The Deep Ocean

I. Waters Below the Epipelagic
   a. Divided into the Mesopelagic and the Deep Sea
      i. Mesopelagic: the zone immediately below the epipelagic, or photic zone
         1. Usually from about 200 - 1000 m
         2. Usually some light, though it’s quite dim.
      ii. Deep sea
         1. Below 1000m
         2. Further divided by depth
            a. Bathypelagic: 1000-4000 m
            b. Abyssopelagic: 4000-6000 m
            c. Hadopelagic: >6000m
   b. Important Ecological Factors
      i. Lack primary production via photosynthesis
         1. Because it’s too dark, they rely upon production from above and the raining of food to live off of
         2. Therefore, life is much less abundant in this realm
            a. Typically 5 or 10 times fewer organisms at 500m than at the surface, and 10 times fewer at 4000m
      ii. Oxygen is supplied via deep thermohaline circulation
         1. Oxygen is brought to the deep ocean in a few places (North Atlantic and Antarctic) where water gets cold and salty enough to sink from the surface
            a. Called the great ocean conveyor

II. The Mesopelagic 200 – 1000 m
   a. World of twilight
      i. In the upper part there is enough light to see, though not enough for phytoplankton to grow
      ii. By 1000m there is no light at all, thus marking the bottom of this zone.
   b. Temperature
      i. Temperature varies much less than in the epipelagic.
      ii. The mesopelagic constitutes the permanent thermocline.
   c. Animals
      i. Tend to be diverse, though not very numerous
      ii. Often referred to as midwater animals.
      iii. Adaptations
          1. Many midwater animals have photophores, light emitting organs that produce bioluminescence.
             a. Helps to break up images and thus blend in with the background.
      iv. Important animals
          1. Krill and copepods are still the dominant members of the zooplankton
2. **Chaetognaths** can be, at times, the most abundant animals of the mesopelagic.

3. Jellies are also common
   a. Jellyfish, siphonophores, comb jellies, larvaceans and pteropods

4. **Squids**
   a. Strong swimmers are considered nekton, while some of the drifters are considered plankton
   b. Many have **photophores**
   c. Because they are almost entirely muscle, squid are very important food source for other predators, include many marine mammals, especially beaked whales
      i. Sperm whales feed almost exclusively on squid

5. **Midwater Fish**
   a. Most are small (2 to 10 cm)
   b. Bristlemouths and lanternfishes are the most abundant groups.
      i. The bristlemouth *Cyclothone signata* is the most abundant fish on earth.
      ii. Lanternfish are called as such because of their photophores. Because of the lack of food…

v. **Adaptations**
   1. Most fish tend to be small
   2. Large mouths with hinged, extendable jaws allows fish to take advantage of whatever comes along.

3. **Migrating vs. Non Migrating**
   a. Non-migrators include small zooplankton (copepods and krill) that feed on detritus.
      i. Also sit and wait predatory fish that ambush their prey, gulping down whatever comes along.
      ii. Lack much muscle, which is costly to maintain.
      iii. Most nonmigrators lack a swim bladder because in deep water it takes a lot of energy to fill it.
   b. **Migrators** vertically migrate on a daily basis, swimming up at night to feed and staying down low in the day to remain hidden in darkness.
      i. Have well developed muscles and bones
      ii. Use swim bladders to maintain buoyancy
      iii. Discovered during WWII as part of the **deep scattering layer** which got picked up on
sonar as a false bottom that would move up at night.

iv. Dominant organisms include lanternfishes, krill, shrimps, copepods, jellyfish and squid.

4. Sense Organs
   a. Tubular eyes
      i. Almost like two sets of eyes
      ii. Can see upward or forward, but not good for lateral vision.
      iii. Have a secondary retina that sees laterally.

5. Coloration
   a. Similar to epipelagic, midwater organisms use countershading, transparency and reduction of the silhouette.
   b. The deeper one goes, the more black or red the fish get (because red light doesn't penetrate to these depths, red appears as black)
   c. Many fish have compressed bodies and/or photophores to help break up silhouettes.
      i. Some animals can change the brightness of their bioluminescence to match that of the downwelling light.
      ii. In turn, some fish have filters on their eyes to distinguish between bioluminescence and real light.

6. Dealing with Lack of Oxygen
   a. At about 500m, there is usually an oxygen minimum layer, where the water is out of reach of the surface and respiration is high. In this layer, oxygen can be reduced to almost nothing.
   b. Many fish and invertebrates that live in this layer have very large gills to extract all the oxygen they need.
   c. They also have special hemoglobin that can work at low oxygen.

III. The Deep Sea
   a. Below 1000m, including the sea floor
      i. Bathypelagic: 1000-4000 m
      ii. Abyssopelagic: 4000-6000 m
      iii. Hadopelagic: >6000m (ocean trenches)
   b. Similar conditions in all of them
      i. Cold: 1 to 2 ° C
      ii. Always dark
      iii. Water properties (chemicals, salinity, etc) very constant.
   c. Characteristics of the Organisms
      i. No countershading
ii. Photophores not for breaking up silhouette, but for communication

iii. Small, but functional eyes

d. Lack of food
   i. 5% of food in euphotic zone makes it to this realm.
      1. Do not vertically migrate; it’s too far.
   ii. Not much life down there.

iii. Fish

   1. Fish are small. 10 cm or less.
   2. Even less muscle than in midwater
   3. More sedentary and ambush predators
   4. Some use lures on the ends of their heads to attract meals.
   5. Reproduction
      a. Hard to find mates
      b. Many are hermaphrodites
      c. Probably use bioluminescence.
      d. In some anglerfish, when the male finds a female, he bites onto her side and then attaches himself for the rest of his life. Called male parasitism.

e. Pressure
   i. The entire physiology must change and greater pressures, but we don't really understand how.
   ii. Fish don’t live below 8370m, but invertebrates can.

IV. Deep Sea Benthos

a. Not much known about it because it's very hard to sample.

   i. Use deep-sea submersibles or sleds to sample the bottom.

b. Feeding

   i. Mostly live off stuff that rains in from above, which is not a lot
      1. Also very low food quality
   ii. Food that does come down, stays on the bottom until it is eaten, thus it is not lost.

iii. Infauna are mostly deposit, not suspension feeders.

   i. Most abundant are polychaetes worms, crustaceans and bivalve mollusks. Sea cucumbers, brittle stars and sea stars may also be common in some areas.

iv. Predators

   1. Few, but present
   2. Sea spiders (pynogonids) can grown to >80cm
   3. Tripod fish sit on the bottom and eat passing plankton.

v. Sometimes, large pieces of food, called baitfalls, like a dead whale, sink to the bottom.

   i. Mobile animals rapidly congregate around this new food source.
   2. Include: amphipods, greanadiers, cusk eels, and hagfishes.
      a. Tend to be large, muscular fish adapted for cruising along the bottom, different from bathypelagic fish

V. Hydrothermal Vents
a. Discovered in 1977 off the Galapagos, a totally new biological community.
b. Communities vary greatly from vent to vent, but all have some commonalities.
   i. Primary producers are chemosynthetic archaea (an ancient form of prokaryote) and bacteria
      1. Sulfide minerals emerge at hydrothermal vents, containing lots of hydrogen sulfide (H$_2$S).
      2. The microbes use the H$_2$S to make inorganic matter that are the basis of the food chain.
      3. Live at temps above 110°C
   ii. The archaea and bacteria cloud the water, and some animals feed by filtering bacteria.
   iii. Giant tube worms
      1. Not filter feeders
      2. Use bacteria that perform chemosynthesis inside their bodies in special organs called a trophosome, feeding body
      3. The worm supplies the carbon dioxide and oxygen, as well as H$_2$S.
         a. Has special hemoglobin that transports H$_2$S.
   iv. Very ephemeral communities
      1. The vents can explode, killing everything.
      2. They can also go extinct, also killing everything.
      3. Therefore, organisms need to be able to move from ‘island’ to ‘island’
      4. Large baitfalls may act as islands that allow these communities to perpetuate
      5. Overfishing of these large marine organisms may impact these other communities.