Lesson I: Environment and Exploration

Keywords: *algae, epipelagic zone, pelagic, zooplankton, biomass, mesopelagic zone, bathypelagic zone, benthic, habitat, messengers, fluorescence, environment, habitat*

Environment: Zones

Even though the deep sea seems like "just a lot of cold, dark water", it may be divided into several habitats based on depth and the characteristics of the ocean that vary with depth. These characteristics are shown in your ocean zones diagram. As you move away from shore, the gently sloping continental shelf underlies shallow waters typically less than 600 feet until you reach the continental slope, where the bottom drops away rapidly.

The average depth of the ocean is 3800 meters, or 12,445 feet. This fact brings up an interesting point, the earth's surface is mainly water; in fact, about 71% of the earth is covered by water. Of that 71%, 80% is water greater than 2000 meters (about 6000 feet) in depth. A simple calculation reveals that 57% of the world is deep-ocean! Thus, the deep sea is the "average" environment on earth. It is more typical of our planet than forests, meadows, swamps, or even the seashore.

The epipelagic zone. The upper part of the ocean where **algae** can grow is termed the "epipelagic" zone, and in a clear ocean like the Gulf of Mexico it reaches to a depth of 600 feet. The prefix "epi" means "upper" and the term "**pelagic**" means "open-ocean" or "ocean". The place where algae can grow is really a thin skin on top of the ocean, yet it is ultimately the source of food for almost everything that lives beneath it. The sun's light allows the algae to grow, small algae-eating animals consume it, and larger animals may then feed on the algae-eaters. The sun's energy is thus passed from algae to animals and provides the fuel for our pelagic life in the deep sea. If we look at the ocean zones diagram, the large numbers of algae eaters and other small animals that are collectively called "**zooplankton**" are represented by the kite-like figure labeled "**biomass**", which simply means the weight of the zooplankton. The fatter the kite, the more animals there are at that depth. If we move along to the next column in the figure, we can see that there is plenty of light in the epipelagic zone. The last and most complicated part of the figure is the section showing how temperature varies with depth. This temperature diagram is pretty typical of a warm ocean like the Gulf of Mexico in the late spring. At the surface, the temperature is warm, about 25°C or 77°F, and where the wind has mixed up the ocean it is the same temperature from the surface down to 90 feet or, in a strong wind, to as deep as 200 feet. Below this "mixed layer" the ocean begins to get colder as we journey to the…

Mesopelagic zone. The mesopelagic zone is the zone known as the middle (meso=middle) ocean, "midwater" or more fancifully, the "twilight zone". It extends from 600 to 3000 feet. The reason it is known as the twilight zone is that the sun's light is getting dimmer and dimmer with increasing depth and the animals that live within it must have well developed eyes in order to see. You can also see in our "kite" diagram that the small animals known as zooplankton (those of us interested in fish think of them as "fish food") are quite a bit less numerous at the bottom of the mesopelagic zone than at the top of it. Temperature in the mesopelagic zone declines with depth from near-surface temperatures at the top of the zone to temperatures of 5°C, or about 40°F, at a depth of 3000 feet. This temperature is the same as that in your refrigerator at home.

The bathypelagic zone. The bathypelagic zone takes its name from the fact that it is very deep (bathy=deep). It extends from 3000 feet to the bottom of the ocean and is very cold throughout. The temperature ranges from 5°C at 3000 feet to about 2° (36°F) at 12,000 feet (see diagram). In the bathypelagic zone, there is no light. The sun's rays cannot penetrate to 3000 feet and because of this, vision becomes less important than a sense of smell or the ability to sense disturbances in the water. You'll notice in our "kite" diagram that there is very little "fish food" in the bathypelagic zone. Meals are few and far between and, as you shall see later, the animals that live there show bizarre adaptations to this life style.

Benthic and near-bottom. Animals that reside permanently on the bottom are termed "**benthic**" species. In the deep sea, they are perpetually in darkness, but they have at least three advantages over their pelagic relatives. First, they do not have to swim to prevent themselves from sinking. They can rest on the bottom, so buoyancy is not as much of a problem. Second, the bottom is the final resting place for anything sinking from the surface. That makes it a richer hunting ground, particularly for scavengers, than the pelagic regions above it where everything is "just passing through". Third, when you are near the bottom, food is most likely going to be found on the bottom, making it easier to search for.

Vertical migrators. Though this isn't a real "**habitat**", it is an important oceanic lifestyle. Some species spend their days in the darker waters of the mesopelagic zone at depths of 750 to 1800 feet. At dusk, they migrate up into near-surface waters to feed and then move down again at dawn. Their migration allows them to permanently reside in dark waters and still have access to the food-rich waters near the surface. Since they are always in the dark, the migratory lifestyle presumably allows these species to avoid visual predators

What is the Deep Sea?

The deep sea is <u>average</u>. The oceans cover about 71% of our earth and about 80% of that is greater than 2,000 meters (6000 feet). If we simply multiply 71% by 80% we find that greater than 57% of our earth is deep ocean. This means that the average environment on earth is deep sea!

The deep sea is <u>dark.</u> Sunlight is filtered as it passes through the ocean. In the first 10 cm. (4 in.), almost all of the red portion of the spectrum is absorbed and is changed into heat energy. 80% of sunlight is absorbed in the first ten meters and by 140 meters only about 1% remains. Blue-green wavelengths are usually able to penetrate to the greatest depth, about 1 km. in very clear ocean waters.

The deep sea is <u>cold</u>. Cold, salty water is denser than warm, less salty water and will sink below the warmer water because of its density. Water at the earth's poles, that is, at the Arctic and Antarctic is colder and saltier than other seawater. Therefore, cold water at the poles sinks and becomes deep water. Thus, the reason why the deep ocean is cold is because the cold water formed in the Arctic and Antarctic spreads throughout the world while being isolated from the warming effects of the sun.

The deep sea is under lots of <u>pressure.</u> Have you ever lifted a gallon of water? Water is heavy. Imagine the weight of many, many gallons of water. At the deepest point of the ocean, the pressure is equivalent to about 50 jumbo jets sitting on top of you!

The deep sea floor is usually <u>soft</u> bottom. This is due to a long-term accumulation of sediments from land sources and from biological oceanic sources such as the microscopic skeletons of planktonic organisms. This ooze is a desirable place for nematodes (roundworms), bivalves (clams, oysters) and other invertebrates to live.

Exploration of the Deep Sea

In the early nineteenth-century it was believed that the deepest ocean waters did not circulate. If they were stagnant, and no new oxygen could reach these waters, they would have to be devoid of life. In the 1830's, a respected naturalist named Edward Forbes took samples at different depths in the British Isles, the Mediterranean, and the Aegean seas and in his comparisons between the different depths (but also between different bodies of water), he noted that he caught fewer animals the deeper he went. Therefore, he concluded that eventually you would go deep enough to reach an "azoic zone", or a zone devoid of life. So, any reports of life found below 800 meters were ignored, even though, around 1810, Sir John Ross, using his own invention, the deep-sea clam, recovered sea stars and worms from Baffin Bay in waters over a mile deep. Ross' nephew found similar marine life in water over 4 miles deep in the Antarctic. However, belief in an azoic zone persisted until the mid-1860s when a transoceanic telegraph cable was brought up from 2000 meters (6,560 feet) covered with encrusting organisms. It could no longer be ignored; there was life in the deep sea. In 1872, the HMS Challenger set sail to begin a 3-year deep-sea exploration. They measured temperatures and depths, studied currents, and collected organisms and sediment samples from all of the ocean basins except the Arctic. Depth measurements were made using a weighted hemp line knotted at regular intervals. They counted the number of knots that were required for the weight to hit bottom. Fishes and other sea life were captured by net and water was collected using water bottles, much as we do today.

Now we have more advanced means of studying the deep ocean. We still use nets, but they are more sophisticated. Present day nets can be triggered to sample only specific depths, using weighted **messengers** or electronic triggers. In addition, modern nets may have sensors that measure temperature, pressure, salinity, plant **fluorescence**, total particulate materials, speed, total volume of water filtered, and more!

Many organisms can avoid nets, or may be too delicate for capture with a net. Sometimes, it is more feasible to take pictures instead of collecting the actual specimen. Cameras have been developed with attached flashing strobes that send images to the surface by fiber-optic cable. Attached sensor packages measure all of the physical and chemical parameters of the organism's **environment**!

Sonar systems were first developed in the 1930s and 1940s by the military to detect submarines, but were also found useful by scientists to measure depth and to quantify fish stocks. Sonar is an acronym for **SO**und **N**avigation **A**nd **R**anging. Sonar works by using sounds generated from a transmitter (transducer) mounted on the bottom of a ship. The sound travels through the water, bounces off the bottom and is detected by a microphone also mounted on the ship's bottom. Sound waves travel at about 1.5 km per second in water. Knowing the time it takes for the echo to return gives you a measure of how far sound has traveled, or the depth! Sound can also bounce off organisms Thus, sonar, or acoustics have also been adapted for measuring plankton and fish abundance.

Cameras can be used in conjunction with the acoustic techniques to aid in actual species identification. Satellite communication systems and acoustic instruments can be mounted on buoys, which can then remotely measure zooplankton abundance and transmit the data to laboratories far away.

Remotely **O**perated **V**ehicles or **ROV**s are becoming more important in oceanic exploration and research. These vehicles can go to moderate depths and perform many sampling and filming functions while being operated from the ship to which they are tethered. **A**utonomous **U**nderwater **V**ehicles or **AUV**s are another class of remotely operated underwater vehicle, however, they are not tethered to a vessel. Another way to observe, or collect is to actually be there. However, a special chamber must be built which protects the humans inside from the intense pressure in the deep-ocean. These special vessels today are known as submersibles, but older, more descriptive names include, bathysphere (deep sphere), or bathyscaphe (deep boat). They have an internal pressure that remains the same as that found at the surface of the ocean (1 atmosphere). In 1934 William Beebe, a renowned zoologist, descended to a depth of 3027 feet in a tethered bathysphere. He was the first man to ever visit the deep sea. Later, Auguste Piccard, a Swiss engineer, designed his deep-diving bathyscaphe, the Trieste. He actually had a passion for hot-air balloons and he used concepts from hot air balloon design in his bathyscaph design. The upper portion was filled with gasoline because it is positively buoyant, and will float in water. Lead shotgun pellets gave it the weight to travel to depth; they were disposed of when it was time to ascend. In 1960, his son, Jacques Piccard went down in history with the Trieste, all the way down to the bottom of the Challenger Deep. He reached a depth of 35,800 feet! Jacques looked around for signs of life…

Next in deep-sea biology, animal distributions!

Discussion Topics/Questions

1. Discuss the distribution of light and its relationship to food availability in the deep sea. How does the distribution of light relate to the distribution of biomass?
2. Why is the deep sea cold? What are the three areas of deep water formation? Point them out on a map.
3. Why was it once believed that there was no life in the deep sea? What happened to change that belief?
4. What does sonar stand for? How can you tell the ocean depth using sonar?

Activity I-1. Why is the Deep Sea Cold?

Supplies:

- thick glass container
- plastic bottle with thin walls that you can easily poke a hole in (make sure the bottle will fit into your glass container lying on its side)
- a microwave
- a large microwaveable
- pourable container
- salt
- large spoon
- blue food coloring

Earlier in the day- warm up some water in the microwave, add some blue food coloring and salt-chill it. When the water is chilled, start warming up some more water without food coloring and salt. Pour the warm water into your container, fill it at least halfway. Fill the plastic bottle about one half to three quarters full with the chilled blue salt water, poke a hole in the side (about the size of the 'o' on your computer keyboard), then set the bottle in the container and let it float with the holed side down (poke a hole somewhere on the top side also, to let air in the bottle). The cool blue water will leak out and settle to the bottom of the container. This is similar to deep water formation in the ocean. Have the students discuss why they think the cooler, saltier water went to the bottom of the container.

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Student Information Sheet

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