CHAPTER 12 LIFE ON THE SEA FLOOR

Key Concepts

Major Concept (I) *Seaweeds are large plant-like, benthic algae.*

Related or supporting concepts:

- Seaweeds belong to the group algae. Algae can be considered as primitive plants.
- The general characteristics of benthic alga are illustrated in figure 12.1.
- Algae differ from true plants in that they do not produce flowers or seeds and their pigments and storage compounds vary.
- Seaweeds grow attached to the bottom. This can be rock, shell material, or any other solid object.
- The part of the seaweed that holds it down is called a holdfast. It is simply an attachment mechanism.
- The holdfast is attached to the substrate, or material of the bottom.
- A holdfast is not a root; it does not absorb water or nutrients.
- A structure similar to a stem extends beyond the holdfast. This is called the stipe. The length of a stipe can vary from very short to as long as 35 m (115 ft).
- The part of the seaweed that photosynthesizes is called the blade.
- The stipe connects the blades to the holdfast.
- The blades come in many different shapes and sizes.
- Algae can be classified by their pigments. There are three different groups: green, brown, and red algae. A variety of algae are shown in figure 12.2.
- Green algae characteristically:
    a. are of moderate size, and
    b. may have thin, flat sheets or delicate branches.
- Brown algae:
    a. range in size from very small to very large,
    b. include the kelp, largest of the algae, and
    c. have a brown pigment that masks the green chlorophyll.
- Red algae:
    a. are the most abundant,
    b. are the most widespread,
    c. have variable forms including:
        i. flat,
        ii. ruffled,
        iii. feathery, and
        iv. branched,
    d. contain a pigment that masks the chlorophyll.

- Kelp have very strong holdfasts and stipes. This allows them to survive in water with strong currents or wave activity.
- The blades of kelp float at the surface due to a gas-filled bubble, or float, at the base of each blade.
- The actual color of a given type of algae may vary. Red algae are not always red, and brown algae can appear different colors as well.
- The different algae often occur in depth zones away from shore. The shallowest are the green algae, then the brown, and finally the red at greater depths.
- The depth at which the groups of algae are found is related to the efficiency of the different pigments at absorbing light of different wavelengths. As an example, the pigment in red algae can trap the blue-green light that penetrates to greater depths.
- Seaweeds can provide both food and habitats for other organisms. They are the marine equivalent of forests and shrubs.
- Organisms that feed directly on the algae include sea urchins, limpets, and some snails.
- Some algae produce calcareous coverings. These algae play an important role in the building of coral reefs.
- Benthic diatoms grow on the substrate. They form a slippery, brown coating and are often elongate in form.

Major Concept (II) *Some marine plants have true roots, stems, and leaves like the plants we are familiar with on land. These plants also produce flowers.*

Related or supporting concepts:

- There are a variety of sea grasses that grow in shallow waters and provide shelter and food for other organisms. Examples include:
    a. eel grass in bays and estuaries along the Pacific and Atlantic coasts,
    b. turtle grass along the Gulf Coast, and
    c. surf grass that thrives in turbulent water.
- Salt marshes at mid-latitudes are dominated by marsh grasses.
- Marsh grasses:
    a. are partly consumed by marsh herbivores,
    b. break down and partially decompose in the marsh, and
    c. are transported to estuaries by tidal creeks where bacteria further break them down and release nutrients to the environment.
- In tropical climates mangrove trees grow in intertidal salt marshes.
- Mangrove trees have root systems that interweave with one another. The root systems trap sediment and organic material. This accelerates the rate at which the swamp fills in and the land moves outward to the ocean.
- Mangrove root systems also provide shelter for some organisms.

Major Concept (III) *Most animals in the oceans are benthic. They can be found at all depths and on all kinds of substrate.*

Related or supporting concepts:

- There are more than 150,000 species of benthic animals compared to approximately 3000 pelagic species.
- Epifaunal animals live on or are attached to rocks or firm substrate.
- Infaunal animals live buried in the substrate. This is usually soft sand or mud.
- About 80 percent of benthic animals are epifauna.
- We can also classify benthos by their mobility. Benthic organisms that are attached to the substrate as adults are called sessile benthos. Those that are free to move are called motile benthos.
- Examples of sessile benthos include:
    a. barnacles,
    b. anemones, and
    c. oysters.

  These organisms rely on their food to come to them either by its own mobility or carried by currents or waves.
- Examples of motile benthos include:
    a. crabs,
    b. starfish, and
    c. snails.

  Motile benthos are able to move in search of food.
- Most benthos are motile in their larval stage. This allows them to colonize larger areas. During this period they are meroplankton.
- The seafloor environment is fairly constant in deep water but extremely variable in shallow, near coastal waters.
- The distribution of benthic organisms is controlled by environmental conditions including:
    a. nature of the substrate,
    b. temperature,
    c. salinity,
    d. pH,
    e. the possibility of periodic exposure to air in the intertidal zone,
    f. oxygen content of the water,
    g. turbidity, and
    h. energy level, or turbulence.

Major Concept (IV) *The diversity and abundance of marine life along rocky shores are enhanced by the variability of environmental conditions found there. This is a region of environmental extremes in the marine realm.*

Related or supporting concepts:

- Perhaps the greatest environmental extremes in the oceans are found in the littoral zone.
- At the top of the littoral zone organisms are exposed to the air for long periods of time. This also makes them subject to:
    a. large variations in temperature,
    b. a very high energy environment, and
    c. possible predation by land animals and birds.
- At the bottom of the littoral zone organisms are exposed to air for only short periods of time.
- Figure 12.3 shows the amount of time an organism would be exposed to air at a given level in the littoral zone.
- In many areas there is a distinct intertidal zonation similar to that shown in figure 12.4. This occurs as organisms adapt to the variable level of stress caused by periodic exposure, turbulence, and loss of water across the littoral zone.
- Intertidal zones are narrow along steep shores and where the tidal range is small. They are wide where the shore slopes gently or the tidal range is large.
- Above the high tide level in the supralittoral zone marine organisms must adapt to nearly continental conditions. This region is above the high water level and covered with water only during storms or unusually high tides.
- Organisms found in the supralittoral zone include lichen and algae on rocks as well as snails, limpets, and barnacles. Examples of these can be seen in figure 12.5.
- The width of the supralittoral zone is a function of:
    a. the slope of the shore,
    b. variations in sunlight intensity and shade,
    c. tidal range, and
    d. average temperature and the occurrence of fogs.
- Organisms found in the midlittoral region include barnacles, limpets, snails, mussels, and chitons. These are illustrated in figure 12.6.
- Chitons and mussels graze on algae covering rocks and are attached to the rocks by strong muscular foot anchors.
- Barnacles are attached to the substrate by cement while mussels use strong filaments or threads. Mussels are filter feeders.
- Midlittoral organisms have smooth, low profile shapes to reduce the effect of pounding waves. They also have tightly closed shells to conserve moisture when the tide is low.
- The midlittoral zone is a region of dense population and heavy competition.
- Organisms of the lower littoral zone are numerous and diverse. Some of those commonly found are shown in figure 12.7.
- Lower littoral zone organisms include anemones, starfish, sea urchins, sponges, worms, sea slugs, and sea cucumbers, as well as many others.

- Octopuses are found in nearshore regions. They are carnivores, feeding on crabs and shellfish.
- The octopus lives in caves or rocky crevasses and can change color and move quickly.
- Research has shown that the octopus can learn and has some memory. It is not an aggressive animal.
- The world's largest octopus is found in the eastern North Pacific and is commonly 3 m (16.5 ft) from tip to tip and weighs 20 kg (45 lbs). The largest examples observed have been in excess of 7 m (23 ft) and weighed as much as 45 kg (100 lbs).

Major Concept (V) *Low spots in the littoral zone can trap water at low tide creating tide pools. The environmental stability of these isolated basins depends on their size and the length of time they remain above the water level.*

Related or supporting concepts:

- Each tide pool has its own special environmental characteristics determined by its size and the length of time it has been isolated. Consequently, each pool will support a special group of organisms able to tolerate the conditions found there.
- Small, shallow tide pools are susceptible to rapid changes in temperature: heating by the sun or cooling at night.
- The salinity of a small pool can also change; increasing with evaporation or decreasing with precipitation.
- Other conditions that can change are pH and concentration of dissolved gases.
- The larger and deeper the pool is, the more stable the environment will be.
- Starfish, sea urchins, sea cucumbers, and fish require deeper pools.
- The fish that inhabit tide pools are often colored like the rocks and algae and spend a lot of time resting on the bottom.

Major Concept (VI) *Unconsolidated sediments on the bottom form a unique environment that supports a different community of organisms from those found on rocky coasts.*

Related or supporting concepts:

- Unconsolidated material on the sea floor is easily disturbed by currents and wave activity. Where this occurs there are few seaweeds attached to the bottom and few grazing animals.
- When sands and muds are deposited in low energy embayments along the coast they are more stable.
- In stable regions, the factors that control the nature of the environment are particle size and organic content.
- Particle size can influence the amount of void space in the substrate. This affects the

cycling of water through the sediment and the amount of dissolved oxygen.

- Coarse sand cycles water and waste material rapidly. Oxygen used by organisms is also replaced quickly.

- Tightly packed substrate can hold waste material and become depleted in oxygen due to a slow rate of replacement.
- Deeper in the sediment, organic matter decomposes. This process uses oxygen and produces hydrogen sulfide. In this oxygen depleted region there are few infaunal organisms. Clams are able to live below the oxygen rich surface layer because they extend siphons upward to take in food and oxygen.
- Where the bottom is protected from current and wave action, grasses may grow and stabilize the substrate. They also provide shelter and food.
- Most organisms in this environment feed on detritus, primarily degraded plant material that has been processed to some extent by bacteria and fungi.
- Feeding habits include:
    a. filtering detritus out of the water, like clams, cockles, and worms,
    b. deposit feeders, like sea cucumbers, that ingest sediment and extract the detritus, and
    c. organisms like the sand dollar that feed off detritus between sand grains.
- The littoral zone on a soft sediment beach exhibits some zonation of organisms but they are not as clearly defined as on rocky shores. Take a look at figure 12.8.
- Examples of organisms that live in areas of soft sediment are shown in figure 12.9.

Major Concept (VII) *The deep sea floor is a very stable environment. This promotes the existence of deposit-feeding infaunal organisms.*

Related or supporting concepts:

- Most of the infauna found on the deep sea floor are small, many being 2 mm or less in size.
- Worms, crustaceans, and sea cucumbers constantly rework the bottom to extract organic matter. This process is called bioturbation.
- Bioturbation produces a well mixed surface layer of sediment on the deep sea floor.
- Photographs of some typical organisms are shown in figure 12.10.
- Types of organisms include:
    a. single celled protozoans,
    b. glass sponges,
    c. tube worms,
    d. sea squirts,
    e. sea anemones,
    f. barnacles,
    g. sea stars, and
    h. snails, among others.

- Glass sponges, sea squirts, and sea anemones attach themselves to scattered rocks on the bottom. They are filter feeders.
- Stalked barnacles attach themselves to glass sponges as well as shells and rocks.
- Tube worms range in size from a few millimeters to 20 cm (8 in).
- Sea spiders, brittle stars, and sea cucumbers can be found at depths as great as 7000 m (23,000 ft).
- Snails are found at the greatest depths. Some examples of snails that inhabit the deepest trenches have no eyes or eye stalks.

Major Concept (VIII) *There are a number of different organisms that will attach themselves to pilings, docks, or boats. Other types of creatures bore into materials. All of these organisms pose a nuisance, or hazard, to structures and vessels.*

Related or supporting concepts:

- Organisms that attach themselves to structures are said to foul them. Included in these types of organisms are:
    a. barnacles,
    b. anemones,
    c. tube worms,
    d. sea squirts, and
    e. algae.
- Because of their adverse economic impact, there has been a great deal of research done on identifying special paints and materials that inhibit their growth on structures.
- Some organisms bore into materials. Examples include:
    a. sponges that bore into scallop and clam shells,
    b. snails that bore into oysters, and
    c. organisms that bore into rock and wood.
- The process of boring may be related to feeding or shelter.
- Organisms that bore into wood do the most damage. One such organism is the shipworm; its effects on wood are shown in figure 12.11.
- A crustacean called the gribble also bores into wood, although not as deeply as the shipworm.
- Shipworms secrete an enzyme that breaks down wood fibers.

Major Concept (IX) *While we are familiar with competition for limited resources, there are many organisms in the marine environment that have close relationships with other creatures.*

Related or supporting concepts:

- When two dissimilar organisms live in a close, intimate relationship it is called symbiosis.

- There are three types of symbiotic relationships: mutualism, commensalism, and parasitism.
- Mutually beneficial relationships between organisms are called mutualism. An example of mutualism is the relationship between the green sea anemone and a single-celled alga that lives in its tissue. The alga receives protection, carbon dioxide, and some nitrogenous compounds. The anemone receives organic compounds and some oxygen from the alga.
- When a relationship is beneficial to one organism and does not harm the other it is called commensalism. This is often the case for worms and crustaceans that attach themselves to shellfish.
- When one organism is harmed by its relationship with another it is called parasitism. Parasitic flat worms, round worms, and bacteria are often found as parasites in all types of marine animals.

Major Concept (X) *The most complex and diverse of all benthic communities are the coral reefs.*

Related or supporting concepts:

- Corals are animals. They are colonial creatures. Each individual coral is called a polyp.
- The largest coral reef in the world is the Great Barrier Reef, which is over 2000 km long off the east coast of Australia.
- Polyps look very similar to small sea anemones with tentacles (see fig. 12.13).
- Polyps extract calcium carbonate from the water to build their skeletal framework.
- Reef building corals require:
    a. warm water; temperatures must not go below 18°C and optimal temperatures are from 23° - 25°C,
    b. clear water free from too much suspended material,
    c. normal marine salinity,
    d. a firm substrate as a base for growth, and
    e. shallow water where sunlight will penetrate.
- Corals live in a symbiotic relationship with the alga zooxanthellae. Some corals receive as much as 60 percent of their nutrition from the algae.
- At night the polyps extend themselves outward and feed off zooplankton. During the day they retract into the skeletal mass and expose their outer layer of cells that are covered with zooxanthellae. The zooxanthellae are thus exposed to sunlight and can photosynthesize.
- Corals are found at restricted latitudes between about 30°N and S, away from cold-water currents, where the waters are warm.
- The depth at which corals are found varies with the species, the temperature, and the turbidity of the water. Caribbean corals are found at depths down to about 50 m. Indian and Pacific corals can be found as deep as 150 m in clear water.

- Water deeper than 50 - 150 m is often too cold for significant secretion of calcium carbonate.
- Corals are generally slow growing, adding from 1 to 5 cm (0.4 - 2 in) per year.
- The shape of the coral structure is often influenced by depth and turbulence in the water as well as species. As environmental conditions vary, both vertical and horizontal zonation is established (see fig. 12.14).
- In sheltered water the coral may be branched. On the windward side the corals are more massive and rounded to withstand pounding waves.
- Below the low tide line on the windward side, to a depth of 10 - 20 m (30 - 60 ft), the face of the coral reef typically has steep rugged buttresses with alternating grooves (see fig. 12.14). The buttresses absorb wave energy while sand and rubble are channeled down the grooves away from the corals that they could cover and smother. Here the corals are massive and rounded.
- The buttresses dissipate wave energy and the grooves drain off fine sediment that could smother the coral.
- Below 20 - 30 m (60 - 100 ft) the corals are less massive. The wave energy is low and the sunlight is only about 25 percent as intense as at the surface. The corals are more delicate and branched here.
- From 30 - 40 m (100 - 130 ft) the slope is gentle and the level of light is very low. Corals are patchy and sediment accumulates.
- Below 50 m (150 ft) the slope falls rapidly to greater depths.
- Coral reef communities are very diverse. Some estimates suggest that as many as 3000 different species of organisms may inhabit a single reef system.
- Coral reefs are delicate systems and can be threatened in a number of ways including infestations of algae, predators, and severe bleaching.
- Sometimes corals will shed their covering of zooxanthellae. This is called coral bleaching. Bleaching may be triggered by disease, pollution, changes in temperature, salinity, or the concentration of ultraviolet light.
- During the 1982-83 El Niño event the tropical eastern Pacific experienced severe coral bleaching. Between 70 and 90 percent of the corals in Panama and Costa Rica and more than 95 percent of Galápagos corals were destroyed. Java Sea reefs lost 80 to 90 percent of their coral.
- Mass bleaching also occurred when water temperatures rose in 1987 and 1990-91.
- The 1997-98 El Niño produced sudden and steep increases in coral bleaching in the Indian Ocean.
- In 2000 it was reported that there was an 11% global reef destruction prior to 1998 and less than a year later another 16% severely damaged reefs from Brazil to the Indian Ocean.
- Some reefs have recovered more quickly than expected but it will take decades for total recovery.
- The exact mechanisms involved in coral bleaching are not known. Two possibilities are that a rise in water temperature causes the algae to produce more oxygen than the

corals can stand, or that stress decreases the amount of nutrients that the coral polyps provide for the algae.

- Reefs are also suffering from a newly recognized disease, coralline lethal orange disease, known as CLOD. CLOD is caused by an orange bacterial pathogen that kills the red algae that cement debris on the reef to create a hard, stable substrate.
- CLOD was first found in 1993 in the Cook Islands and Fiji. It has since spread to a 6000 km (3600 mi) range in the South Pacific.
- Between 1996 and 1997 Florida coral reefs experienced a 300% increase in black band disease. This is believed to have been due to poor water quality and polluted runoff into Florida Bay.
- Periodic surges in the population of the crown-of-thorns sea star cause tremendous damage. Increases in their population have been tentatively linked to high precipitation, low salinity, and nutrient runoff.
- Coral reefs are also in danger from human activities including:
    a. mining for building material,
    b. the activities of shell and coral collectors,
    c. dynamiting and poisoning to harvest fish,
    d. careless sport divers and boats, and
    e. pollution.
- The clearing of mangroves and expansion of banana and citrus plantations have increase the amount of silt, pesticides, and fertilizers in the reef environment.
- Sewage from hotels and resorts provide nutrients that promote algal growth. In Belize the largest barrier reef in the Western Hemisphere is being damaged by algal overgrowth.

Major Concept (XI) *Benthic organisms represent a very valuable natural resource for harvesting. The problems associated with managing this resource are similar to those encountered in the finfish fisheries.*

Related or supporting concepts:

- Popular benthic organisms that are harvested commercially include:
    a. crustaceans such as:
        i. crabs,
        ii. shrimp,
        iii. prawns, and
        iv. lobsters, as well as
    b. shellfish or mollusks including:
        i. clams,
        ii. mussels, and
        iii. oysters.
- While there are not large numbers of these organisms harvested, 6.8 million metric tons of shellfish and 5.3 million metric tons of crustaceans in 1997, their value per

pound is extremely high.

- Aquaculture added an additional 9.4 million tons of shellfish and 1.2 million tons of crustaceans.
- Some benthic organisms have been over-harvested in the past, damaging the fisheries. A classic example is the depletion of the king crab fishery of the Bering Sea. The tonnage harvested went from a high of 70,000 metric tons in 1979 and 84,000 metric tons in 1980 to only 7000 metric tons in 1985. With tight controls the fishery recovered somewhat yielding 15,000 metric tons in 1990 but then dropped to only 8,000 tons in 1997.
- Aquaculture, or mariculture, projects have focused on a variety of different benthic species including clams, oysters, mussels, and shrimp (see fig. 12.16).
- The world harvest of crustaceans, mainly shrimp from aquaculture, increased from 200,000 metric tons in 1985 to 1.2 million metric tons in 1996 for a total of value of $7 million.
- Aquaculture still suffers from high costs, intensive labor, and the need for continued research on diet and disease prevention.
- Seaweed is harvested for table food as well as processing for by-products by a number of different countries. Seaweeds have traditionally been eaten most widely in Japan, China, and Southeast Asia.
- One type, called nori, is used in Japan for soups, stews, and as a wrapping for clumps of rice and fish.
- Seaweed has also been used as a winter food supplement for livestock and as a fertilizer.
- Important by-products that can be extracted from seaweeds include:
    a. algin from brown algae, and
    b. carrageenan and agar from red algae.
- Algin is a stabilizing agent used in the manufacture of dairy products such as ice cream, candy, paint, ink, and cosmetics.
- Agar is an important substance used in biomedical research as a medium for growing cultures. It is also used in the pharmaceutical industry and in some desserts.
- Carrageenan is another stabilizer and emulsifier used in ice cream, salad dressing, soups, pudding, cosmetics, and medicines. It prevents the ingredients used to make these products from separating. Algae rich in carrageenan are harvested from New England and northeastern Canadian coastal waters.
- About 1 million pounds of agar and 10 million pounds of carrageenan are used in the United States each year.
- Benthic organisms are also being studied for biomedical purposes. Many of them produce compounds that have therapeutic uses. Some examples include:
    a. anti-inflammatory and antibiotic substances from sponges,
    b. anti-microbial compounds from corals,
    c. a cardiac stimulant from the sea anemone, and
    d. a muscle relaxant from a marine snail.

- Most of the biomedical substances studied come from soft-bodied organisms that produce toxins for defense.
- The identification, testing, approval, and marketing of these substances is both time-consuming and costly. From discovery to application it may take 10 to 15 years and hundreds of millions of dollars.

Major Concept (XII) *Genetic manipulation of some marine organisms may increase the harvest of species from mariculture programs by developing organisms that are more resistant to disease and that grow more rapidly.*

Related or supporting concepts:

- It is estimated that by the turn of the century 20 percent of the world's consumption of fish will have been raised commercially.
- Genetic engineering research is being conducted in North America, Japan, and northern Europe to produce fish that:
    a. reach saleable weight more quickly,
    b. are more resistant to disease, and
    c. are better able to withstand cold temperatures and freezing in winter.
- Some success has been achieved in producing fish that have growth rates 20 - 46 percent faster than normal.
- One type of alteration produces fish with a third set of chromosomes, or triploids. These fish are not able to reproduce, so the energy that they would normally expend generating eggs or sperm can be used for larger and more rapid growth.
- The production of triploid trout in the United Kingdom is common.
- Another technique used is to alter fish eggs so that only the female chromosomes develop. This produces only female offspring, which typically grow larger and live longer for many food fish. For example:
    a. female flounder attain twice the size of males,
    b. female coho salmon have firmer and better tasting flesh, and
    c. an increase in the numbers of female sturgeon would produce an increase in the production of caviar.
- Triploid oysters have been produced that grow larger and do not exhibit the normal decrease in quality of flesh during the summer when they enter a reproductive phase.

Key Terms and Related Major Concepts

At the back of the chapter in your book there are a number of key terms. You should be able to find the following terms referenced in the major concept indicated in parentheses.

holdfast(I)
substrate(I)
stipe(I)
blade(I)
kelp(I)
epifauna(III)
infauna(III)
sessile(III)
motile(III)
intertidal zonation(IV)
detritus(VI)
bioturbation(VII)
mutualism(IX)
symbiosis(IX)
commensalism(IX)
parasitism(IX)
polyp(X)
zooxanthellae(X)
nori(XI)
algin(XI)
agar(XI)
carrageenan(XI)
triploid(XII)

Test Your Understanding With The Following Questions:

FILL IN THE BLANK

1. Fish that have been genetically altered to have three sets of chromosomes are called _____.
2. Organisms that are firmly attached to the bottom and do not graze for food are called _____.
3. The _____ is the equivalent of the stem or trunk of a land plant.
4. The material of the sea floor is called the _____.
5. The disruption of bottom sediment by organisms is called _____.
6. Organisms that live in the bottom are called _____.
7. When one organism benefits at the expense of another in a relationship it is called _____.
8. An individual coral animal is called a _____.
9. _____ is a relationship between organisms when one benefits and the other is unaffected.
10. Zooxanthellae is a species of _____.

TRUE - FALSE

1. Intertidal zonation is not very pronounced along rocky shores.
2. Fish are being genetically engineered to grow larger in commercial farms.
3. Corals thrive at temperatures down to about 12°C.
4. Soft substrate in coastal waters promotes colonization by grazing animals.
5. The most abundant and widespread of the large marine algae are the red algae.
6. The blades of kelp are kept near the surface by gas-filled floats.
7. Organisms at the top of the intertidal zone have more stressful environments than those at the bottom.
8. Intertidal zones tend to be broader on gently sloping beaches.
9. Seaweed is used in the manufacture of some cosmetics.

10. Relatively few sand and mud animals are detritus feeders.

MULTIPLE CHOICE

1. The relationship between coral and zooxanthellae is an example of:
    a. mutualism
    b. parasitism
    c. commensalism
    d. symbiosis
    e. a and d
2. The relationship between roundworms and marine mammals infected by them is an example of:
    a. symbiosis
    b. commensalism
    c. parasitism
    d. mutualism
    e. infectism
3. Corals require:
    a. near normal salinity
    b. relatively clear water
    c. shallow depths
    d. warm temperatures
    e. all of the above
4. Which of these algae are found at the shallowest depth along rocky shores?
    a. green
    b. brown
    c. red
    d. yellow
    e. none of the above

5. Seaweeds are attached to the bottom by:
    a. an anchor
    b. a holdfast
    c. a sucker
    d. cement
    e. roots
6. Organisms in tide pools may have to endure:
    a. colder than normal temperatures
    b. higher than normal salinity
    c. warmer than normal temperatures
    d. lower than normal salinity
    e. all of the above.
7. Shipworms:
    a. can secrete an enzyme that breaks down wood

b. bore shallow holes in rock
c. can pose a major threat to wooden boats
d. a and c
e. are sessile organisms

8. Reef-building corals cannot withstand temperatures below ____ °C.
   a. 20
   b. 18
   c. 21
   d. 30
   e. 24
9. Which of the following materials is used in medical research to grow cultures?
   a. carrageenan
   b. algin
   c. agar
   d. jellgan
   e. kelp juice
10. By the turn of the century it is estimated that about ____ percent of the world fish consumption will come from mariculture.
   a. 20
   b. 15
   c. 10
   d. 25
   e. 30

Answer Key for 'Key Terms' and 'Test Your Understanding'

FILL IN THE BLANK

1. triploids
2. sessile
3. stipe
4. substrate
5. bioturbation
6. infauna
7. parasitism
8. polyp
9. commensalism
10. algae

TRUE - FALSE
1.F 2.T 3.F 4.F 5.T 6.T 7.T 8.T 9.T 10.F

MULTIPLE CHOICE
1.e 2.c 3.e 4.a 5.b 6.e 7.d 8.b 9.c 10.a