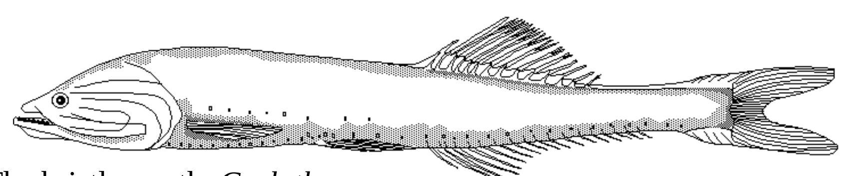
Lesson III: Animal Adaptations and Distributions II

Keywords: *ichthyologist, vertebrate, metabolic rate, olfactory organs, crustaceans, antennae, lateral line, Eurypharyngidae, neuromast, demersal, diversity, epifauna, infauna, morphology, decomposition, polychaetes, holothurian, crinoid, rattail, brotula, halosaur, swimbladder*

This program is a continuation of the previous show in which we began our journey through the deep sea. If you remember in our last show we started out in the epipelagic or surface zone and went on to the mesopelagic or twilight zone where there is very little light. We even discussed how some organisms, the vertical migrators, migrated daily between the two zones.

Today we will journey even deeper, beyond the point where the sun's rays can reach to explore deep water and ocean bottom creatures. You may wonder why one would study the deep sea. But, if you remember from last week's show, about 60% of the world is deep sea. It is the average earth environment. It is more representative of our planet than a meadow or a forest! Knowing this, where do you think the world's most abundant fish is found? The epipelagic zone? Of course not, they are found in the meso and bathypelagic zones. Any **ichthyologist** (a person that studies fish), will tell you that the world's most abundant **vertebrate** (animal with a backbone) is the bristlemouth. These are also known by their **genus** name *Cyclothone.*



The bristlemouth, *Cyclothone acclinnidens*

Deep Sea Adaptations

The average depth of the ocean is 3800 meters or 12,500 feet. It is not all 3800 meters deep; the ocean floor has irregular topography, just like on land. In fact, several places far exceed the average depth. The deepest point of the oceans is located in the Western Pacific, north of New Guinea in the Marianas Trench. It is one of many deep trenches in the Western Pacific. It is known as the *Challenger Deep*, named after the British vessel that took the first sounding in 1951, establishing it as the deepest point in the world's oceans. Mount Everest could be dipped in it with over a mile to spare!

There are several general changes that occur in organisms as they live deeper in the ocean. As mentioned in the previous show, food becomes scarcer the deeper you go. This is because the food web begins with the phytoplankton, which can only occur in the photic or well-lit zone. One consequence of living in a food poor environment is a greater water content. There is a higher percentage of water in an organism's tissues the deeper it lives in the water column. This happens because there is less food available to build strong muscles, so bathypelagic organisms tend to have weak, flabby muscles. Even bones become less dense as you go deeper in the water column.

Every organism, whether it lives in the deep sea or on land, uses the energy it receives from the food it eats for three purposes; growth, reproduction and maintenance. However, the environment in which an organism lives affects how much energy is used for each purpose. Today we will look at how an organism living in a food-poor environment would direct its energy stores. Growth, is useful: the larger you are, the fewer things can eat you. Reproduction is helpful to ensure survival of your species. Maintenance is the energy used to stay alive, such as the pumping of your heart! We can measure maintenance by measuring the **metabolic rate**, which is a measure of how fast an organism makes things like muscles and how fast it can break down other things like food. Scientists have shown that the metabolic rate of deep-sea fishes decreases the deeper they live. A fish living at 1000 meters breathes more slowly than an animal living at the surface.

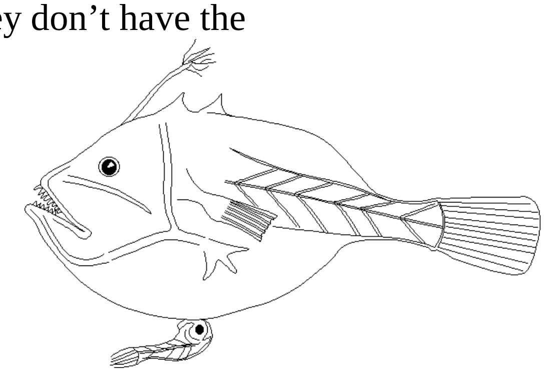
This gives the fish two basic advantages:

1. It allows more of the food it eats to be directed into growth and reproduction.
2. It allows it to live much longer on the food it does eat; it doesn't burn it up as fast as a shallower living fish.

Now, with these basics in mind, on to the bathypelagic zone!

Organisms of the bathypelagic zone

The **bathypelagic zone** is similar to the mesopelagic zone. It is cold (2-5°C). It is dark, but here, there is no sunlight at all. The pressure is enormous; it ranges from 1500 to 6000 pounds per square inch or psi. Food is even sparser than in the mesopelagic zone, therefore organisms have higher water content. Many fish are black in color and their eyes are usually reduced. The only light available are flashes of biological light (bioluminescence) produced by the organisms themselves. Some male angler-fishes have sensitive, specially adapted eyes, which help them not only catch luminescent prey, but to find the flashing lure of the female angler-fish. They are an exception to the rule of reduced eyes in the bathypelagic zone. Some of the male anglerfish also have well-developed **olfactory organs** (responsible for sense of smell, like your nose), to help them locate the females. The male anglerfish is much smaller than the female and they don't have the luminescent lure that the females have. Their main purpose is to locate a female. The females do not have a well-developed sense of smell. She uses her lure to attract prey and a mate. This is a strategy for living in the food poor environment of the bathypelagic zone. A large fish requires more food than a small one. The males do not need to be large, a small male can make a lot of sperm. But the females can produce more eggs if they are large, therefore they do need to attract prey and hence they have the luminescent lure. They just hang out and wait for prey to come to them. The males put more energy into their olfactory organs and in the active searching for females. However, once he finds the female he bites down and becomes a permanent attachment! The male anglerfish receives his nourishment from the female and she receives sperm from him. Some females may have more than one male attached!

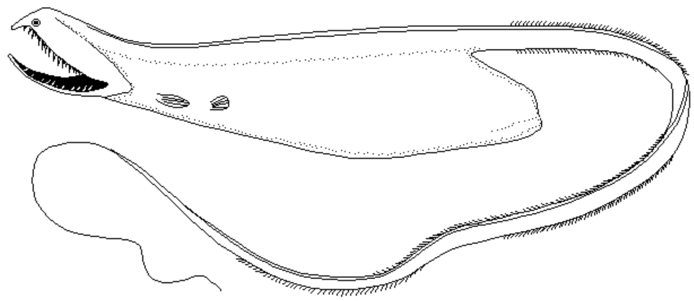


Female Anglerfish *Haplophryne mollis* with male attached

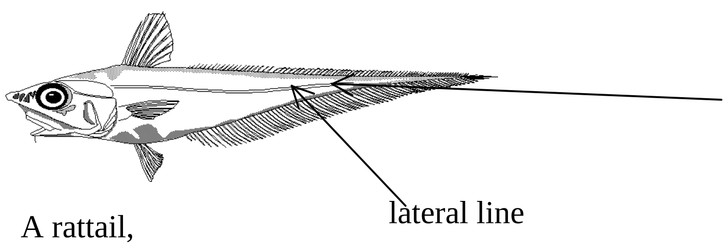
Many of the **crustaceans** in the bathypelagic zone have the reddish coloration that is found in the mesopelagic zone. They have olfactory hairs and extremely long **antennae**, which are used for touch. On the other hand, squids, have virtually no olfactory organs and therefore need well-developed eyes at all depths.

Most fish in the deep-sea have very large mouths and teeth, and often have stomachs capable of distending to accommodate large prey. Some fish have pigmentation in the gut wall. This is probably to hide any light produced by luminescent prey items. Here is a picture of a gulper eel, **Eurypharyngidae**, notice its tiny eyes and huge mouth. Some fish can even unhinge their jaws so that they can open them wide enough to eat a large organism.

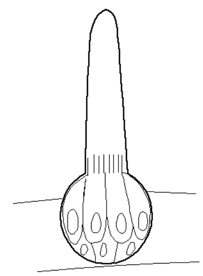
Eurypharyngidae



Another way that bathypelagic fishes differ from their shallower living counterparts or even their benthic or bottom living counter parts is in their **lateral line** system. The lateral line system in fishes gives them a “distance touch” sense; it helps them detect motion around them. It usually consists of a canal which contains specialized cells called **neuromasts** which contain cilia (sense hairs) covered by a gelatinous cupula. When there is a nearby disturbance the cupula bends and moves the cilia, which stimulate sensory cells below. An easy way to understand this is to cup your right hand and just lightly touch the hairs on your left arm. The motion of your hand moved your arm hairs and stimulated the nerve cells below. Most fishes contain the neuromasts in canals, either open mucous filled canals or closed canals, such as a lateral line. This helps buffer the stimulus of currents or other water movements not caused by other organisms. However, in the bathypelagic fishes the neuromasts are found in either wide open canals such as found in the flabby whale-fishes or on long stalks such as those found on the gulper eels! This may be due to the rather inactive life style of the bathypelagic fishes and gentler water movements. Water movements above the bathypelagic zone and at the very bottom in the benthos tend to be stronger. Also, many of the fish themselves are more active than the bathypelagic fishes, therefore, creating more water movement against the sensitive neuromast.



A rattail, Macrouridae



A free ending neuromast

Organisms of the Benthos and Near-Bottom

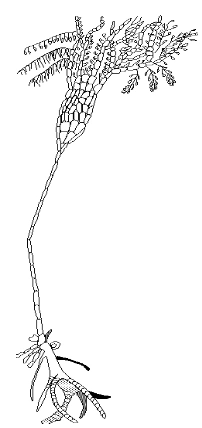
Animals that reside permanently on the bottom are called benthic organisms. Organisms that live on or near the bottom are known as **demersal** organisms. The **diversity** of organisms that live on or near the bottom is greater than that of the deep-sea pelagic organisms and they are usually of a larger size. There are about 1,000 known species of demersal fish alone between 1,000 and 7,000 meters depth. They are found just offshore all they way down to the deepest part of the ocean. The types of organisms change with increasing depth. In the deep sea there is total darkness in the bathypelagic zone, however, the benthic organisms here have a few advantages over their pelagic counterparts. They do not have to swim to keep themselves from sinking. They can just rest on the bottom; buoyancy is not a problem. In addition, anything sinking will end up on the bottom, instead of just passing through as it would in the meso and bathypelagic zones. Therefore, if you are looking for food, the bottom is where you will probably find it. The greater abundance and diversity of organisms in the deep-sea benthos as compared to the bathypelagic zone is a testament to this "easier existence".

An easier existence in the benthos and near-bottom not only allows a greater abundance and diversity of organisms but it also allows organisms to have more muscular bodies and better developed organ systems than is possible in the bathypelagic zone. More food, more muscle, and better-developed organ systems, all allow the benthic and near-bottom organisms a more active life style than that found in the bathypelagic zone.

The bottom of the deep sea is a very large habitat; it encompasses about 80 percent of the ocean floor and 60 percent of the earth's surface. Most of it is covered by sediment, usually soft muds and oozes. Exceptions would be near the crests of oceanic ridges and seamounts. There are organisms that live in the sediment called **infauna** and organisms that live on top of the sediment called **epifauna**. Most large animals of the deep-sea benthos are unique to that zone, though, they are similar in body structure or **morphology** to shallower benthic animals. Abundance and diversity decreases, as the distance from land and the depth increases. There are bacteria present in the sediments in the deep sea and here, just as everywhere else; they are the principal organisms responsible for **decomposition**.

One obvious difference that deep-sea benthic organisms have from shallow-water benthic organisms is that many are blind. In fact, less than ten percent of deep-sea species can even detect light.

Some benthic groups are more important in the deep sea than they are in the shallow water benthos. In fact, the elapsoid **holothurians** a group of sea cucumbers, are found in the deep sea and no where else! There are some areas of the deep-sea where sea cucumbers are the dominant organisms. There are also more species of **Crinoids** in the deep-sea benthos than there are in shallower waters.

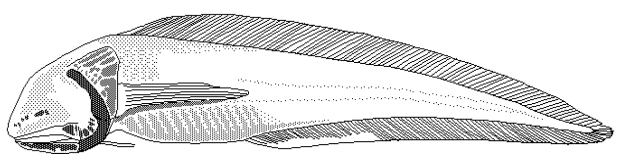


A crinoid

Polychaetes, the segmented worms that are so common in the shallow water benthos are also very common in the deep-sea benthos. Demersal shrimp are red, like their deep-water, pelagic cousins but they are heavily armored. They can afford this extra protection because staying afloat is not a problem for shrimp that live near the bottom of the ocean!

Many of the deep-sea near-bottom or demersal, fishes have an elongate body form. The most common of thesefishes are the rattails, (Macrouridae),brotulas (Brotulidae), and halosaurs (Halosauridae). There are many speculations as to why the elongate body form is so common. One theory is that a longer body allows for a longer lateral line and therefore greater sensory perception. Their lateral lines, unlike the bathypelagic fish, are usually in a canal which protects the specialized cells from the more rapid water movement caused by their stronger swimming ability.

Many of these fish also have an abundant outer coverage of sensory cells that allow them to literally “taste” the presence of prey. This allows them to locate prey without visual aid. They are usually slow swimmers. Most regulate their buoyancy using a swimbladder, just as most other bony fish, however, their swimbladders are often reduced. It is energetically expensive to maintain a large swimbladder and there is not much food in the deep sea. Many of the benthic fishes do not have a swimbladder since they just sit on the bottom. The demersal sharks use their large oily livers to regulate their buoyancy just like other sharks.



Abyssbrotula

The deepest living fish known is the demersal *Abyssobrotula galatheae*; (as seen above), a blind elongate fish that feeds on benthic invertebrates such as polychaetes (worms). It probably locates its prey using a well developed sense of smell. The sense of smell is often well-developed in demersal fishes. A deep-sea community that certainly deserves special mention is a hydrothermal vent community. The first one was discovered just in 1977 in the Galapagos Rift found between South America and the Galapagos Islands. The vents are found on rocky surfaces where new ocean floor is being formed by sea floor spreading. Seawater seeps through cracks in the new seafloor and comes back out at the vents, now super-heated at some vents up to 350°C. The scientists that discovered these vents also saw four foot tall tubeworms around the vents. Research on these giant tubeworms showed that these worms had no digestive system! How were these tubeworms growing so large? How were they digesting this unseen food? It turned out that these tubeworms had bacteria in their tissues that were using the chemicals spewing out from the vents to make food which the tubeworms were then utilizing!

Fun Facts

- The temperature of almost all of the deep ocean is only a few degrees above freezing, 39 degrees Fahrenheit.
- At the deepest point in the ocean the pressure is over eight tons per square inch, or the equivalent of a person supporting about fifty jumbo jets.

Discussion Topics/Questions

1. What is believed to be the world's most abundant fish? Where is it found?
2. What is the average depth of the ocean? Where is the deepest point? How did it get its name?
3. List and discuss the changes that occur in organisms the deeper they live in the water column.
4. How might some organisms find prey in the absence of light? Mates?

Activity III-1. Where do I live?

Have the students match the pictures with the organisms and tell where they think it lives (bathypelagic, epipelagic, deep sea benthic, shallow water benthic, mesopelagic, etc.) Have them list the adaptations the organisms might have and how they help them live where they do. Cut out the pictures from the following pages. Remove the names and descriptions from the student's copies.

Activity III-2. Build a Deep Sea Vent

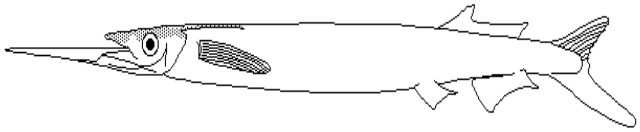
Build a deep-sea vent using paper mache, play dough, paint and what ever else they might find useful. Don't forget to show all of the organisms found there such as bacteria, giant bivalves, tubeworms and fish. There is also black smoke billowing out of the vents. Have them use their imaginations!

Activity III-3. Create a Drifter

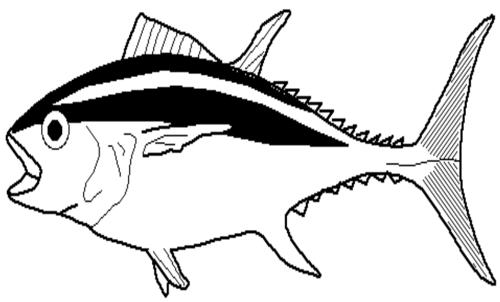
Build or draw a deep-sea, mid-water or benthic organism or, build or draw a deep-sea, midwater, or benthic environment. Use your imagination. What adaptations would be necessary to live there?

Report topics:

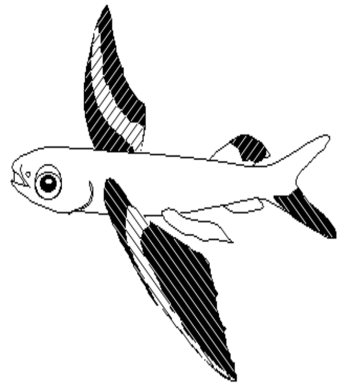
1. Deep Sea Vent Communities and history.
2. What is known about rattails (Macrouridae)? Where are they found? What are they related to? What do they eat?
3. Since sight is not important in the deep sea the importance of the sense of sound increases. How do fishes hear? Do fish have ears?
4. How do sharks regulate their buoyancy?



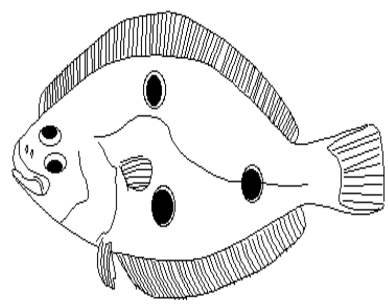
Ballyhoo *Hemiramphus brasiliensis*
silvery, greenish on back. Elongate lower jaw for funneling phytoplankton.



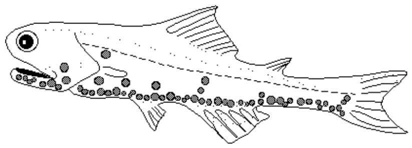
Bigeye tuna *Thunnus obsesus*
Elongate, streamlined body. Countershading with bluish-black above, silvery white below. Narrow caudal peduncle, lunate caudal fin. epipelagic



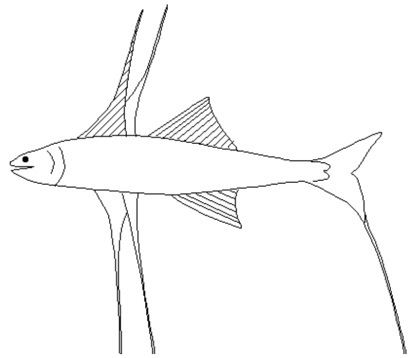
Bandwing flyingfish *Cypselurus exsiliens*
Body streamlined, elongate, bluish black above, silvery below. Enlarged pectorals for gliding in the air over the water's surface. epipelagic



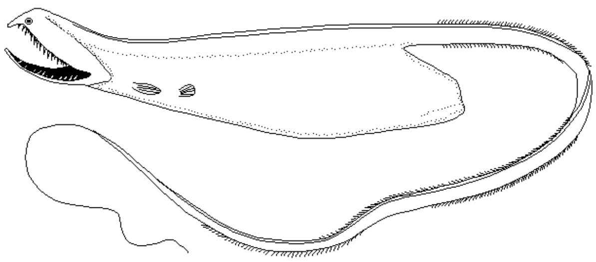
Gulf flounder *Paralichthys albigutta*
Body compressed. Both eyes on left side of head. Eyes large, protruding. benthic



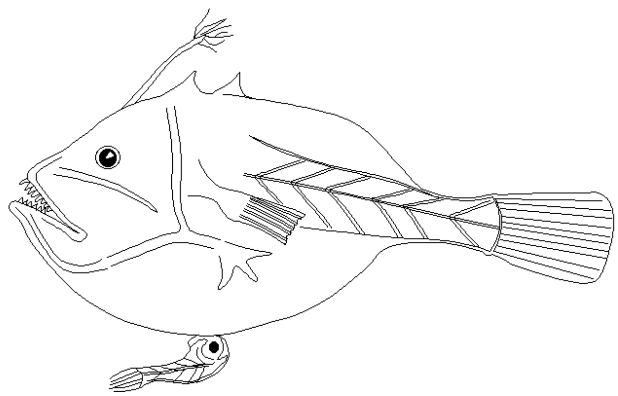
lanternfish *Myctophum punctatum.*
small size. many light organs.
large eyes.
Mesopelagic zone



tripodfish *Ipnopidae species*
Eyes tiny, almost absent. Elongate pelvic and dorsal fin rays. Fleshy pads with sensory cells for taste,on ends of elongated pelvics. Deepsea benthic



Gulper Eel Eurypharyngidae
Many light organs. Very small eyes. Extremely large mouth. Bathypelagic zone



Anglerfish *Haplophryne mollis*
Body transparent. Small eyes. Fishing lure. Large mouth and stomach. Males small. When the males find a female they bite in and become permanently attached. Mesopelagic/bathypelagic

STUDENT INFORMATION

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Organisms of the Bathypelagic Zone

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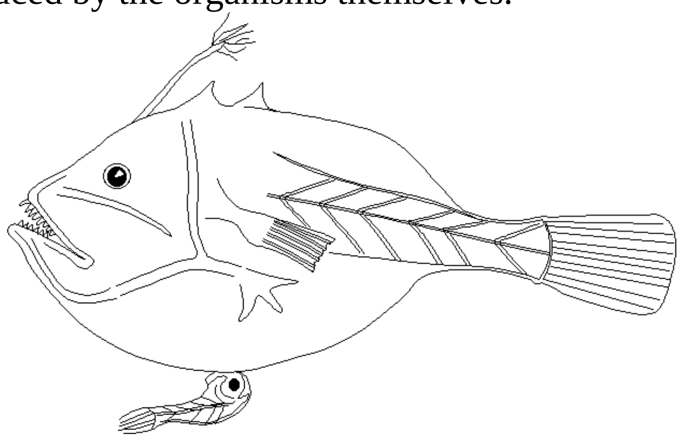

A female Anglerfish *Haplophryne mollis* and attached male.

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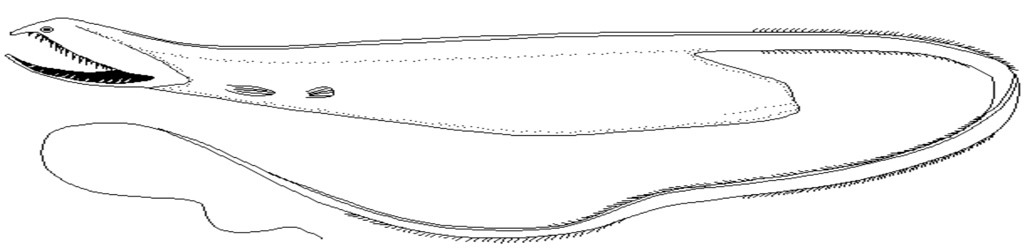

Eurypharyngidae

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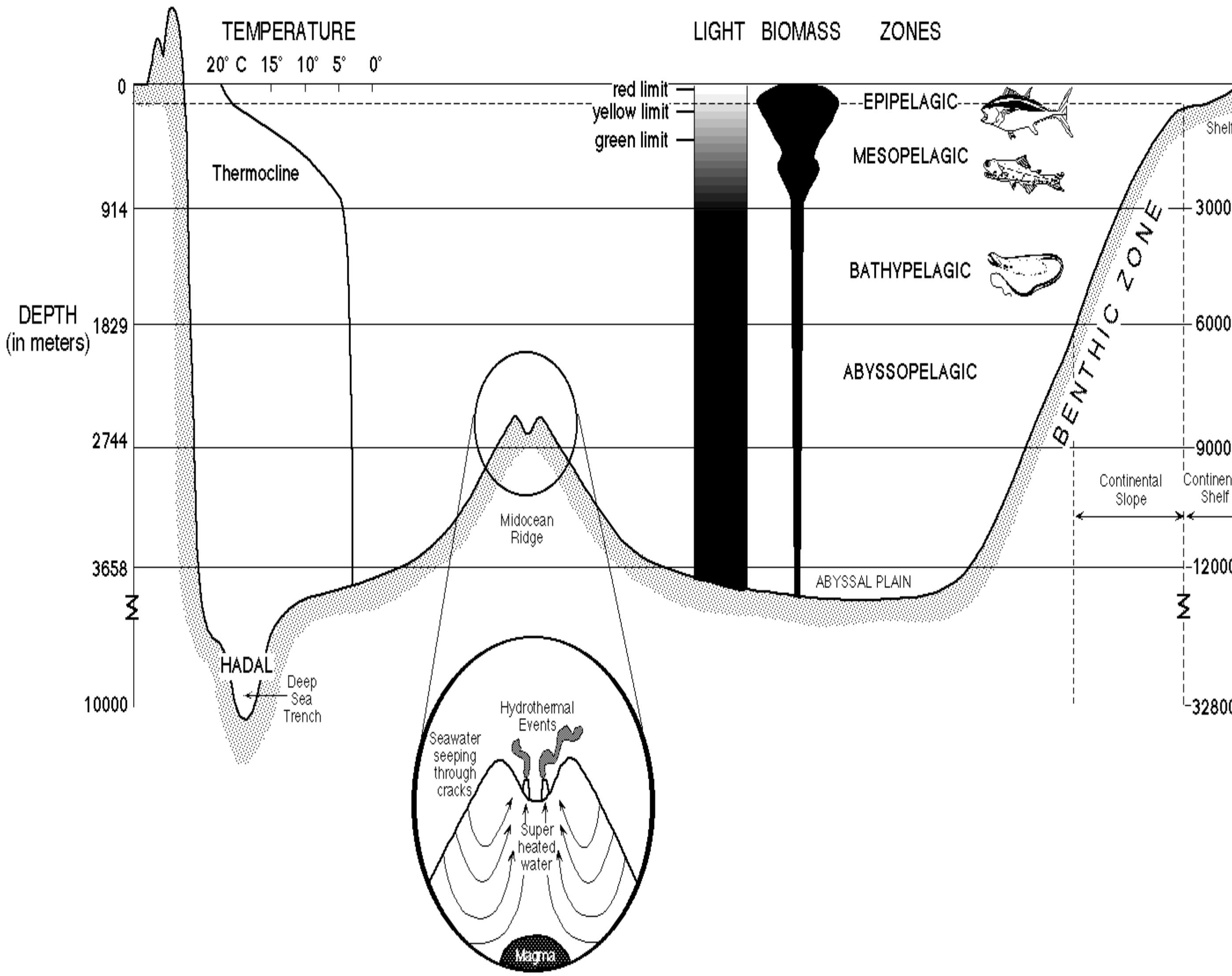
TEMPERATURE
20° C 15° 10° 5° 0°
LIGHT
BIOMASS
ZONES
red limit
yellow limit
green limit
EPIPELAGIC
MESOPELAGIC
BATHYPELAGIC
ABYSSOPELAGIC
Thermocline
DEPTH
(in meters)
0
914
1829
2744
3658
10000
3000
6000
9000
12000
32800
Shelf
BENTHIC ZONE
Continental Slope
Continental Shelf
Midocean Ridge
ABYSSAL PLAIN
HADAL
Deep Sea Trench
Hydrothermal Events
Seawater seeping through cracks
Super heated water
Magma