life microscopic plants called phytoplankton grow in this well-lit region, using light energy for photosynthesis. Planktonic animals like copepods, arrowworms and larval fishes are also abundant here, feeding on the plants or on the plant-eaters.

Below the sunlit region is a twilight zone of faint light. This midwater zone extends from about 300 feet to 3,500 feet (1,066 meters) below the surface. Many fishes like the bristlemouths found in the twilight zone are migrators that swim up each night to feed in the richer photic waters above and return to the depths each day.

The deepest zones never see the light of day. In the darkness below 3,500 feet (1,066 meters), the waters are cold and rich in nutrients, but without light, there is no plant production. Instead, the deepest organisms eat other deep sea animals or depend on other food raining down from shallower waters.

Adaptations in Deep Sea Animals

Look at all the seaweeds, invertebrates and fishes crowded together on our rocky shores. Compared to these complex communities in shallow water, deep sea animals are few and far between, forming patches of life in the seasonless depths. Most deep sea animals just don't look or act like their shallow-water cousins. The unusual body shapes and colors and behavior of deep sea animals may seem strange to us, but these adaptations suit them for survival in their deep dark habitats.



Lanternfish

Camouflage

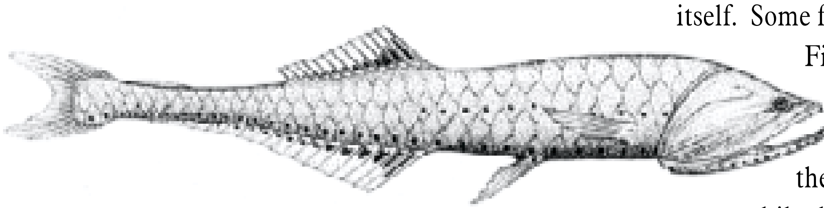
In the darkness of the deep sea, an animal's body color can camouflage it or attract attention. Transparent midwater invertebrates like arrowworms seem invisible in the dim ocean twilight. Midwater fishes like the hatchetfish have silvery skin that reflects light. In the deeper dark habitats, fishes like gulper eels have black skin to help them hide in the darkness, while red shrimps and purple jellies appear black in the absence of red light.

Bioluminescence

Bioluminescence, the production of light by living animals, is a common adaptation in deep sea fishes and invertebrates. Some animals grow luminescent bacteria in special body pockets: others produce their own light in body organs called photophores. In the darkness of the deep sea, animals can use light to inform, confuse or attract other deep sea animals.

Siphonophore

Some animals, like deep sea jellies and squid, use bioluminescence to escape danger. To distract predatory fishes, these escape artists release a bioluminescence substance and then swim away to safety in the darkness. Biological lights, like the luminous "bait" on the top fin of the anglerfish, can also help lure prey. Photophores arranged in specific patterns help fishes like lanternfishes recognize potential mates. The lights may also work like taillights on a car to help a lanternfish judge its distance from other fish in a school.



Bristlemouth

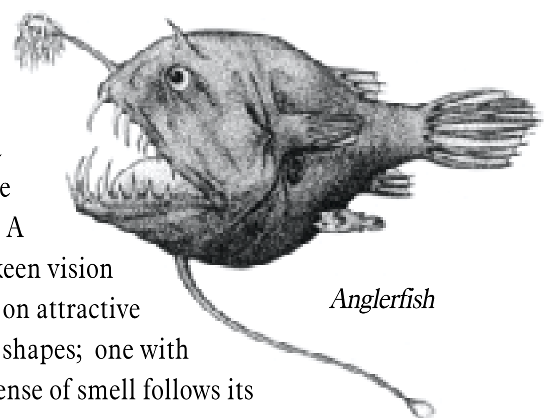
Vision

Besides making their own light, many midwater animals have visual adaptations to the darkness. Fishes and invertebrates in the twilight zone have large, well-developed eyes. Some have eyes that are dark-adapted to see more red; others have optical lenses that can detect bioluminescence or concentrate the dim twilight. In contrast to the twilight zone, many animals in the darkest depths have small, poorly developed eyes.

Feeding

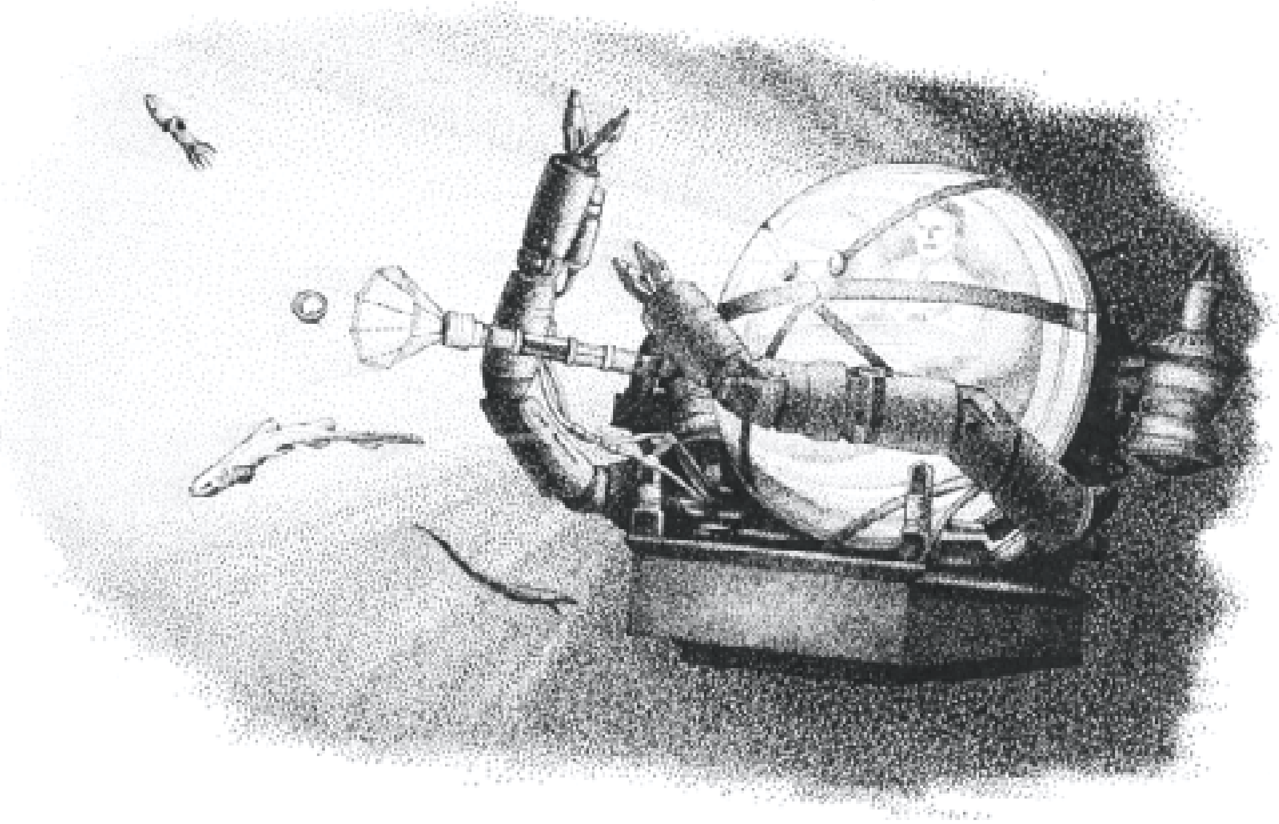
In the deep sea where food is scarce, animals have adapted to make the most of every meal. Compared to the sleek, muscular tuna of shallower water, a deep sea fish doesn't need as much food to support its small, flabby body, weak muscles and lightweight skeleton. A fish like the gulper eel with its huge mouth, unhinging jaws and expanding stomach can engulf and swallow a fish larger than itself. Some fishes migrate to areas with more food. Fishes like bristlemouths swim upward to feed in shallow water at night and return to hide in the depths during the day. Other fishes feed in shallow water while they're young, moving into deeper water as they mature.

Reproduction



Anglerfish

How does a deep sea animal ever find a mate in the darkness? A fish with keen vision may focus on attractive lights and shapes; one with an acute sense of smell follows its nose. Incredibly different in size and shape, some male and female anglerfish have developed mating behavior that keeps them together for life. The tiny male anglerfish uses his keen sense of smell to search out the larger female and then bites on to permanently attach himself as a parasite on her. The parasitic male and anglerfish relies on the female's circulatory system to nourish him. His sole remaining function is to produce sperm for reproduction.



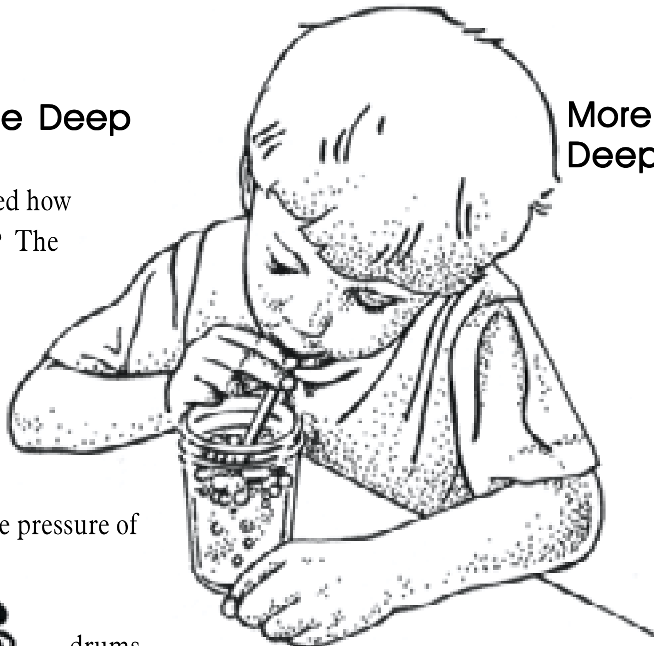
Scientists use submersibles like Deep Rover to study the deep sea.

Some animals like arrowworm have adapted in the opposite extreme, eliminating differences between the sexes by developing both male and female sexual organs. An hermaphrodite, an animal that is both male and female, can make both eggs and sperm. An animal that is only female must locate a male of the same species to reproduce; encounters with other females (half the population) won't be successful. In contrast, any two hermaphrodites can mate and when they do, twice as many eggs can be fertilized at one time. A hermaphrodite that can fertilize its own eggs has added insurance that it can reproduce even if it never finds a mate.

The strange-looking animals of the deep sea probably have many other adaptations that we don't yet understand. There's still a huge, mysterious world of animals deep below for us to explore.

Pressure in the Deep

Have you ever noticed how water pressure feels? The next time you go swimming, dive down to the bottom of the pool. Do you feel pressure in your ears? That's the pressure of the water pressing on your ear drums. Try some experiments to learn more about pressure.



MATERIALS

- Straw
- Cup of water

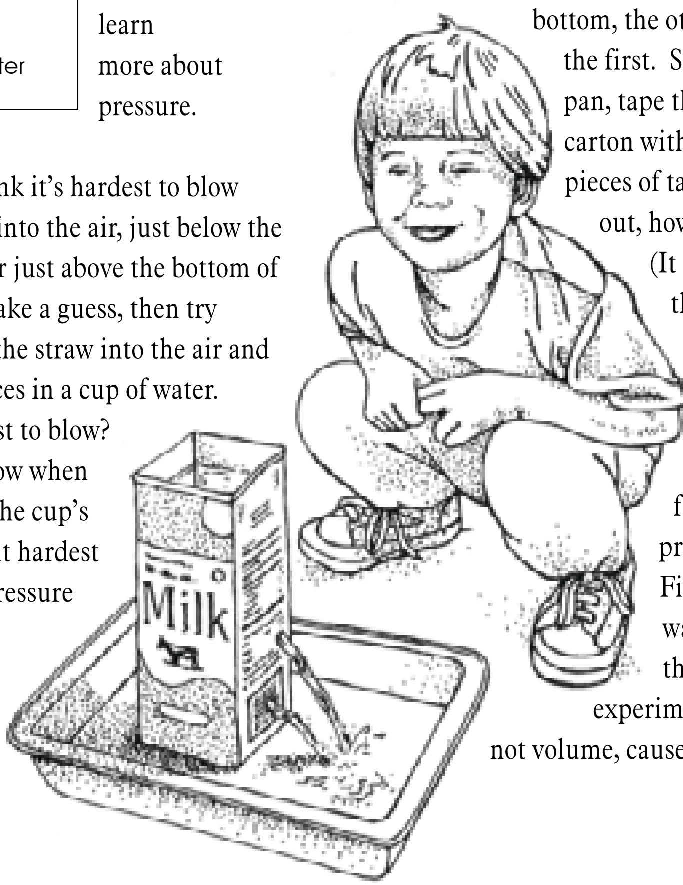
Where do you think it's hardest to blow through a straw: into the air, just below the surface of water or just above the bottom of a cup of water? Take a guess, then try blowing through the straw into the air and into different places in a cup of water. Where is it hardest to blow? (It's hardest to blow when the straw is near the cup's bottom.) Why is it hardest to blow there? (Pressure increases as you go deeper.)

More Pressure in the Deep

MATERIALS

- Two milk cartons: one half-gallon size and one quart size
- Pencil
- Tape
- Deep pan
- Water

Use the pencil to poke two identical holes in each milk carton: make one hole two inches from the bottom, the other hole three inches above the first. Stand one carton in a deep pan, tape the holes closed and fill the carton with water. Remove the two pieces of tape. As the water shoots out, how does the flow change? (It slows down because there's less pressure as the water drains out.) Which hole squirts farthest? Why? (The bottom hole squirts farther because there's more pressure the deeper you go.) Fill the second carton with water to the same depth as the first and repeat the experiment to show that depth, not volume, causes greater pressure.



Even More Pressure in the Deep

MATERIALS
- Plastic garbage bag
- Deep container (A plastic water pail works great!)

Do you think pressure comes from above, below or all around? To test your guess, put your arm and hand in a plastic garbage bag and immerse them in a deep container of water. Where do you feel pressure? (The pressure comes from all sides.) Animals in the deep sea live in pressure that is a hundred times greater than we live in on land.

How do these animals survive such forces? (Hint: only the gas spaces in animals' bodies are crushed by pressure. Water and most oils don't compress under pressure.)

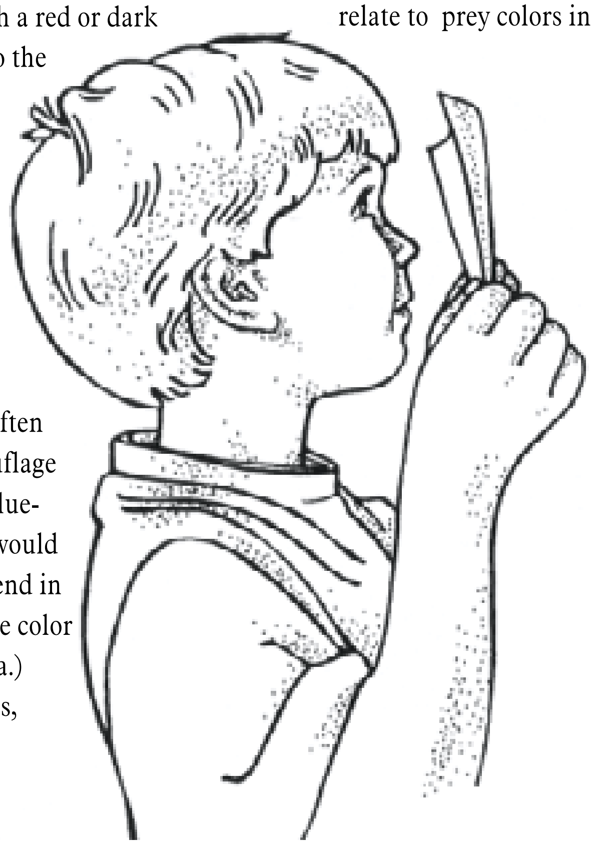
Changing Colors

MATERIALS

- Blue, green, red and yellow sheets of colored plastic
- Hole punch
- Red, blue, green, yellow and black construction paper (one sheet of each color)
- One yard of black material
- Graph paper
- Pencil

Do this one by your self, at school or at a party!

Experience the color changes that occur 100 feet (30 meters) under water. Look at objects of various colors through filters made of colored plastic. Which colors disappear in blue light? What happens to the objects when you look through a red or dark green filter? What happens to the colors? Why does this happen? (Read about light in the section, "What Is the Deep Sea?" on page 90.) In the deep sea, blue-green light penetrates the deepest; all other colors are absorbed in shallower water. Deep sea animals, like many animals, often have coloration to help camouflage them. Experiment with the blue-colored plastic. What colors would best help deep sea animals blend in with their surroundings? (The color red looks black in the deep sea.) If you look at deep sea animals, many are red and black!



Searching for prey

Using a hole punch, make five sets of colored dots (20 each in blue, red, yellow, green and black). Scatter all the dots on a square yard of black material and take turns as predators. Each predator gets 15 seconds to pick up dots, one at a time. How many dots did each predator collect? Make a bar graph comparing the color and number of dots collected by each predator. Which color dot was captured most often? Would predators be more efficient if all prey were black? Would predators be more efficient if they worked together as a team?

Try the above activity again, but this time look through blue filters when picking up the colored dots. Compare your results. How do these results relate to prey colors in the deep sea?

Design an Animal

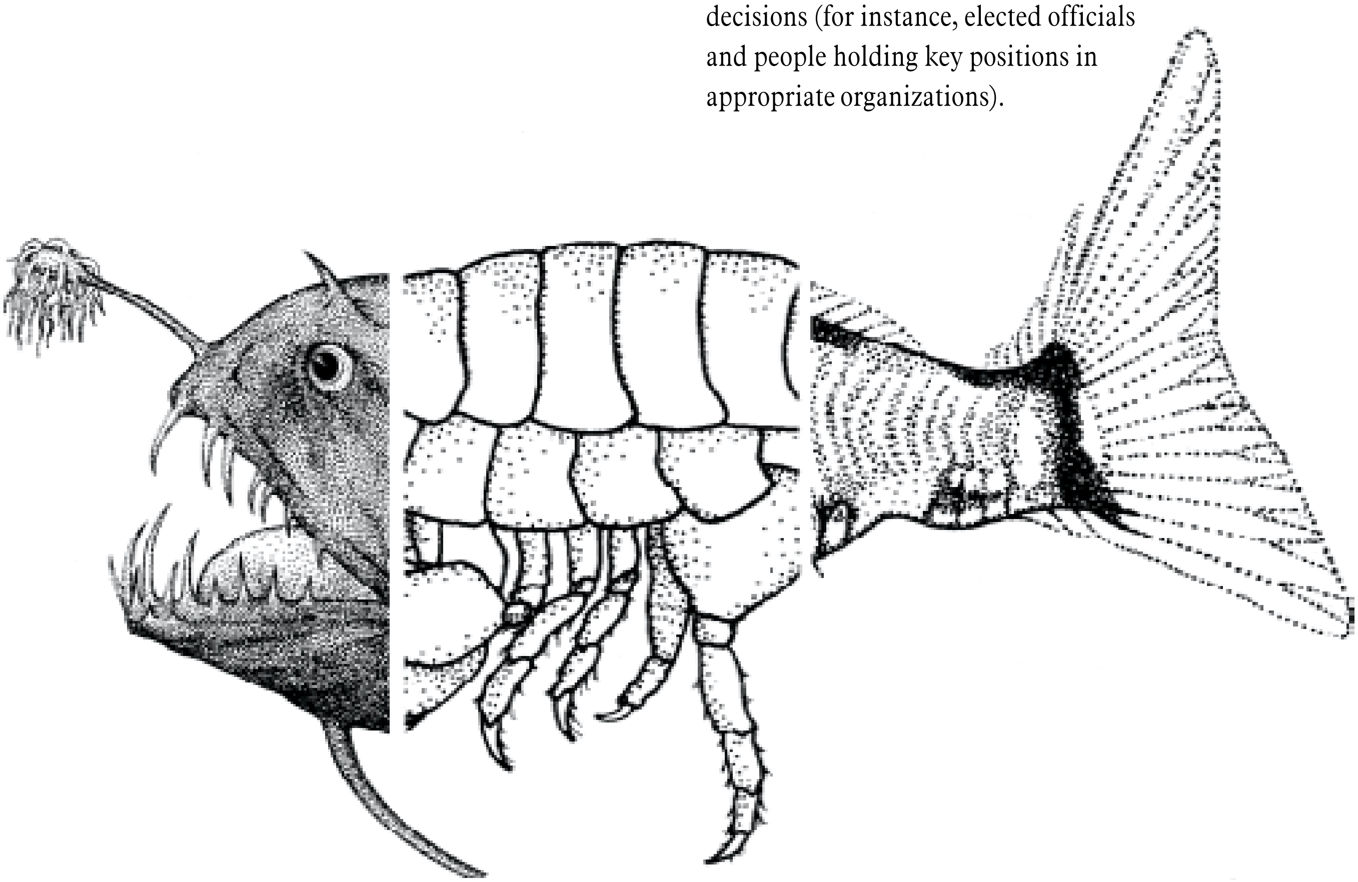
MATERIALS
- Paper
- Favorite drawing materials

Design and draw animals suited to live in a cold, dark environment under great pressure. What adaptations help your animals cope with the physical conditions of the deep sea? How do they find food, avoid being eaten, reproduce and communicate with one another?

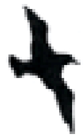
What Do You Think?

MATERIALS
- Paper
- Pencils

Nuclear wastes, dredge spoils, sewage treatment plant effluents and other wastes are sometimes dumped in the deep sea. Research and discuss these issues with your friends, classmates or family. Draft a management plan for one of these issues, then poll others about different management options. Build the results of your polls into your plan as appropriate, then share your findings with people who play a key role in making decisions (for instance, elected officials and people holding key positions in appropriate organizations).



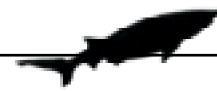
What's it like Down There?



MATERIALS
• A variety of arts and crafts materials

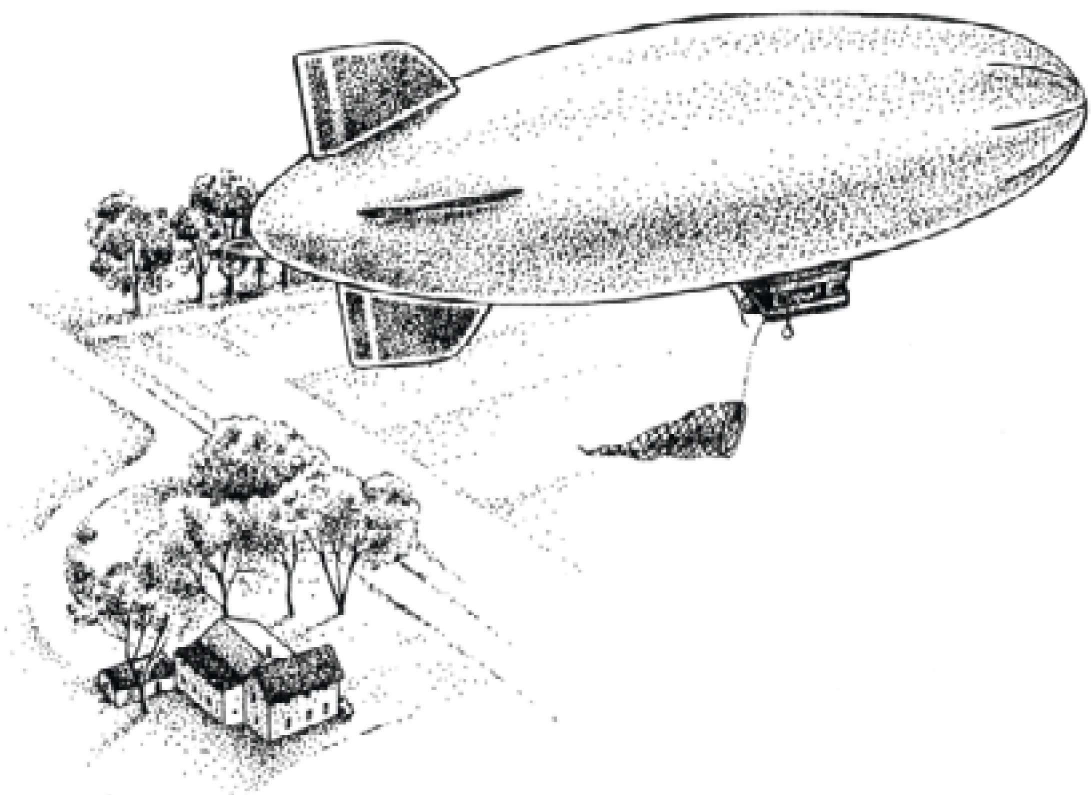
Exploring the deep sea is much like exploring your town from a blimp during the night and taking samples with a butterfly net attached to a long string. How long would it take to get a complete picture of the environment you're studying? Would you ever? Invent and build models of equipment that would help you better study the deep sea. Debate the costs, risks and benefits of using a remotely-operated vehicle (ROV) versus actually being there.

Unknown Worlds



MATERIALS
• Paper
• Pen or pencil

List several ways the deep sea is similar to and different from outer space. Would you like to explore these environments? What would you hope to find? What would you bring on an expedition to outer space? What would you bring to explore the deep sea? Are these kinds of explorations worthwhile things to do? Why? How do you feel about going to an unknown place? Record your thoughts on a piece of paper. Share them with your family or friends.



Schooling Fishsticks

A great activity for a party!

Each species of deep sea lanternfish glows with a unique pattern of body lights. These lights, called photophores, help lanternfishes find mates and avoid predators in the darkness of the deep sea. Photophores along the side of a fish's body attract mates, while those on its belly help the fish match the dim light above, protecting it from predators. Bioluminescent light may help other fishes form schools to avoid or confuse predators.

MATERIALS

- One 18" stick or dowel for each student
- Cardboard for mounting fish patterns
- One copy of the lanternfish pattern (both sides) for each student
- Black permanent marker
- Tape
- Glue
- Optional: Non-toxic glow-in-the-dark paints (available at arts and crafts supply stores)
- Brushes

Getting Started

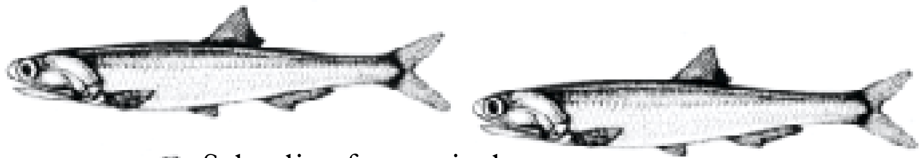
Make a copy of the lanternfish pattern (both sides) for each child. Cut out the pattern. Glue one half of the fish pattern to one side of the cardboard and the other half to the other side of the cardboard to form a sturdy lanternfish. Trim the cardboard to match the fish's shape. Divide the paper fishes into groups (four or five fish per group). Give each fish group a unique pattern of lights: use the marker to darken specific spots one each fish in a group. (The light patterns on both sides of a fish should match. Each group has a different pattern, but fish in the same group have the same pattern to show they're the same species.) You can paint the light spots with glow-in-the-dark paint to represent bioluminescent spots. Attach the fishes to the sticks with tape.

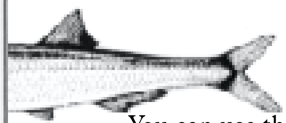
Getting ready

Make a copy of this lanternfish pattern (both sides) for each child. For a BIG impact, enlarge the fish on a copy machine.

Lights attract attention

Mix up all of the fishsticks, then give one to each child and ask: Where do you think lanternfishes live? What clues helped you guess where they live? Why do you think they're called lanternfishes? Explain that each species of lanternfish has a unique pattern of body lights to help them find mates. Have children hold their fishsticks up to attract the attention of other fish with the same light pattern. Look-alikes unite into their groups. (If you've painted glow-in-the-dark spots on the fishes, turn out the lights for this part of the activity.) Have each group of children list ideas about how bioluminescence helps lanternfishes survive.





Schooling for survival

You can use the fishsticks to show children how schooling fishes move. (Lanternfishes don't school, but you can use them as an example.) Outside, let each group of children swim a simple course, following these rules.

The fish swim close together, but without touching.

All fish in a school maintain the same speed and direction.

The front fish of the school determines the direction and speed of all.

Each time the school turns, the front fish becomes the new leader.

A school that is forced to divide must reunite as soon as possible.

How did you feel about being part of a school? What was difficult about moving as a group? What was easy? What cues did you use to stay together? Would it be harder to school in the dark? Why? How does schooling help fishes?

To show how fishes school to survive, you can have many speicies unite to form a huge school, using the same rules. Have the school swim a fixed course while you play the predator. Attack the school, but only capture those fishes that leave the ranks. The school may change direction to avoid you, but it must stick to the course. (No running.) If a fish turns or changes speed to avoid a predator, the rest of the school must follow. A fish who's caught becomes a predator and may help attack the school. The game ends when the school reaches the end of the course or when all the children have been captured.

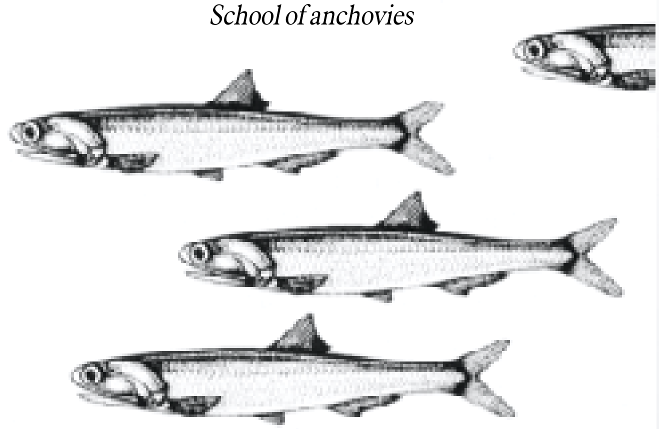
How did being in a large school differ from being in a small school? Did you feel safer from predators at the outer edge or in the middle of the school? If predators formed a school, do you think they would find food more effectively? Why or why not?

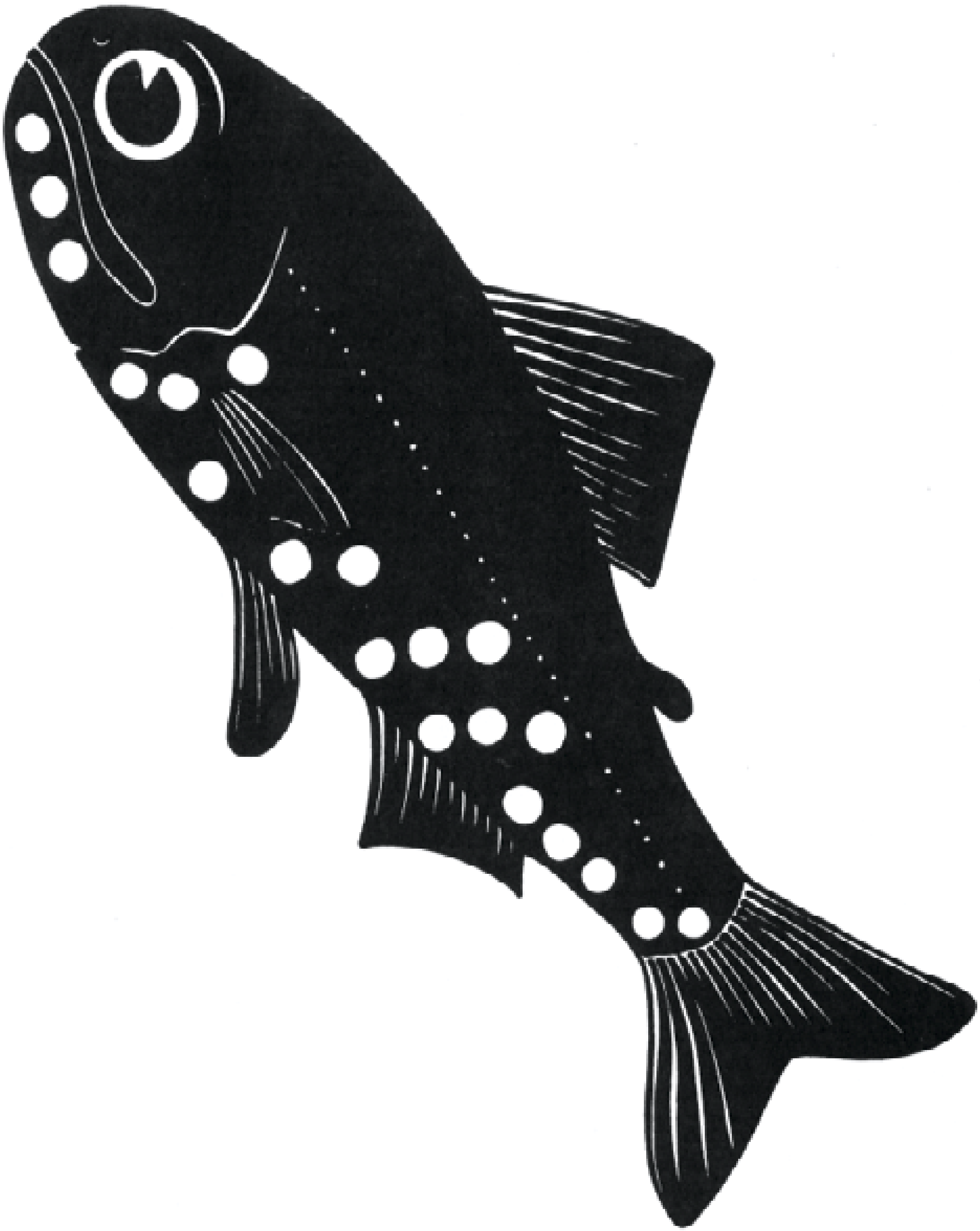
Follow-up

Grow bioluminescent bacteria at home or in your classroom. To grow the bacteria, you'll need luminescent bacteria (Vibro fischeri) plates and photobacterium agar plates. You can order these from: Carolina Biological Supply Company, P.O. Box 187, Gladstone, Oregon, 97027. Instructions are included.

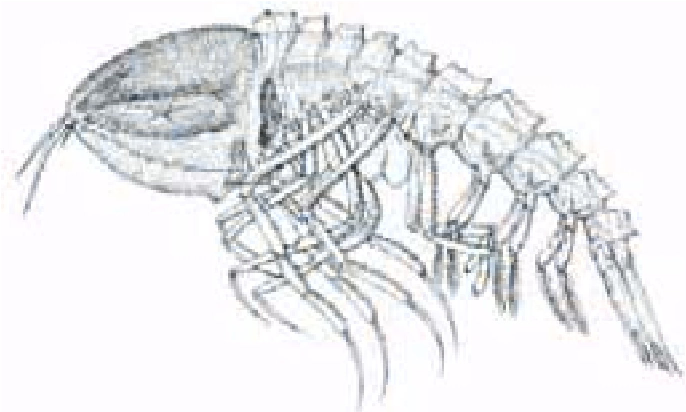
Visit an aquarium to observe schools of fishes. Do real fishes follow the same rules for schooling? What land animals work together in groups? How are they different from schools of fishes?

School of anchovies





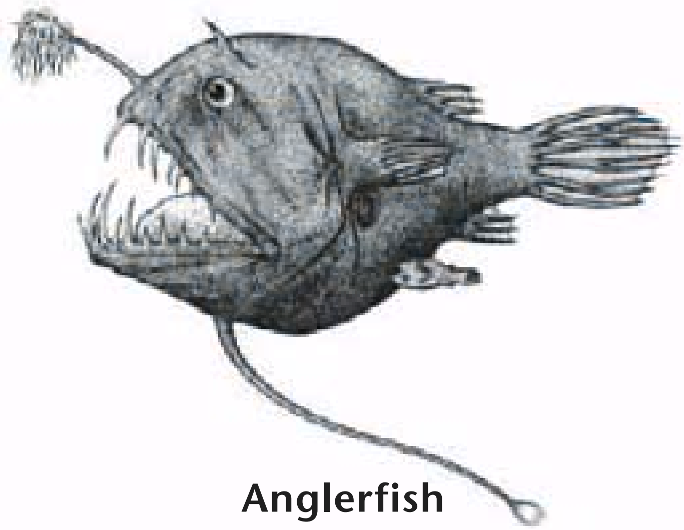
Critter Cards - The Deep Sea



Amphipod

Amphipod
Cystisoma fabricii [Size: to 6 in. (15 cm)]

This amphipod swims slowly through the water, paddling its three pairs of swimming legs located near the rear of its body. Swimming slowly may be fine; its crystal-clear body probably makes it hard for predators to see in the dim light. This crustacean's two huge compound eyes may help it to scan the dimly lit water in search of prey, though scientists don't know yet what it eats.



Anglerfish

Anglerfish
Linophryne coronata [Size: to 4 in. (10 cm)]

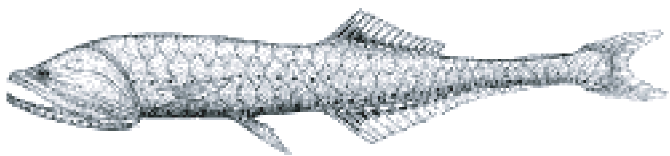
A female anglerfish may attract prey with lights: part of her top fin looks like a fishing pole with bait that lights up. The glowing bait may lure fishes to her huge mouth. A male, barely half the female's size, depends on a female for food. Once mature, he may use his keen sense of smell to find a mate. Then he bites her and hangs on. His body fuses to hers and they become mates for life.

Blackdragon

Blackdragon
Idiacanthus antrostomus [Size: to 15 in. (38 cm)]

How can you tell a female blackdragon from a male? A female is darker and larger, and a long whiskerlike barbel dangles from her chin. At night, she swims hundreds of feet up to the sea's surface to feed. At dawn, she makes her way back down to the deep sea. Without a working stomach, a male doesn't migrate for food. Unable to eat, he may only live for a year, just long enough to mate.

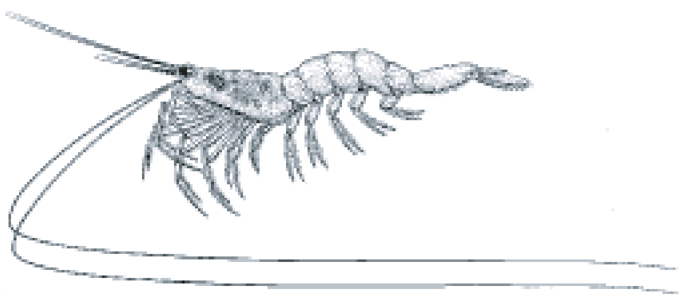
Critter Cards - The Deep Sea



Bristlemouth

Bristlemouth
Cyclothone sp. [Size: to 3 in. (8 cm)]

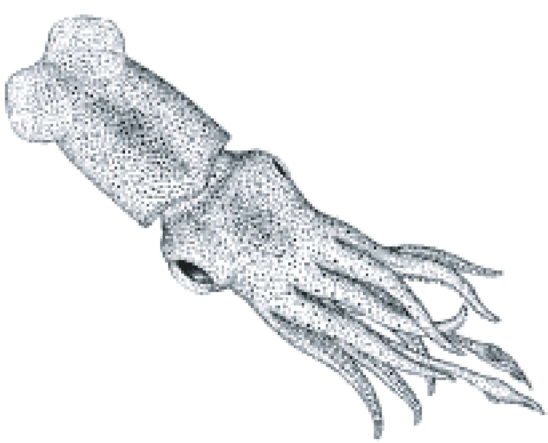
Many species of bristlemouths live below 1,000 feet (300 meters) where there's little light. Like many deep sea fishes, some of these bristlemouth species have poorly developed eyes and must rely on other senses to make their way in the darkness.



Deep sea shrimp

Deep sea shrimp
Sergestes similis [Size: to 1.5 in. (4 cm)]

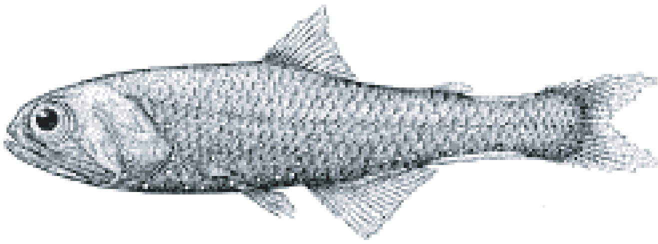
This shrimp's long antennae–nearly four times the length of its body–may help this animal find food or mates by sensing chemicals produced by other animals. This shrimp also uses bioluminescence to help it survive. Light-producing organs dot the underside of its red-and-white splotched body. The lights may attract mates, or they may help the shrimp hide from hungry predators.



Deep sea squid

Deep sea squid
Histioteuthis meleagroteuthis
[Size: to 12 in. (30 cm)]

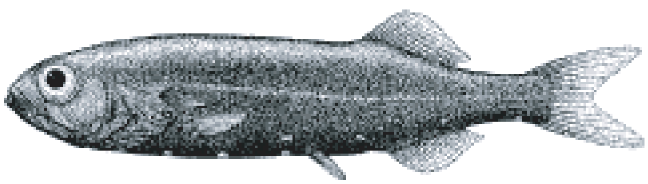
All squids, from this foot-long deep sea species to its 50-foot-long relative, grab prey with their two longest tentacles. And all squids use their eight arms to carry prey to their mouths. But unlike other squids, the deep sea squid's left eye is much larger than its right one. Each eye works differently, but no one's sure why. How do you think the different-sized eyes might help this animal survive?



Lanternfish

Lanternfish
Stenobrachius leucopsarus [Size: to 5 in. (13 cm)]

Each species of lanternfish has its own pattern of light-producing photophores. Lanternfishes may use these patterns to find mates of their own species. Some males may attract mates by flashing a large photophore near their tails. Or maybe this light confuses predators, causing them to attack the male's bright tail instead of his darker head. What do you think the lanternfish uses its taillights for?



Shining tubeshoulder

Shining tubeshoulder
Sagamichthys abei [Size: to 13 in. (33 cm)]

Tiny tubelike projections above each pectoral fin set this fish apart from others. Tubeshoulders can squirt a bioluminescent cloud from their tubes, perhaps dazzling predators with a flash of light as they slip away into the darkness. Tubeshoulders, born with gray-blue bodies and white tails, become shiny black as adults. As they grow, photophores develop along their undersides and on their heads.

Siphonophore

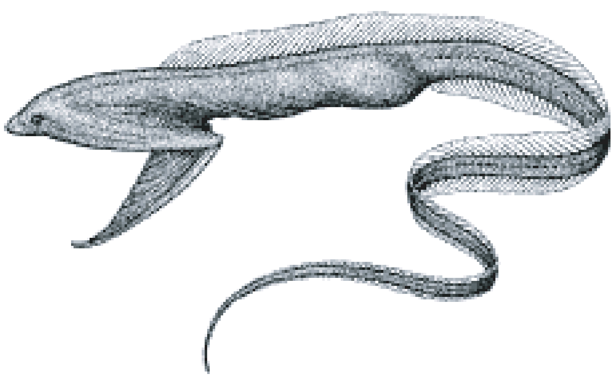
Siphonophore
Apolemia sp. [Size: to 98 ft. (30 m)]

A siphonophore is a chain of specialized parts; each one plays a role in the life of this animal. A floating buoy leads, followed by a cluster of round swimming bells that pulse to propel the chain (which can stretch nearly half the length of a football field). To eat, a siphonophore dangles a curtain of stinging tentacles that stun shrimp, ellies and other prey. The tentacles carry the prey to one of the mouth parts.

Filetail catshark

Filetail catshark
Parmaturus xaniurus [Size: to 22 in. (56 cm)]

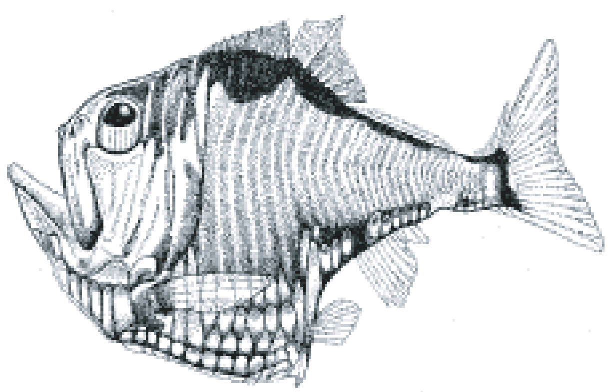
A filetail catshark swims gracefully along the muddy seafloor. Gray-brown above and pale below, this fish blends in with its benthic habitat. Its large green eyes look upward, unlike those of shallow-water sharks. Catsharks lay eggs with curly corners. The curls catch on edges of rocks and sponges to anchor the egg case near the deep seafloor. Here it'll stay for two years while a tiny catshark grows inside.



Gulper eel

Gulper eel
Eurypharynx pelecanoides [Size: to 16 in. (40 cm)]

The gulper eel's species name, *pelecanoides*, comes from its pouchlike mouth that looks like a pelican's bill. This fish usually eats prawns and small fishes, but with its huge mouth, it may swallow even larger prey. When hungry, this flexible fish may wriggle its tail in front of its mouth. The tail's tip glows in the dark and may lure prey close.



Hatchetfish

Hatchetfish
Argyropelecus sp. [Size: to 4 in. (10 cm)]

Shaped like the head of a tiny hatchet, this fish is countershaded to hide it from predators. Its back is dark; its belly is shiny silver with two rows of glowing photophores. A hatchetfish scans the water above for prey with tubular eyes. Its eyes can focus near or far, but only upward. Its large mouth points upward, too, ready to snap up prey once it's been seen.