Lesson II: Animal Adaptations and Distributions I

Key words: *Photosynthesis, topography, phytoplankton, nutrients, phytoplankton blooms, buoyant, cilia, fusiform, lunate, caudal peduncle, deep scattering layer, diel migrations, euphotic, metabolism, pupil, rods, cones, retina, photophores, ventral, microhabitat, food-poor, opportunistic, gill rakers*

During this program we will discuss organisms of the epipelagic and mesopelagic zones focusing on the adaptations that allow them to live in these environments. Included in this show will be the vertical migrators.

Organisms of the Epipelagic Zone

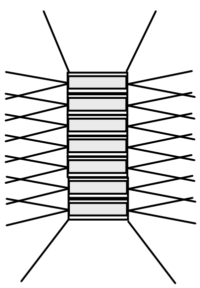
The **Epipelagic zone** is the uppermost layer of the ocean; it is located between the surface and 600 feet in depth. It is in this thin layer that all **photosynthesis** takes place. The epipelagic zone only represents 2-3% of the entire ocean, beyond this, light is too dim for photosynthesis to occur. In fact, in all the world's oceans, 65% of the plankton are in the top 500 meters.

Not all surface waters are productive and much is featureless. Therefore in the surface waters, temperature, light, **topography,** and distance from land tend to determine organism distribution. **Phytoplankton** need **nutrients** (fertilizer) in addition to lots of sunlight. Much of the open ocean is nutrient poor and there is little phytoplankton growth. Areas close to land tend to have higher nutrient content because of runoff from land. These areas with higher nutrients have **phytoplankton blooms. Zooplankton**, (small animals that float with the currents that we think of as fish food) feed on phytoplankton and are present in higher numbers where blooms occur.

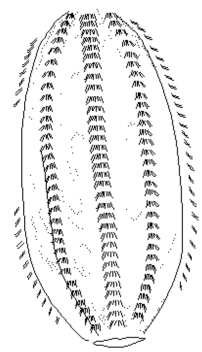
In the well-lit epipelagic-zone, most predators use vision to seek out prey. There are several adaptations that allow prey organisms to survive here. One adaptation is small size. The most numerous organisms of the sunlit zone, the zooplankton, are small. When you are small, not only are you hard to see, but it is easier it is to stay afloat. If an organism is small and light it can stay up in the water column longer. Larger gelatinous organisms, like jelly-fish are also very hard to see because they are transparent and they have a density close to that of water; this allows them to be both hard to see and neutrally **buoyant.**

Some of these organisms have **cilia,** tiny hairs on their body, this increases their resistance to sinking, and can also be used for locomotion, touch, or to sense water movement.

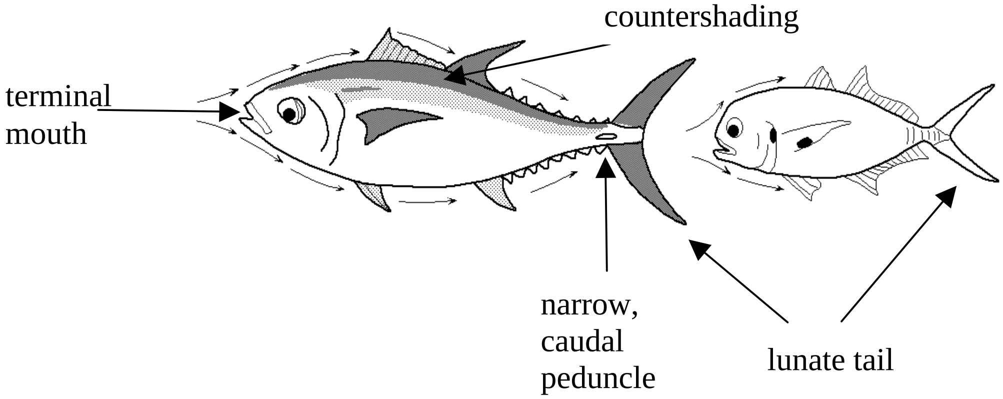
A diatom



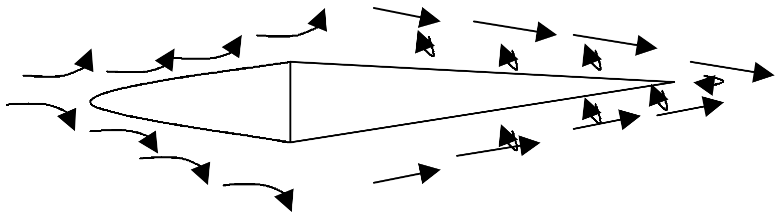
A comb jelly



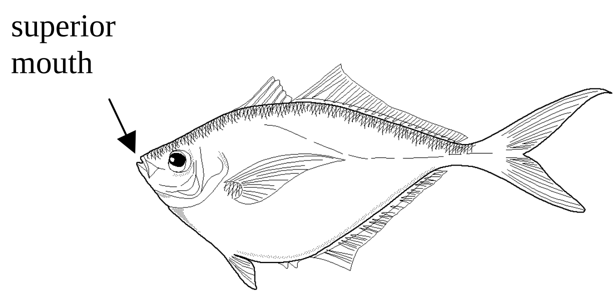
Most epipelagic fishes have streamlined or **fusiform** bodies (spindled-shaped like a submarine), that allow them to slide through the water more easily, which is important if you are swimming continuously. Many have adaptations that help them swim fast such as a **lunate** tail or a narrow **caudal peduncle**. They also have a lot of muscle mass, which enables them to be strong swimmers. Good examples of these adaptations can be seen in a tuna fish, shown below. This picture also shows water flow over the fusiform shape.



Generalized Fusiform Body Shape



These large visual predators often have terminal mouths (see above) because they use their speed to ram their prey right into their large mouths. The oceanic plankton feeders often have superior mouths, so they can pick on the plankton at the surface of the water.



Atlantic Bumper

Coloration, or countershading is another important adaptation in the epipelagic zone. Most epipelagic organisms have countershading (see the tuna on the previous page): dark on top, and silvery below. For anything swimming above (predator or prey) they blend into the darker water below and for anything looking up at them from below, they blend into the lighted surface above! Often, their colors are silvery; this reflects and scatters incoming light making their silhouettes difficult to see. As mentioned above, zooplankton of the epipelagic zone are usually small and hard to see. If they are larger, they are transparent, like jellyfish.

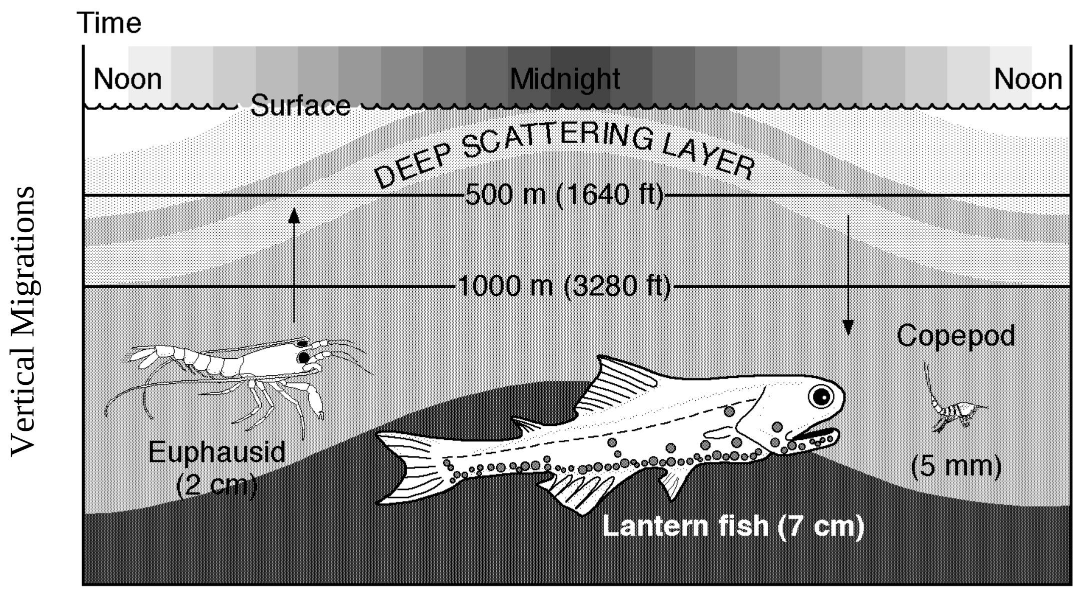
Organisms of the Mesopelagic Zone

If we proceed in our journey through the water column, the next zone that we encounter is the **mesopelagic** or twilight zone. It is called the twilight zone because it is dimly lit. The amount of light is insufficient for plants to carry out photosynthesis yet it is bright enough to tell the difference between night and day. The mesopelagic zone ranges from about 600 feet to about 3000 feet in depth, depending on how far sunlight can reach. The amount of suspended material, in the water, like silt or algae can determine how deep sunlight can reach and which wavelengths are absorbed first. First, a short discussion on what light is may help. Sunlight is actually composed of many different wavelengths, each of which is a different color; you can see this when you pass light through a prism. Long wavelengths are red. Short wavelengths are blue. When you look at the ocean, it appears to be blue or green, that is because the shorter wavelengths are being reflected. The longer red wavelengths are being absorbed in the surface waters; at depth red wavelengths are no longer present. A red organism will not have a wavelength to reflect and will therefore appear black. Another important issue governing life in the twilight zone is that we lose the air-water interface; it becomes an entirely three-dimensional world! We have nothing to compare it to in our terrestrial existence. Even birds have to land on the ground or in a tree sometime! Organisms of the mesopelagic zone may never see a physical boundary of any kind. This makes it very difficult for researchers to study organisms of the mesopelagic zone. When held in captivity they tend to ram themselves into the sides of their aquarium until they kill themselves. They are unable to deal with boundaries.

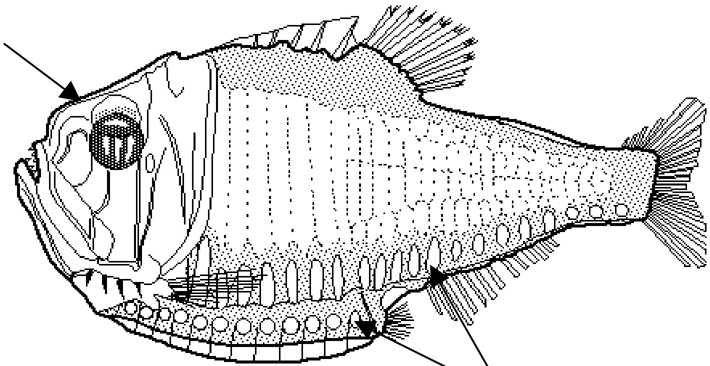
The mesopelagic zone is also where we encounter the permanent **thermocline** (see diagram), a region of marked vertical temperature change. Temperature decreases from near surface temperatures to about 4-8°C at about 1000 meters (3280 feet). The temperatures encountered by mesopelagic organisms are therefore a function of how deep they live.

Pressures are far greater than in the epipelagic zone. Pressure increases by one atmosphere with every thirty feet of depth. Pressure in the mesopelagic zone ranges from about 300 pounds per square inch (psi) to 1500 psi.

The fact that many organisms leave the surface waters during the daylight hours and then return at night has been known since the *Challenger* expedition in the 1860's. However, it wasn't until the development of sonar and the increasing use of submarines in warfare that it attracted large amounts of scientific interest. This is because there are so many of these vertical migrators that they create what is known as a **deep scattering layer.** The animals reflect sound waves and appear on an echogram as a phantom bottom, because it moves around depending on the time of day! The navy was of course interested because they wanted to hide their submarines beneath it. Many researchers speculated as to what could possibly cause it. Some thought giant squid, and others thought shrimp or fish. Well, the fish and shrimp camp won. Tows were made at the exact depth and time of the deep scattering layer. They brought up many small euphausiid shrimp, lanternfishes (myctophids) and large shrimp. These vertical migrations are known as **diel migrations**, because the journey has two parts: up at dusk and down at dawn. Vertical migrators occur at all latitudes in all oceans. Different organisms migrate at different times to different depths. This migration allows organisms to remain at a constant level of low light at all times. Zooplankton migrate up at night to feed on phytoplankton, which always stay in the **euphotic** zone and small fish follow the zooplankton. Then, around sunrise they migrate back to the depths to avoid daylight. There are several theories as to why this might occur. It may be that in the absence of light they are less visible to predators or possibly, their **metabolism** slows when they return to cooler, darker waters. Since they are cold blooded, the cold temperature at depth allows them to burn up the food they have just consumed more slowly! It is easy to see how this helps to bring food to the food-poor depths. Some organisms do not make the migration, they simply wait for the food to come back to them!



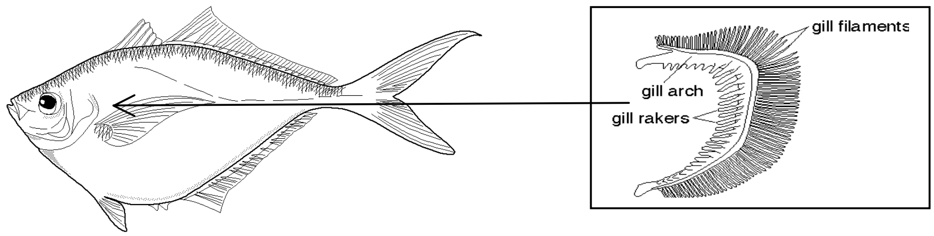
We have already discussed the dim light that reaches the twilight or mesopelagic zone as you might guess it has profound effects on the adaptations of the organisms living here. The eyes of mesopelagic organisms are well developed and though they may look similar to eyes of an epipelagic organism, if we look closer, we find important differences. Often the eyes are larger, but even if they are not, the **pupil**, the part of the eye that lets in the light, is larger. Also, fishes of the epipelegic zone have both (light sensitive layer located inside **rods** and **cones** in their **retina** the back of the eye)**,** the rods absorb light and cones allow them to see color. Fishes of the mesopelagic layer and deeper only have rods, with a few exceptions. Not only do they have all rods but the actual part of the rod that absorbs the light is longer. Many fish of the mesopelagic zone have eyes that are outwardly different, tubular eyes that are upwardly directed are a common adaptation; this may help to see things above them that are silhouetted in the dim light.



The hatchetfish- *Argyropelecus*

In the upper mesopelagic zone fishes tend to still have silvery upper bodies to help them blend with light coming down from the surface. But in the mesopelagic zone many fishes also have **photophores** on their **ventral** surface. There are many theories as to the function of the photophores such as blending with the surface light, species identification (to aid in finding a mate), flashing to confuse a predator or to attract prey. Maybe depending on the circumstances they fill all of these functions! All of these would be useful in the deep sea, as there are no **microhabitats**; that is, there are no bushes to hide behind or caves to duck into. Animals must carry their own concealment with them and yet be able to make themselves known to mates.

Not only is the mesopelagic zone dark, it is **food poor**. The inhabitants of the twilight zone must be able to utilize a wide range of prey items in order to survive, or in ecological terms, they must be **opportunistic**. Therefore, in comparison with most surface dwelling organisms their mouths are pretty large. If they happen upon another organism they may try to eat it, no matter how large. They also have a set of fine **gill rakers** so that really small things cannot slip away either. In surface dwelling fish the gill rakers can be very finely spaced for those that filter plankton to widely spaced for carnivores. But in the twilight zone nothing is wasted!



Earlier, we discussed the distribution of light through the water column. Long wavelengths (red light) are absorbed in the upper ten meters therefore any organism that is red in the mesopelagic zone is functionally black! There is no red light to reflect the red color back. There are many crustaceans in the twilight zone that have the special adaptation of being red. However, there are also fish in the mesopelagic zone that have a special adaptation to allow them to see these red crustaceans. A few of the fish have a special cheek light organ that emits light in the far-red portion of the spectrum, this allows them to see these invisible shrimp!

In our next show we journey even deeper in the ocean, to a place where the sun's rays never reach, the **Bathypelagic Zone.**

Fun Facts

- Some shampoos contain oils from the orange roughy fish. The orange roughy is a deep-sea species from New Zealand.
- Sea-serpent sightings are attributed to the oarfish. It is the longest bony fish in the world with a magnificent red fin along its 50-foot length, horse-like face, and blue gills.
- Some deep ocean fish have organs below their eyes, which give out both red and ordinary light. The fish can then see red animals that are invisible otherwise, and illuminate others with the red light only they can see.

Discussion Topics/Questions

1. What are some advantages to being small in the epipelagic zone?
2. Why is proximity to land important in determining animal distributions? How might this affect the deep sea?
3. Plants need sunlight. Why is productivity low in some areas where there is a lot of sunlight?
4. Compare and contrast some of the adaptations for living in the epipelagic zone with those for living in the mesopelagic zone. Why are these adaptations important?
5. What are some advantages and disadvantages of vertical migrations?

Activity II-1. Seeing Red

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1. Buy a red light bulb and put it in a small lamp. Give the students red pencils and have them write a note or a word. Make sure the room is totally dark then turn on your red lamp. Have the students read their words. Can they see them? Ask them why they think this is so? How does being red help organisms that live in the mesopelagic zone?

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STUDENT INFORMATION

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