Chapter 10 – The Open Sea

Chapter Summary

The pelagic realm is a three-dimensional, nutritionally dilute habitat wherein rates of primary production tend to be low, few obvious ecological niches are present, and two major ecological groups, the zooplankton and nekton, are dominant.

Zooplankton are represented by more than 5,000 species of permanent holoplankton (including all three protozoan phyla, cnidarians, ctenophores, chaetognaths, crustaceans, and invertebrate chordates), and larval stages of many invertebrates and fishes (the temporary meroplankton).

The many nektonic animals that inhabit the pelagic environment are strong swimmers that are able to move freely both horizontally and vertically. They have developed several adaptations that enable them to take advantage of this huge habitat. These adaptations include behavioral mechanisms such as vertical movements and schooling, and morphological adaptations such as a streamlined body shape, fins, and gas inclusions. Other physiological adaptations are also important, such as gas exchange mechanisms.

Small-scale variations in environmental features, as well as the local intensity of grazing or predation, chemical and physical gradients, and behaviors (such as aggregation or avoidance) result in patchy distributions within the pelagic realm, from several kilometers down to microscopic distances.

The pelagic realm is divided into the epipelagic zone, which corresponds to the photic zone, the mesopelagic, and the deep sea or bathypelagic zone. The epipelagic is abundant with both light and food from the primary producers; however, the risk of predation is high from the numerous predators that live in these well-lit waters. The mesopelagic is dimly lit so primary productivity is restricted and the only food available is that which slowly sinks from the epipelagic. However, the deep, dark waters of the mesopelagic represent a safe haven free from the predation pressures of the epipelagic. Perhaps because of these discrepancies in food supply and predation pressures, many mesopelagic animals undergo a complex vertical migration. Although the exact species composition of the vertical migrators and the direct advantages of this behavior are still poorly understood, it is thought that the feeding advantages may be enough to influence these animals to venture out on these long, nightly journeys.

Zooplankton feed using many diverse mechanisms. There are filter and suspension feeders, such as the gelatinous zooplankton, there are herbivorous grazers, such as the copepods, and carnivorous predators, such as the chaetognaths. Some complex trophic relationships are dependent on the species of zooplankton involved in the ecosystem. The Antarctic food web is an example wherein nearly all of the larger animals feed on one species of krill.

Morphological adaptations that have enabled animals to be successful in the pelagic realm include streamlined body shape, unique fin shapes, and swim bladders. Streamlined bodies along with specialized fins enable many fishes and mammals to be very fast and efficient swimmers. In addition, living and moving in three dimensions well above the seafloor creates buoyancy problems for pelagic animals because bone and muscle are more dense than seawater. Stored fats and oils, which are only slightly less dense than seawater, or an internal gas-filled flotation organ are common buoyancy devices employed by pelagic marine animals that enable them to exploit the entire pelagic environment. The body shape of a fast swimmer, such as a tuna or dolphin, is a compromise between different hypothetical body forms, each of which
reduces some component of the total drag and enables the animal to slip through the water with as little resistance as possible. Moreover, nearly 75% of the total body weight of a tuna is composed of swimming muscles. The major blood source for the red muscle masses of most tuna is a cutaneous artery that is associated with extensive countercurrent heat exchangers that facilitate heat retention within the red muscle. As a result, little of the heat generated in the red muscles is lost and the have red muscle masses that are much warmer than the surrounding water.

A great number of fishes, squids, and larger crustaceans travel in well-organized schools. These schools usually consist of a single species, with all members similar in size and speed. Schooling probably provides some degree of protection to those species that utilize this behavior.

Larger and faster nekton participate in regular and directed migrations that serve to integrate the reproductive cycles of adults into local and seasonal variations in patterns of primary productivity. Migration routes, which can be inferred by employing visual or electronic tags and from distributional patterns of eggs, larvae, and variously aged individuals of a species, often correlate well with patterns of ocean surface currents. Because some of these migrations can be very lengthy, it has always been of considerable interest to scientists to elucidate the mechanisms of orientation. Although precise mechanisms of orientation are poorly understood, it is thought that biological clocks are important factors in the timing aspect of navigation, and a variety of environmental factors, such as day length, water temperature, and food availability, serve as cues to adjust or reset the timing of these clocks. In addition, spatial orientation may be aided by ocean currents, temperature, landmarks, and celestial cues. Examples of species that perform extensive oceanic migrations include salmon, green sea turtles, California gray whales, and anguillid eels.

To compensate for reduced visibility and their inability to smell under water, odontocetes and some other groups have a sophisticated system of echolocation for target detection and orientation.

**Objectives**

1. To introduce the major taxonomic groups of zooplankton.
2. To describe the environment that is the pelagic realm.
3. To describe the vertical migration of zooplankton.
4. To discuss the vertical distribution of nektonic animals.
5. To summarize the unique feeding mechanisms of characteristic members of the zooplankton community.
6. To study the buoyancy strategies of nekton.
7. To summarize mechanisms of locomotion in fishes and other nekton.
8. To study schooling as a unique adaptation of the nekton.
9. To examine the details of how migration integrates feeding and reproduction in an exemplary species, the northern elephant seal.
10. To examine some extensive oceanic migration patterns in an effort to deduce mechanisms of orientation and navigation.