CHAPTER 14 THE LIVING OCEAN

Objectives

1. To better understand the complex environments that are found in, and adjacent to, the ocean basins.
2. To learn how the changes in important physical properties in the oceans, including temperature, pressure, concentration of dissolved gases and nutrients, and the availability of light effect marine organisms.
3. To see how organisms can adapt to survive in the ocean realm.
4. To review the processes that create habitats in the sea and how they, in turn, affect marine organisms.

Key Concepts

Major Concept (I)

The tremendous variety of marine organisms that inhabit the diverse oceanic environment are classified into groups to simplify identification and illustrate similarities and differences between them.

Related or supporting concepts:

- Marine organisms are divided into the following three groups based on their life styles and habitat:
    a. plankton that float or drift with the currents and includes both animals and plants (fig. 14.1),
    b. nekton that are able to swim freely and includes only animals (fig. 14.2), and
    c. benthos that live attached to, on, or in the bottom substrate of the sea floor and may include plants and animals (fig. 14.3).
- The scientific classification of organisms is known as taxonomy.
- More than 200 years ago Carolus Linnaeus proposed the first classification scheme that divided organisms into two kingdoms, plants and animals.
- The Linnean system has since developed into a five-kingdom system that is the most widely used classification system today. The five kingdoms in this system are: Monera (single-celled organisms without a membrane-bound nucleus), Protista, Fungi, Plantae, and Animalia.
- A new system (fig. 14.4) that is based on genetic and biochemical research defines three **domains** above the kingdom level:
    a. Bacteria,
    b. Archaea, and
    c. Eukarya (all nuclei-containing organisms)
- Members of the Monera Kingdom are placed in either the Bacteria domain or the Archaea domain. The Eukarya domain includes all other Kingdoms.
- Classification schemes for living organisms are always subject to modification as new discoveries are made.

Major Concept (II)

In the vast oceanic environment, both the water and the sea floor are divided into specific zones that have distinct characteristics and support different populations of organisms (fig. 14.5).

Related or supporting concepts:

- The two major (and most obvious in terms of their differences) zones in the marine environment are the pelagic zone, which is the water, and the benthic zone, which is the sea floor. Each of these is further subdivided into a number of smaller zones.
- The pelagic zone consists of two subdivisions; the neritic zone (water lying above the continental shelf), and the oceanic zone (the main body of water that lies off the continental shelf). The oceanic zone is vastly larger that the neritic. The relatively small neritic zone is distinguished from the rest of

the water realm because of the tremendous variations found in this shallow environment.

- The oceanic zone is then further subdivided on the basis of depth into the following zones:

Zone	Depth Range (m)	Depth Range (ft)
epipelagic	0–200	0–660
mesopelagic	200–1000	660–3300
bathypelagic	1000–4000	3300–13,200
abyssopelagic	4000–deepest depths	13,200–deepest depths

- All oceanic zones with the exception of the epipelagic are aphotic. The epipelagic and neritic zones coincide roughly in depth and are both in the photic region of the water.
- The benthic zone is divided into the following zones:

Zone	Depth Range (m)
supralittoral (splash)	area just above the high water mark, where wave spray can reach
littoral (intertidal)	area between low and high tide
sublittoral (subtidal)	the rest of the continental shelf below low tide level
bathyal	200–4000 (660–13,200 ft)
abyssal	4000–6000 (13,200–19,800 ft)
hadal	6000–deepest depths (greater than 19,800 ft)

- The properties of the littoral and epipelagic zones depend on latitude and time, ranging from tidal periods to annual cycles, since they are so shallow.
- The hadal zone shows no seasonal change and is associated with the ocean's trenches and deeps.

Major Concept (III)

Organisms that live on land are surrounded by the low-density atmosphere, and hence, must expend a lot of energy in supporting themselves. Marine organisms are surrounded by seawater, which has a density close to their own and provides some of the necessary support. Special adaptations by many organisms provide additional support.

Related or supporting concepts:

- The support that seawater provides for marine organisms is called buoyancy. It helps keep floating organisms near the surface, reduces the amount of energy used by swimming organisms, and helps support bottom-dwelling organisms.
- In additional to the buoyancy of seawater, many organisms have developed special mechanisms that allow them to easily maintain a preferred depth in the water.
- A wide variety of organisms have the ability to secrete and store gas in their bodies to lower their overall density and increase their flotation. These include:
    a. some jellyfish-type organisms such as the Portuguese man-of-war and the by-the-wind sailor,
    b. some varieties of algae,
    c. floating snails,
    d. the chambered nautilus,
    e. the cuttlefish (a relative of the squid), and
    f. fish with swim bladders.
- Fish with swim bladders fill them by either gulping air at the surface or releasing gas from their blood.
- While it is relatively easy for fish with swim bladders to maintain a constant level in the water, they must regulate the gas pressure in their swim bladders to change depth. As a fish dives deeper, the gas in its bladder will be compressed and provide less buoyancy. If it ascends, the gas will expand.
- Fish that live at great depths, 7000 m (23,000 ft) or more, and fish that migrate vertically have fat-filled swim bladders.
- Two classes of fish that do not have swim bladders are those that swim constantly and use their fins to maintain position (such as mackerel, some tuna, and sharks), and bottom-dwelling fish.
- Some very small animals and plants store their food reserves as droplets of oil. This has the effect of

reducing their overall density.

- Increasing the surface area of an organism relative to its volume helps it maintain its position in the water column by increasing the frictional drag with the water. Microscopic plants and some animals do this by having a spherical shape, being small, and often developing spines or complex extensions that increase the drag even further.
- Large organisms generally have tissue that has a higher density than seawater so they have developed a number of ways to minimize their density. These include:
    a. the replacement of high-density ions in body tissues with low-density ions by some squid,
    b. the storage of low-density fat, or blubber, by whales and seals, and
    c. the storage of oil in muscles and the liver by sharks and some fish.
- Birds are particularly well adapted considering the fact that they do not live underwater. Seabirds use a combination of hollow bones, stored fat deposits, air sacks, and an oily secretion called preen that seals their feathers and traps air between the feathers and the skin to make it easy to float on the surface and retain body heat.
- In general, the buoyancy provided by the seawater that they live in allows marine organisms to be relatively delicate creatures and still survive in their environment.
- Delicate animals also move with the current in the sea rather than having to have mechanical strength to withstand the water's motion (think of the difference between a tree and a piece of thistledown in the wind).

Major Concept (IV)

The difference in salt content between seawater and the body fluids of most marine organisms causes a migration of water molecules through cell membranes in a process called osmosis.

Related or supporting concepts:

- The body fluids of marine organisms are separated from seawater by semipermeable membranes (cell walls) that allow the passage of water molecules but inhibit the passage of salts.
- Most fish have body fluids with lower salt concentrations than seawater, thus water molecules tend to move from the organisms to the seawater by osmosis.
- To prevent dehydration, fish must constantly work to expel salt from their tissues and increase the concentration of water molecules. They do this by drinking large volumes of seawater and expelling the salt through their gills.
- Some organisms, like sharks and rays, have body fluids that have salt concentrations nearly equal to that of seawater so they are not faced with this problem.
- Many organisms can effectively maintain a fluid balance only when the difference in salt concentration is small. In this way they will be limited in their ability to move long distances by salinity variations in the water. The largest salinity changes occur in shallow water, particularly near coastlines, so organisms that live near the surface or the coast are usually more limited in their distribution. Deep-water organisms can disperse over broad regions because of the nearly constant salinity of deep water.
- Some animals can survive drastic salinity changes over their lifetimes. An excellent example is the salmon, which spawn and spend the juvenile portion of their lives in fresh water before moving out to sea as adults. The Atlantic common eel has a life cycle that is exactly opposite that of the salmon.
- Some species are limited in their ability to move anywhere they want to by changes in salinity.
- Salinity barriers are more common in shallow water than in deeper water and they are most common in coastal water where runoff from the land can alter the salinity dramatically and rapidly.

Major Concept (V)

Temperature variations in seawater have an effect on marine life in two ways. Changes in temperature result in density changes in the water that affect buoyancy, and temperature plays a role in determining the metabolic rates of cold-blooded organisms.

Related or supporting concepts:

- A decrease in temperature results in an increase in the density of seawater and the buoyancy it provides for marine organisms. In general, microscopic organisms that inhabit warm water develop spines and ornate appendages, have larger surface areas, and more frequently produce gas bubbles to increase their flotation, while those that inhabit cold, more viscous water can retain smoother profiles and still have little trouble remaining near the surface.

- Stable water columns with increasing density with depth, or decreasing temperature with depth, allow near-surface organisms to remain at shallow depths, thus enhancing rates of photosynthesis and increasing productivity. Unstable water columns result in sinking surface water that carries organisms out of the photic zone and decreases the region's productivity.
- Marine animals have different ways of regulating their body temperature. Most fishes and all subtidal invertebrates vary body temperature according to the environment. These organisms are known as poikilotherms.
- Poikilotherm body temperatures will vary with changes in their environment. In cold water, metabolic rates will usually be lower and growth rates of organisms will be slower, although they can attain larger sizes. The opposite will be true in warm water.
- Seabirds and mammals are homeotherms. They maintain nearly constant body temperatures that are well above the temperature of the seawater.
- Homeotherms are less restricted by temperature changes and their natural habitats cover broader regions. An excellent example of this is the annual migration of whales between polar and tropical waters.
- Some fish are able to store heat in muscle tissue allowing them to swim rapidly for long distances and durations in cold water. These are good predators and include some tuna, sharks, and dolphin fish.
- At depths below the thermocline, temperature is nearly constant regardless of latitude, producing a very stable environment.

Major Concept (VI) *The change in pressure with depth in the seas is so great that organisms must adapt in special ways to survive.*

Related or supporting concepts:

- The greatest effect that increasing pressure with depth has on marine organisms is in the compression of gas-filled cavities or lungs.
- Deep-dwelling organisms such as worms, crustaceans, and sea cucumbers, are not affected by pressure because they do not have gas-filled cavities or lungs.
- Marine mammals can dive to tremendous depths and remain underwater for long periods of time because of a variety of physiological adaptations. These include:
    a. streamlined shapes that reduce drag, increase swimming efficiency, and reduce oxygen consumption,
    b. a much higher concentration of the protein myoglobin, which binds oxygen in muscle tissue, compared to similar terrestrial organisms (concentrations as much as 3 to 10 times higher),
    c. lungs that completely collapse during dives, preventing absorption of gases under pressure into the blood,
    d. the diverting of blood flow away from all parts of their bodies except the brain and heart, and
    e. the tolerance of higher concentrations of dissolved gases and waste products in their blood and tissues than land animals.
- Deep-diving marine organisms often have a very high oxygen capacity for their body weight. Weddell seals have an oxygen capacity of 87 mL/kg and penguins have an oxygen capacity of 55mL/kg. Both of these are much higher than human oxygen capacity of about 20 mL/kg.
- Sperm whales can dive to depths exceeding 2000 m (6600 ft) in search of food. Record diving depths for a variety of animals are given in table 14.2 in your book.
- Human divers deal with the increased pressure either by descending in a rigid pressure suit or by breathing gases under the same pressure as the environment. Air breathed under pressure for extended periods can cause the buildup of nitrogen in the blood and tissues. Rapid ascent may produce nitrogen bubbles in the blood and tissues, causing the bends, a condition that can be crippling and even fatal.

Major Concept (VII) *Most life in the marine realm requires carbon dioxide and oxygen.*

Related or supporting concepts:

- Carbon dioxide enters the water through exchange with the atmosphere, production by respiration, and the decay of organic material. It is required by plants for photosynthesis.
- There is no shortage of carbon dioxide in seawater so it is not a limiting factor for plant productivity.
- Carbon dioxide also plays a critical role in buffering the pH of seawater, thus making it a stable environment for life.
- Oxygen enters the oceans at or near the sea surface by direct exchange with the atmosphere and production in photosynthesis. The availability of oxygen at depth depends on vertical mixing to bring it from the surface.
- The saturation value of oxygen in seawater is a function of the water's temperature, salinity, and pressure. The solubility of oxygen increases as the temperature and salinity decrease and as the pressure increases.
- On warm, quiet days, the temperature and salinity of water in shallow pools and bays can increase, thus decreasing the water's ability to hold oxygen.
- Organisms living in shallow coastal waters where the oxygen concentration in the water can drop in response to environmental conditions can be easily driven out into deeper water where conditions are more uniform.
- Only anaerobic, or non-oxygen-requiring, bacteria may populate deep, isolated basins with little or no dissolved oxygen in the water.

Major Concept (VIII) *The sea's plant life requires nutrients to survive and the lack of any essential nutrient will adversely affect plant productivity.*

Related or supporting concepts:

- Two nutrients that act as fertilizers for ocean plants are nitrate (NO_3^-) and phosphate (PO_4^{-3}).
- Nutrients are removed from surface waters and incorporated into plant tissue during photosynthesis.
- These nutrients are returned to the water either through the expelling of waste products or at depth as a result of the decay of organic material.
- Nutrients that are released at depth are brought back to the surface in zones of upwelling. These regions typically have very high levels of productivity because of the nutrient rich waters. In addition, these upward moving waters are often cold and therefore rich in important dissolved gases as well.
- Diatoms require dissolved silica to form their rigid outer coverings.
- Iron, manganese, and zinc are required in some physiological systems.
- Zinc and copper are required in some enzyme systems.

Major Concept (IX) *The oceans can be divided vertically into two layers, an upper photic zone, where sufficient sunlight penetrates to support photosynthesis and a lower aphotic zone, where the intensity of sunlight is too low or doesn't penetrate at all, so there is no photosynthetic activity.*

Related or supporting concepts:

- Water is semi-transparent to sunlight; sunlight will pass through water and gradually be absorbed and scattered until, at some depth, there is total darkness.
- The depth of the photic zone at any given location depends on how rapidly light is absorbed and scattered at that spot. This can change with varying sea surface conditions, time of day, and the seasons.
- Sunlight will penetrate to greater depths if the Sun's rays are more nearly perpendicular to the water's surface, if there is less suspended particulate matter in the water, and if the light is closer to the blue-green wavelengths of the spectrum.
- The base of the photic zone is the depth at which the intensity of solar radiation is too low to support

photosynthesis (this does not necessarily mean that there is absolutely no light). This is also the top of the aphotic zone.

- Ironically, where the conditions for plant productivity are best, single-celled plants may multiply to numbers large enough to limit light penetration and reduce the depth of the photic zone.
- Sunlight alone is not sufficient for plant productivity. Plants require nutrients also.

Major Concept (X)

In addition to sunlight, another kind of light is produced through a chemical reaction called bioluminescence in marine organisms.

Related or supporting concepts:

- Bioluminescence is produced by a chemical interaction between the compound, luciferin, and the enzyme, luciferase. It is the same process we more often see in fireflies or glowing fungus on land.
- Bioluminescence produces light with a 99% efficiency.
- A wide variety of organisms are bioluminescent, including microscopic organisms in shallow water, squid, shrimp, and some varieties of fish.
- Bioluminescence of plankton is triggered by agitation in the water that disturbs the organisms. The wake of a boat will often glow at night with bioluminescence.
- Animals that feed on bioluminescent organisms can concentrate these chemicals in their systems and glow, for example, jellyfish.
- Some mid-depth and deep-water fish have organs called photophores that produce visible light that can be used for identification or communication, to lure prey or confuse predators, or to help the fish see in total darkness.
- Other fish have photophores on their ventral (lower) surface, making them more difficult to see from below when viewed against the lighter surface water.
- Some fish have photophores below their jaws or on the end of flexible dorsal spines that act as lures for prey.

Major Concept (XI)

Marine organisms use color to their advantage in many different ways. Color is definitely used to enhance survival through camouflage and as a warning to predators. It is probably used in other ways as well that will be discovered through additional study.

Related or supporting concepts:

- Color in varying intensities, or the lack of it, can be used as camouflage to hide organisms from predators. Examples include:
    a. transparent organisms such as jellyfish that are hard to see in the water,
    b. some varieties of fish that have dark backs and light underbellies (fig. 14.10), a pattern called countershading, so they are difficult to see from above against the dark deep water and from below against the light surface water (herring, tuna, and mackerel are examples),
    c. drab colored fish of coastal, temperate regions that blend with the color of kelp beds and are difficult to see in turbid water,
    d. bottom-dwelling fish that can change their color like chameleons to match the sea floor (fig. 14.12), and
    e. shrimp that are red when seen at the surface are difficult to detect in the deep water where they live because red wavelengths of light are rapidly absorbed in seawater. When a red object is illuminated by blue light it will appear black.
- Color can also confuse a predator by directing it to a relatively non-vital part of the prey's body. This is often the case with bright colored tropical fish that have markings similar to false eyes on the rear part of their bodies.
- Some fish use color to advertise their presence. Bold coloration increases during the breeding period of some species, possibly to attract a mate.
- Bright colors may also serve as warnings to potential predators that the prey is poisonous or unpalatable for some other reason (a biological STOP sign). This is the case for some sea slugs and

poisonous shellfish.

Major Concept (XII) *The constant motion of water in the oceans affects the distribution of organisms and patterns of productivity in the seas, both by transporting the nutrients and gases necessary for life and by carrying floating or drifting organisms with the currents.*

Related or supporting concepts:

- Ocean circulation plays a critical role in bringing food, nutrients, and dissolved gases to organisms as well as in dispersing their waste products.
- Upward motion of deep water replenishes the photic zone with nutrients that are critical for photosynthesis. In addition, the cold, oxygen-poor water absorbs oxygen from the atmosphere and from the near surface waters where it is produced by photosynthesis. These areas of upwelling are very productive biologically.
- Regions of down welling usually correspond to surface areas of low biological productivity. The surface convergence in these areas often concentrates organisms in a small region, creating good feeding grounds for other animals.
- The currents can carry plants and animals that have no independent mobility. In order to avoid being carried beyond suitable environments, some drifting organisms will descend deeper during the night to levels where the currents move in the opposite direction of those at the surface so they can return to roughly the same location they started from during the day.
- In other cases, populations appear to remain in the same location by reproducing rapidly on the upstream end of a current to replace the organisms lost at the downstream end.

Major Concept (XIII) *Organisms that live on the sea floor must adapt to different types of bottom.*

Related or supporting concepts:

- The bottom on which an organism lives is called the substrate.
- Examples of different substrate include rock, mud, sand, or gravel.
- The substrate provides food, shelter, and a place of attachment.
- Organisms that live on, such as crabs, or attached to, such as barnacles, the substrate are called epifauna.
- Organisms that burrow and live buried in the substrate, such as clams, are called infauna.
- Substrates are most variable along shallow coastal areas. Here we can find rocks, gravel, sand bars, and mud flats along the same strip of coast.
- At increasing distance from the shore and depth below the surface the substrate particles become smaller and eventually the substrate is very homogeneous.
- Sediment grain size is also important for bottom-dwelling organisms. Seaweeds may require rocks or large cobbles for attachment while a burrowing worm would need fine-grained mud.
- Infauna that derive some of their nourishment by ingesting sediments are called deposit feeders. The sediment typically includes some organic matter.
- Organisms attached to the sea floor often modify their habitat in ways that provide food, shelter, and additional surfaces for the attachment of additional organisms. Examples include seaweed forests, eel grass beds, and coral reefs.

Major Concept (XIV) *Many organisms form close relationships with other organisms.*

Related or supporting concepts:

- Close relationships between dissimilar organisms are forms of symbiosis.
- A relationship in which one partner benefits but the other is not affected is called commensalism.
- A relationship in which both partners receive benefits from the relationship is called mutualism (fig. 14.13).
- A relationship in which one partner benefits at the expense of the other partner is called parasitism.

Major Concept (XV) *While it may seem as if there are no limits to movement for organisms in the oceans, they can be restricted both horizontally and vertically by a number of different types of invisible barriers.*

Related or supporting concepts:

- Barriers to movement in the oceans can be created by changes in a number of different physical properties that will restrict the movement of specific organisms. These include changes in temperature, pressure, salinity, turbidity, and sunlight, as well as more substantial barriers such as sea floor topography that may isolate basins from one another.
- In general, the significance of barriers decreases with increasing depth because of the nearly constant physical properties of deep water.
- Horizontal boundaries in shallow water are often caused by two or more water masses meeting.
- Vertical boundaries in shallow water are often the result of strong thermoclines, haloclines, and/or pycnoclines.

Major Concept (XVI) *Human interaction with the marine environment has increased dramatically over the last 150 years--so much so that we have altered and modified extensively both habitats and ecosystems. As our knowledge of habitats, organisms, and their interactions increases, we may have the opportunity to prevent, decrease, or mitigate our actions.*

Related or supporting concepts:

- Habitat alterations and modifications of our coastal areas have been extensive.
- The impact of human activities is greatest in coastal bays and estuaries where marine environments are small and somewhat isolated from the open ocean.
- In some cases habitats have been artificially altered to enhance the survival of one species (considered desirable for some reason) over other species (considered relatively undesirable). One example is the construction of artificial reefs to increase and concentrate the population of sport fish.
- Many activities in coastal regions do not destroy habitats so much as they simply alter them.
- Many regions employ a coastal-management philosophy called mitigation. If a project will result in the destruction or alteration of a habitat, the developer may be required to mitigate the ecological impact by either purchasing additional real estate of a similar habitat that will be preserved or re-engineering an area to create a similar habitat that can be preserved.
- Pressures to develop the deep-sea for mining and energy will undoubtedly increase in the future. Possible projects include tropical OTEC plants and mining manganese nodules.
- How mitigation can be effectively carried out in the open-ocean or deep-sea environments has not been considered yet.

Matching Key Terms with Major Concepts

At the end of the chapter in the textbook is a list of key terms. You should be able to match each of these with one of the previously listed major concepts. To test your ability, try to match the following key terms with the number (I–XVI) of the appropriate major concept identified in this section:

nitrate	barrier	neritic zone
buoyancy	substrate	anaerobic
plankton	bioluminescence	photophore
phosphate	osmosis	mesopelagic zone
mitigation	camouflage	bends
nekton	cold-blooded	photic zone
benthos	littoral zone	luciferase

poikilotherm	homeotherm	taxonomy
domain	hadal zone	epipelagic zone
flotation	countershading	epifauna
infauna	deposit feeder	symbiosis
commensalism	mutualism	parasitism

Test Your Recall

Answer the following questions to test your understanding

FILL IN THE BLANK

1. Water provides ____________________ to support marine organisms because of its relatively high ________________ , compared to air.
2. Many fish have gas-filled _______________ ___________________ to help them become neutrally buoyant.
3. Small organisms maximize their ___________ ___________ - to - volume ratio to increase floatation.
4. Water molecules pass across membranes in a type of diffusion called _____________________.
5. Most marine organisms are ________________ - blooded.
6. Divers breathing air under pressure must be particularly careful to guard against the effects of increased __________________ in their blood and tissues.
7. Organisms that do not require oxygen are called ___________________.
8. Photosynthesis consumes ___________ ____________ and produces ________________.
9. The zone in which there is no photosynthesis is called the _______________________ zone.
10. Bioluminescence is produced by an interaction between the compound ______________________ and the enzyme _______________.
11. Many deep and mid-water fish carry light producing organs called _______________________________.
12. Many tropical fish have very ______________________ colors.
13. Zones of upwelling often coincide with regions of ______________ productivity near the surface.
14. Zones of down welling often coincide with regions of _____________ productivity near the surface.
15. The material of the sea floor is called the _________________.
16. The sea floor environment is called the ________________ zone.
17. The water over the continental shelf is called the _____________ zone.
18. The sea floor zone often associated with deep trenches is the _______________________ zone.
19. Organisms that float or drift with the currents are ________________.
20. Free-swimming organisms are called ___________________.

TRUE - FALSE

1. Some marine organisms increase their flotation by secreting gas bubbles.
2. Many single-celled organisms are small and roughly spherical to help them remain near the surface.
3. Most marine fish have water molecules passing into their tissues by osmosis.
4. Marine organisms generally use less energy to maintain position in their environment than land organisms.
5. Some fish store salt in their gills.
6. Species may be geographically limited by changes in water temperature or salinity.
7. There are usually more barriers present in coastal and shallow waters than in deep mid-ocean waters.
8. Some species of organisms can be isolated on the tops of submerged mountains.
9. Marine fish are able to regulate their body temperatures.

10. Air-breathing marine mammals can remain submerged for no longer than half an hour.
11. Oxygen in the deep waters of the oceans comes from, at, or near the surface.
12. The aphotic zone is the region where no sunlight penetrates the water.
13. The photic zone is always highly productive because of the availability of sunlight.
14. Bioluminescence is due to a chemical reaction.
15. Some marine organisms can change color to match their surroundings.
16. Floating organisms can ride opposing currents at different depths to maintain a relatively constant position from day to day.
17. Bottom topography can isolate organisms to specific regions of the sea floor.
18. Organisms that live on substrate are carnivores.
19. The bathyal zone is below the abyssal zone.
20. The most general taxonomic category is the phylum.

MULTIPLE CHOICE

1. The buoyancy of water
   a. is a result of its relatively high density.
   b. helps minimize the energy expended by marine organisms.
   c. increases with increasing salinity.
   d. increases with decreasing temperature.
   e. all of the above.
2. The swim bladders of fish
   a. have a tendency to expand as fish approach the surface.
   b. have a tendency to contract as fish dive.
   c. help fish remain neutrally buoyant.
   d. a and b above.
   e. all of the above.
3. In the process of osmosis
   a. water molecules tend to pass out of the tissues of fish.
   b. water molecules tend to pass into the tissues of fish.
   c. salt molecules pass out of the tissues of fish.
   d. salt molecules pass into the tissues of fish.
   e. a and d above.
4. Species may be limited in their geographic distribution by changes in
   a. temperature.
   b. salinity.
   c. density.
   d. light intensity.
   e. turbidity.
   f. all of the above.
5. The Atlantic common eel
   a. has a low tolerance to salinity changes.
   b. spends its juvenile stage in seawater.
   c. spends its mature stage in seawater.
   d. spends its entire life span in the Sargasso Sea.
   e. is a freshwater eel.
6. Productivity at and near the surface is enhanced
   a. by a stable water column.
   b. by an unstable water column.
   c. in zones of upwelling.
   d. a and c above.
   e. b and c above.
7. Metabolic processes of marine organisms are often controlled, in part, by
   a. temperature.
   b. color.
   c. turbidity.

d. salinity.
e. buoyancy.

8. Seasonal changes have the largest impact on organisms in
   a. deep polar waters.
   b. shallow coastal water at mid-latitudes.
   c. coastal waters near the equator.
   d. intermediate depth water in the tropics.
   e. deep water at mid-latitudes.
9. Organisms that live on the deep sea floor typically
   a. secrete gases into swim bladders for floatation.
   b. are spherical to maximize their surface area-to-volume ratio.
   c. are brightly colored.
   d. drift with the currents.
   e. lack gas-filled cavities or lungs.
10. Air-breathing marine mammals can dive deeply for long periods of time because
    a. their blood can absorb higher concentrations of dissolved gases without ill effect.
    b. they can divert blood flow away from non-vital body parts for short periods of time.
    c. they can temporarily collapse their lungs completely.
    d. all of the above.
    e. none of the above.
11. Sperm whales have been known to dive to depths of as much as
    a. 2000 m.
    b. 1000 m.
    c. 500 m.
    d. 100 m.
    e. 50 m.
12. Which of these statements is true of carbon dioxide in the oceans?
    a. it helps to buffer the pH of seawater
    b. it is consumed by plants
    c. it is produced by animals
    d. it is produced by the decay of organic matter
    e. all of the above
13. The amount of oxygen in the water is influenced by
    a. the temperature of the water.
    b. the pressure of the water.
    c. the salinity of the water.
    d. a, b, and c above.
    e. a and b above.
14. The photic zone
    a. is the upper 100 m of water.
    b. is the same as the littoral zone.
    c. varies in depth depending on a number of factors.
    d. is most heavily populated by benthic organisms.
    e. none of the above.
15. Bioluminescence
    a. is common in whales.
    b. produces heat for cold-blooded organisms.
    c. is a chemical process.
    d. is similar to fireflies on land.
    e. c and d above.
16. Some fish are very brightly colored
    a. at extreme depths.
    b. to send warnings.
    c. to attract predators.
    d. all of the above.

e. none of the above.

17. Zones of upwelling
    a. help plankton remain near the surface.
    b. return oxygen from the surface to deep waters.
    c. bring warm water to the surface to enhance photosynthesis.
    d. are often regions of low productivity.
    e. are related to areas of surface convergence.
18. Barriers in the oceans
    a. are often more pronounced in shallow water than deep.
    b. may be solid or invisible.
    c. are typically related to temperature variations in the abyssal zone.
    d. a and b above.
    e. all of the above.
19. The substrate of the sea floor
    a. provides a habitat for some organisms.
    b. provides food for some animals.
    c. is highly variable in coastal regions.
    d. tends to be more uniform in deep water.
    e. all of the above.
20. The intertidal zone corresponds to
    a. the hadal zone.
    b. the oceanic zone.
    c. the littoral zone.
    d. the epipelagic zone.
    e. the splash zone.

Visual Aids: Test Your Understanding of the Figures

1. Take a look at figure 14.9 and explain how the region populated by phytoplankton might change from open ocean to coastal waters.
2. The zones of the marine environment are based largely on changes in depth. You can see this quite easily in figure 14.5. How do you think the depth range of the mesopelagic zone was chosen? Think about how profiles of temperature, salinity, and density would look superimposed on this zonation.

Study Problems

1. If the area of the marine environment is about 321 million km^2 and the area of the continental shelf regions is about 24.4 million km^2, what percent of the benthic environment falls in the sublittoral zone?
2. Looking at figure 14.9, determine the decrease in percentage of solar energy at a depth of 10 m in turbid water compared to clear water.
3. At what depths will 90% of the available solar radiation be lost in clear and in turbid water?
4. What is the approximate relative concentration of nitrate to phosphate in seawater below the photic zone?

Answer Key for Key Terms and Test Your Recall

KEY TERMS

nitrate (VIII)
buoyancy (III)
plankton (I)
phosphate (VIII)
mitigation (XVI)
nekton (I)
benthos (I)
poikilotherm (V)
domain (I)
flotation (III)
barrier (XV)
substrate (XIII)
bioluminescence (X)
osmosis (IV)
camouflage (XI)
cold-blooded (V)
littoral zone (II)
homeotherm (V)
hadal zone (II)
countershading (XI)
neritic zone (II)
anaerobic (VII)
photophore (X)
mesopelagic zone (II)
bends (VI)
photic zone (IX)
luciferase (X)
taxonomy (I)
epipelagic zone (II)
epifauna (XIII)

infauna (XIII)	deposit feeder (XIII)	symbiosis (XIV)
commensalism (XIV)	mutualism (XIV)	parasitism (XIV)

FILL IN THE BLANK

1. buoyancy, density	2. swim bladders	3. surface area
4. osmosis	5. cold	6. nitrogen
7. anaerobic	8. carbon dioxide, oxygen	9. aphotic
10. luciferin, luciferase	11. photophores	12. bright
13. high	14. low	15. substrate
16. benthic	17. neritic	18. hadal
19. plankton	20. nekton	

TRUE - FALSE

1.T 2.T 3.F 4.T 5.F 6.T 7.T 8.T 9.F 10.F 11.T 12.F 13.F 14.T 15.T 16.T 17.T 18.F 19.F 20.F

MULTIPLE CHOICE

1.e 2.c 3.a 4.f 5.b 6.d 7.a 8.b 9.e 10.d 11.a 12.e 13.d 14.c 15.e 16.b 17.a 18.d 19.e 20.c

STUDY PROBLEMS

1. 7.6%
2. 12%
3. 4–5 m, 23–24 m
4. about 10:1