Lab #9: Prelab Reading

COASTAL MARINE BIOLOGY
A LOOK AT WHAT'S DOWN THERE

Meet at the Marine Science Institute touch tanks (Reef Program)

Objectives: To familiarize yourself with the marine organisms of thelocal area, and their specific adaptations to the environment in which they live.

Preparation and materials:
Do PreLab homework contained in this section

Activities: Meet at Marine Science Institute to observe local marine animals

Introduction

You may have noticed, during walks on the beach, that many unusual plants and animals inhabit the swath of land surface which lies between the high and low tides. This intertidal zone is alternately exposed to both the ocean and the atmosphere, and the organisms that have adapted to this harsh environment have found ways of surviving during each of these periods which are unique and fascinating. Some of the creatures which we will observe today will be familiar to you from your own explorations, but many will not, so take the time to study everything carefully.

Most of the animals that we will see today are invertebrates, animals that have no backbone or vertebrae. Some, like sponges, loosely interconnected aggregates of cells, are simple organisms, but many are highly adapted and complex organisms which have body plans, feeding strategies, and reproductive strategies entirely alien from our own. Most of the organisms will be from the following groups:

1) Algae - non-vascular plants; green, red, and brown algae; kelp
2) Sponges - simple filter-feeders, all sessile (attached)
3) Cnidarians - sac-like body structure, nematocysts (stinging cells), sessile and motile forms; jellyfish, anemones, corals
4) Annelids - segmented worms, motile; polychaete worms, tubeworms
5) Mollusks - soft-bodied animals usually covered by a shell, motile; limpets, snails, mussels, clams, chitons, cephalopods (squid , octopus, and cuttlefish)
6) Crustaceans - segmented body and joints with a chitinous exoskeleton, sessile and motile forms; shrimp, barnacles, crabs, lobster, ostracods, copepods, horseshoe crabs
7) Echinoderms - spiny-skinned animals with an endoskeleton and a water-vascular system (tube feet), sessile and motile forms; starfish, sea urchins, sand dollars, sea cucumbers

Aside from the common tide pool organisms, we will also see some of the organisms which inhabit near-shore environments, such as the subtidal soft bottom and kelp beds. All of these specimens have been collected by the Marine Science Institute for future study, so don't touch or disturb any of the animals unless otherwise indicated.

HELPFUL DEFINITIONS AND DESCRIPTIONS

Benthic - organisms that live in, on, or attached to the bottom of the ocean. Benthic organisms include: the **epifauna**, those that live at the water-substrate interface, attached to the substrate or freely moving over it; and the **infauna**, those organisms which live within the sediments. Benthic organisms do not swim or float in the water column.

Nektonic - marine organisms that can swim well enough to move independently of the currents. The nekton includes pelagic organism such as squid, marine mammals, and fish.

Autotroph - an organism capable of producing organic molecules from inorganic substances. Autotrophs include plants that make food from inorganic carbon dioxide and water, harnessing the energy of the sun in a process known as photosynthesis; and bacteria that use the energy stored in methane or hydrogen sulfide in a process known as chemosynthesis.

Heterotroph - an organism which utilizes organic compounds as food. Heterotrophs rely on other organisms for food, and cannot make their own food from inorganic compounds. There are several trophic levels of heterotrophs. Herbivores, organisms which consume only plant material, feed at the lowest heterotrophic level. Carnivores eat herbivores and occasionally other carnivores. Carnivores feed at the highest trophic levels in the food chain. Other heterotrophs whose level in the food web varies, include omnivores which eat both plant and animal matter, detritivores which eat the waste products of other heterotrophs, and decomposers, which break down organic tissues after an organism's death.

Ecosystem - All organisms in a biotic community and the abiotic (physical) environmental factors with which they interact make up the ecosystem. Within the ecosystem, biotic factors influence abiotic factors and vice-versa.

Food chain - the simple representation of the passage of energy from primary producers through a series of herbivores and carnivores. This is a simplified version of a food web, because it is inferred that organisms at each level are only eaten by organisms of the next higher trophic level. At each step of the food chain, energy is transferred from one trophic level to the next. Because an organism must use energy in order to

maintain itself, energy is lost with each transfer. Only about 10% of the food energy consumed by an organism is available for growth at each trophic level. Phytoplankton are the exception and only incorporate 2% of the sun's energy. Groups of interrelated food chains make up a more complex food web.

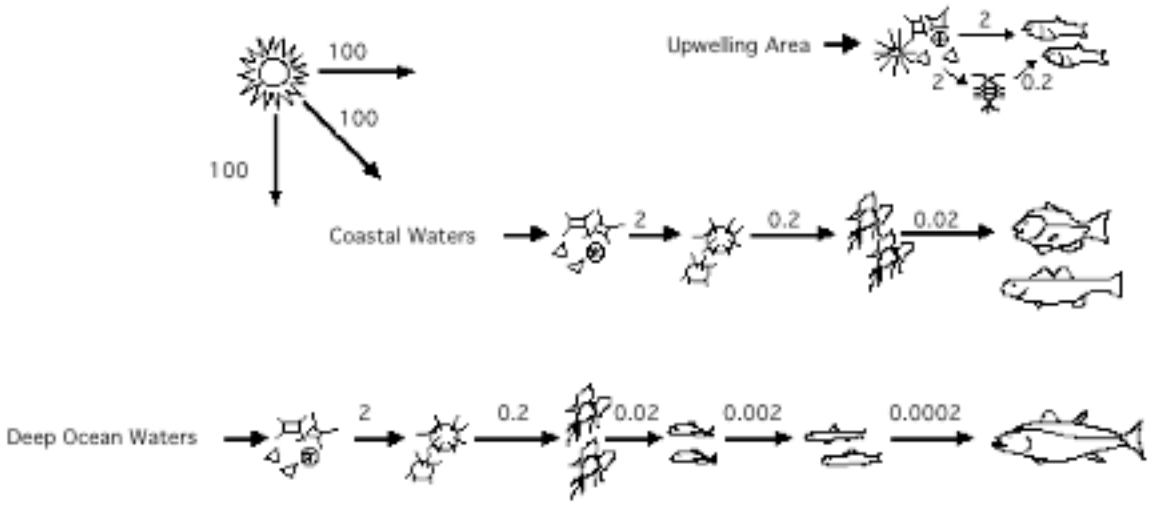


Figure 1. Energy flow through several types of food chains. The figure describes what happens to 100 calories of energy from the sun, in each case (from "Ocean Science", by K. Stowe, pge 593, Wiley, 1993).

Symbiotic - the relationship between two different species of organisms where one or both organism benefits, and neither is harmed. In the ocean, bacteria and unicellular algae, carrying out primary production via photosynthesis or chemosynthesis, commonly have symbiotic relationships with marine invertebrates. The algae or bacteria benefit by having a protected environment within the invertebrate, and the invertebrate benefits by receiving organic material (carbohydrates) and dissolved oxygen (by-products of primary production).

Food web - the complex relationship between primary producers, consumers, and decomposers in an ecosystem. Complexity arises due to the fact that organisms rarely eat only one food type, and in turn are eaten by more than one type of predator. The food chain is a simplified representation of this complex relationship. Groups of interrelated food chains make up the food web. The food web represents the path of energy transfer through an ecosystem. The transfer efficiency between trophic levels is usually about 10%, but has been measured up to 20% in highly efficient ecosystems, such as upwelling zones. The food web is more complex for open ocean organisms. Because open ocean food webs have more steps (predators are barely larger than their prey), the net energy transferred from phytoplankton to the highest

trophic levels is much less than it would be for a short food chain (as is found in upwelling zones). All life in a food web is ultimately supported by plants.

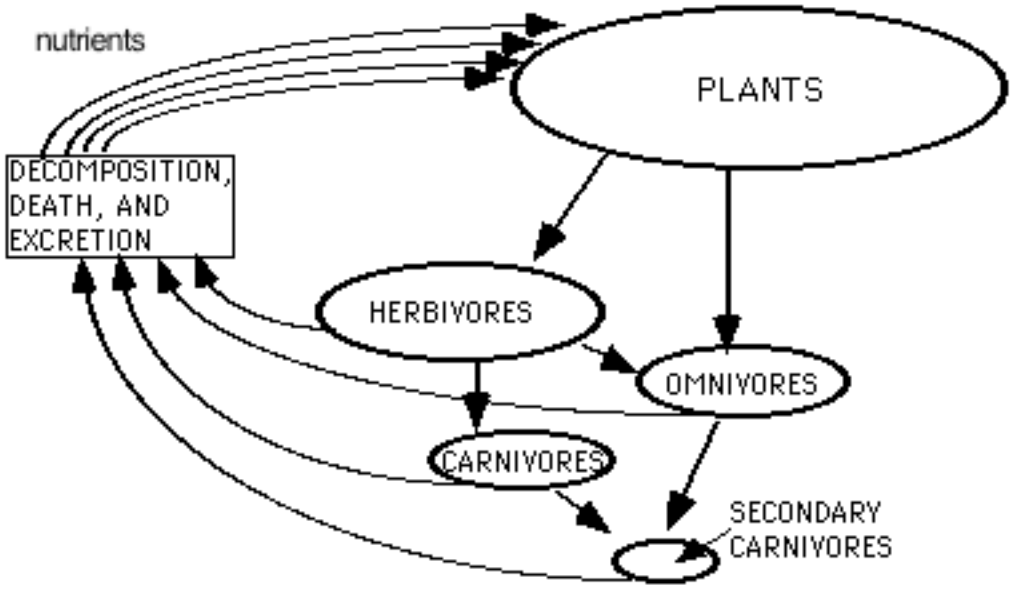


Figure 2. Cycling of nutrients (from "Ocean Science", by K. Stowe, pge 446, Wiley, 1993).

Pelagic - organisms that live in the water column, not on the bottom of the ocean, as do benthic organisms.

Meroplankton - zooplankton which are planktonic (float passively in the water column) for a portion, not the entirety, of their life cycle. Meroplankton include the larval forms of benthic invertebrates.

Trophic level - successive stages of nourishment levels in a food chain, measured in terms of how many different organisms the organic matter has been in since its original synthesis in plants. The first trophic level is represented by primary producers (plants), the second trophic level is made up of herbivores, and carnivores constitute the third and higher trophic levels. The concept of trophic levels can be thought of as who eats whom. Plants, the lowest trophic level, are eaten by higher trophic levels. There is a loss in net energy transfer between trophic levels. Only about 10% of the net food energy intake is used for growth at each trophic level, the rest is used for maintenance (including reproduction) of the organism. In general, the individuals at each trophic level tend to be larger and more complex than those at the lower trophic levels on which they feed.

Euphotic zone - the surface layer of the ocean which receives enough sunlight to support photosynthesis. The depth of the euphotic zone is affected by several factors including turbidity, latitude, and season. Turbidity is a measure of the particulate or sediment load of the surface water. The distance that light can penetrate decreases

with increasing turbidity. Latitude and seasonality affect the angle of the incoming light. The maximum depth of the euphotic zone is rarely more than 100 meters. In the very clearest open ocean, the euphotic zone can extend to a depth of approximately 150 meters.

Niche - the full range of biological and physical conditions under which an organism can live and reproduce. The realized niche is largely determined by interactions with other species.

PRELAB EXERCISE: COASTAL MARINE BIOLOGY

The following exercises are to be completed prior to lab.

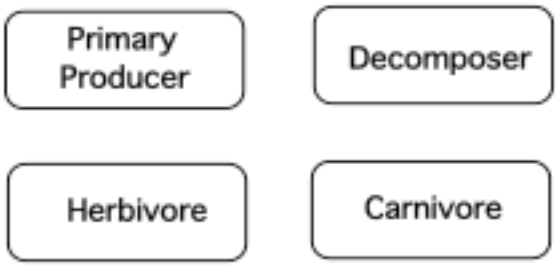
In this lab we are going to familiarize ourselves with marine organisms from the local area and the adaptations that have evolved to enable them to live in their environment.

1. Create a simple food chain (at least 4 steps) of marine organisms with which you are familiar. Begin this food chain with an autotrophic organism.

2. Why would you only find kelp growing in the euphotic zone?

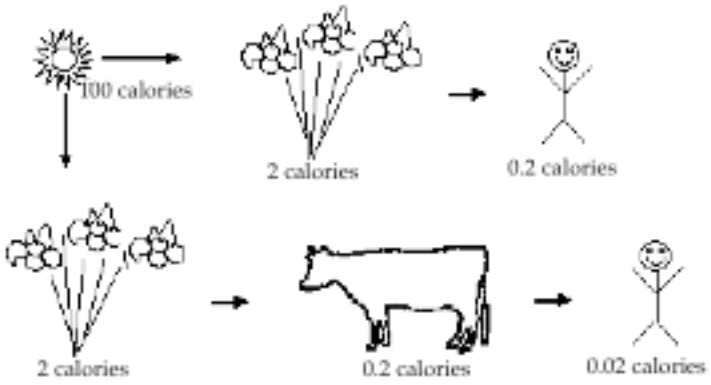
3. A symbiotic relationship occurs between a polycheate worm and the giant keyhole limpet. The polycheate lives in the fold between the mantle and the muscular foot of the keyhole limpet. What possible benefits could the polycheate worm derive from this relationship?

4. Draw in arrows indicating the direction of net energy flow for the following diagram of a food web.



5. How much solar energy does a vegetarian utilize when eating 1,000 calories of plant material (use the information in the figure below) ?

6. How much solar energy (in calories) does a meat eating person utilize when eating 1000 calories of meat? Use the diagram below to make your determination. The numbers below each figure are the number of calories stored at each trohic level.

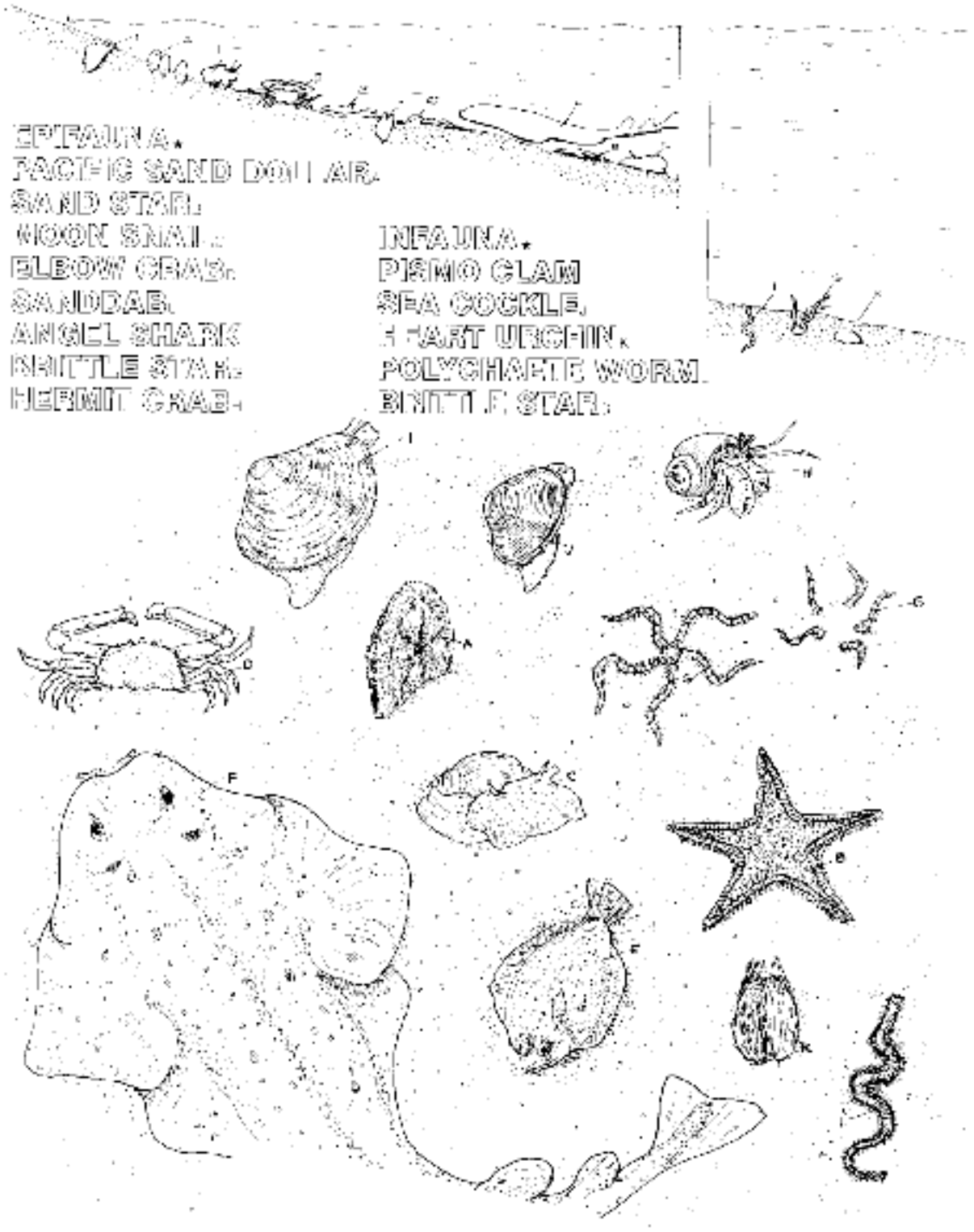


LAB EXERCISE: COASTAL MARINE BIOLOGY

The following exercises are to be completed during lab

On the following page you will find an illustration of the common organisms found in the subtidal soft bottom environment. Locate as many of them as you can in the collection area and observe the patterns of coloration and camouflage utilized by these organisms in order to hide from predators. Once you are familiar with the area, proceed with the rest of the lab at your own pace.

SUBTIDAL SOFT BOTTOMS.



EPIFAUNA.
PACIFIC SAND DOLLAR.
SAND STAR.
MOON SNAIL.
ELBOW CRAB.
SANDDAB.
ANGEL SHARK
BRITTLE STAR.
HERMIT CRAB.

INFAUNA.
PISMO CLAM
SEA COCKLE.
HEART URCHIN.
POLYCHAETE WORM.
BRITTLE STAR.

ROCKY SHORES

Many areas along our coastline are rocky and steep, with large boulders, ledges, overhangs, cracks, and channels providing the only surface area on which organisms can live. Many plants and animals have adapted to this high-energy environment which is continuously battered by waves and tides. Most of these organisms inhabit specific levels in the intertidal zone as shown in the illustration on the following page.

1) Find as many of these organisms as you can and label on the figure whether they are colored for camouflage, or whether they are brightly colored and noticeable.

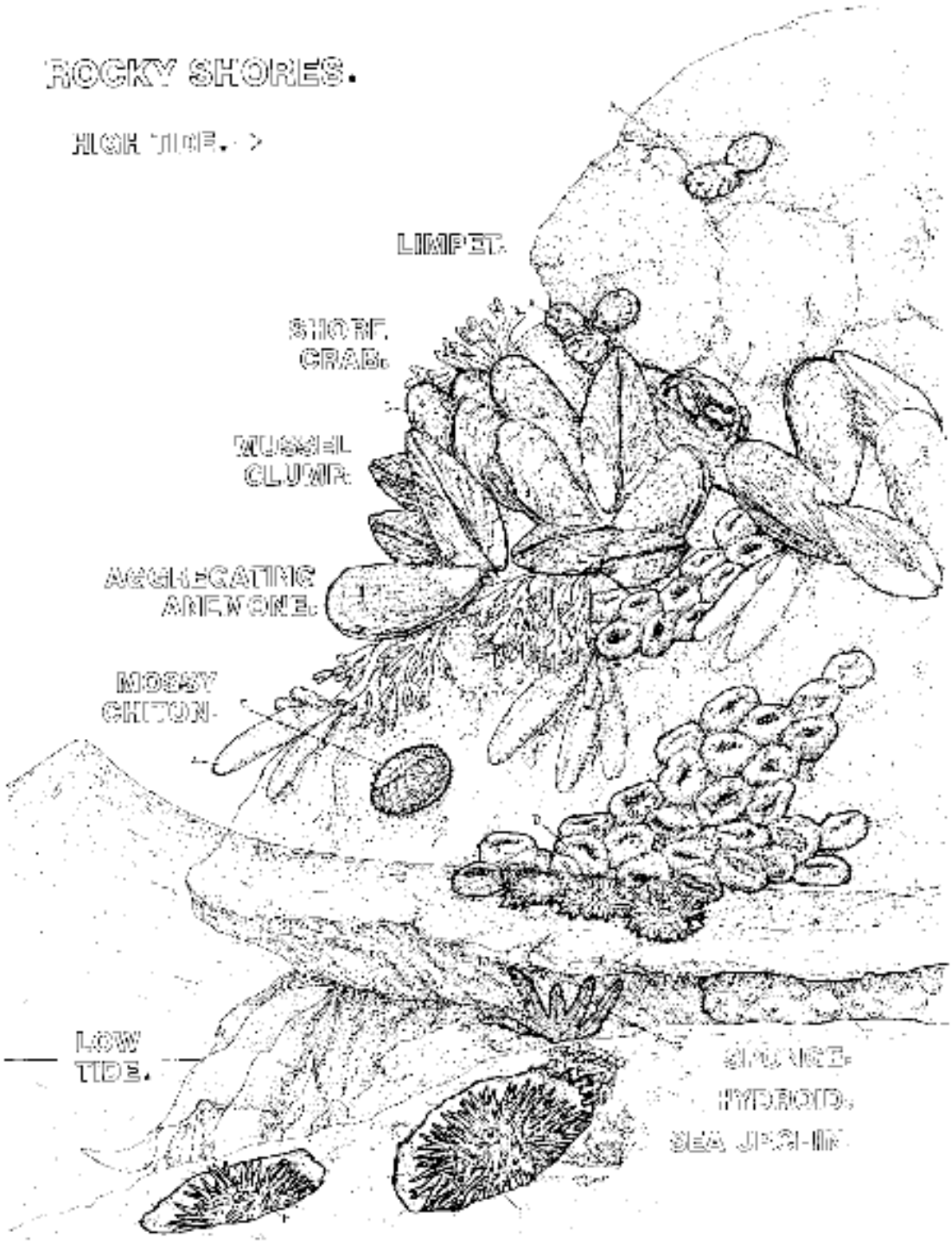
2) Sea urchins are related to starfish; they both have a water vascular system comprised of many small tube feet which they use for locomotion and feeding. The sea urchin, however, is covered with spines with which it can actually burrow into solid rock. What purpose might this burrowing serve?

3) Observe the sea urchins in the large tank. Some of them are attached to the sides of the tank. How does such a spiny creature manage to do this?

4) Sea urchins are herbivores; they mainly eat algae and other vegetation. Where are their jaws and mouth located?

5) Clumps of mussels usually occur in bands at a certain level in the intertidal zone. The bottom of the mussel band is determined by the level at which sea stars (starfish) prey on the mussels. Above this height, the starfish are exposed to the air for too long, and they begin to dry out. What do you suppose determines the top of the mussel band?

6) Aggregating anemones reproduce asexually, by binary fission. This means that when the anemone is ready to reproduce, it splits in half, and each half becomes a new anemone which can then grow and split again. Each of the anemones has the same genetic make-up, and therefore the anemones in the group are all clones of the original anemone which started the group. If two different groups of anemones invade the same area, aggressive encounters occur which are called clone wars. Due to these interactions, a gap results between the two groups which is called the anemone-free zone. What feature(s) do sea anemones possess which allows them to attack one another?


ROCKY SHORES.
HIGH TIDE.
LIMPET.
SHORE CRAB.
MUSSEL CLUMP.
AGGREGATING ANEMONE.
MOSSY CHITON.
LOW TIDE.
SPONGE.
HYDROID.
SEA JACKET.

TIDE POOL

Tide pools are found extensively along the California coastline, especially along the rockier sections of the central and northern coast. Tide pools form when depressions in the rock become reservoirs of sea water as the tide recedes. These pools may form at any level between high and low tides, but the pools which are closer to the low-tide line, and therefore less often exposed to surface conditions, are more richly colonized by tide pool organisms. The organisms which reside in tide pools are often permanent residents which have adapted to an environment which is in a state of constant fluctuation.

1) Find as many of these organisms as you can and label on the next page whether they are colored for camouflage, or whether they are brightly colored and noticeable.

2) Find a sea anemone in one of the tanks and observe it closely for a few minutes. What function do its tentacles perform?

3) If one of the anemones in the touch tank is touched or prodded lightly, what is its reaction?

4) Most sea anemones have a symbiotic relationship with single-celled plants called zooxanthellae which they harbor within special cells in their outer layer. These tiny plants give the anemone its characteristic green color. The anemone provides the plant with a protected environment in which to live. What benefit do you suppose the anemone derives from this relationship?

5) Unlike typical sea stars (starfish), brittle stars have arms which detach from the main body disc quite easily, giving them their name. In what way does this peculiar ability help the brittle star to survive?

6) Find a limpet or snail in one of the glass display tanks which is attached to the glass facing you so that you can see its underside. Limpets and snails have a feeding mechanism called a radula which they use to scrape food from the surface of rocks or other objects. Observe it carefully for a moment to find the radula. What is it feeding on?

TIDE POOL.

ATTACHED.
CORALLINE ALGAE.
  FINGERLING.
  ARTICULATED.
EELGRASS.
SPONGE.
SOLITARY CORAL.
GIANT GREEN
  SEA ANEMONE.
RED ALGAE
MOTLE.
HERMIT CRAB.
TIDEPOOL SCULPIN.
BRITTLE STAR.
BROKEN-BACK SHRIMP.
DUNCE CAP LIMPET.
SEA STAR.
POLYCHAETE WORM.
ROCK CRAB.

KELP BED

The kelp bed habitat is a very productive and diverse cold-water marine habitat characterized by the presence of very large brown algae, called kelp. The kelp bed is populated by many organisms which find protection and resources throughout the confines of the kelp forest.

1) Of the organisms shown in the illustration on the following page, which ones are nektonic and which ones are benthic? Label them Nektonic, or Benthic on the next page.

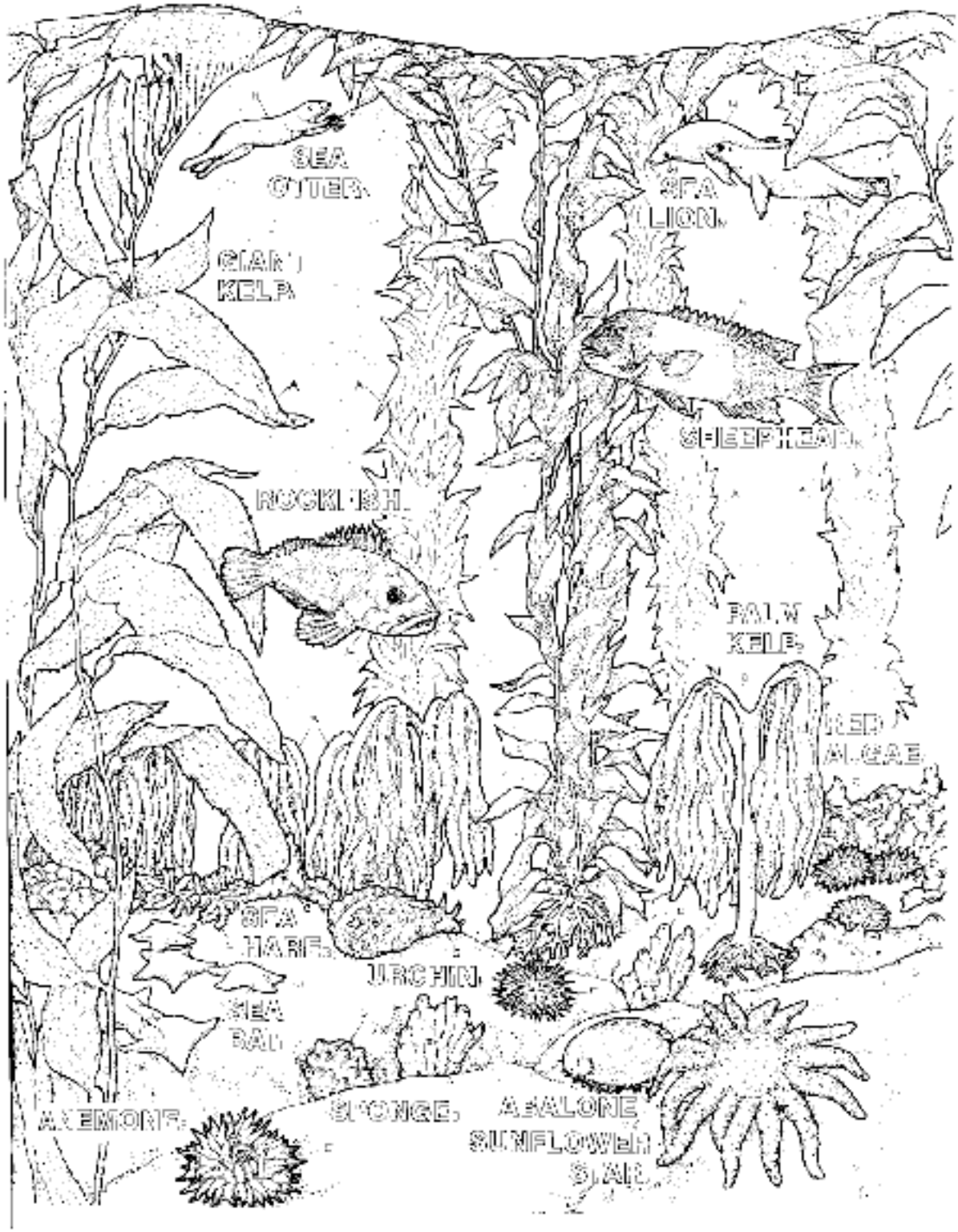
2) Kelp beds commonly grow at water depths between 20 and 30 meters, and they require cold water and a rocky bottom to which they can attach. What other factor(s) might regulate the depth at which the kelp can grow?

3) Kelp also requires a large amount of water movement to insure a constant supply of dissolved nutrients for its photosynthetic needs. Is kelp autotrophic or heterotrophic?

4) Examine the kelp fronds in one of the tanks near the back of the room carefully. What keeps the blades afloat?

5) A complex relationship exists between the giant kelp, sea otters, and sea urchins. Sea otters live in the canopy of the kelp forest for protection from large predators, for resting, and for the plentiful food supply found in the kelp bed. Sea otters, unlike other marine mammals, do not have an insulating layer of body fat or blubber to protect them from the cold Pacific water. Consequently, sea otters must consume large quantities of food each day in order to counteract this. One of the sea otter's favorite food sources is the sea urchin, which they consume in vast quantities. One of the sea urchin's favorite food sources, on the other hand, is the giant kelp which makes up the kelp bed. Write a brief paragraph explaining what might happen to these rich near-shore kelp habitats if this delicate natural balance is disrupted?

KELP BED.


SEA OTTER
GIANT KELP
SEA LION
SHEEPSHEAD
ROCKFISH
PALM KELP
RED ALGAE
SEA HARE
URCHIN
SEA BAT
ANEMONE
SPONGE
ABALONE
SUNFLOWER STAR

PLANKTON

Plankton are the passively drifting or weakly swimming organisms found at most depths in the water column. They inhabit waters ranging from open ocean to estuarine. Phytoplankton are microscopic plants living in the uppermost section, the euphotic zone, of the pelagic realm. Zooplankton are animal members of the plankton. They consume phytoplankton and other zooplankton.

Use the identification cards located by the microscopes while viewing the plankton to assist in answering the following questions.

1) Identify and classify at least three plankton types.

2) Can you differentiate multi-cellular from single-celled organisms? If so, how?

3) Can you identify any meroplankton? If so, can you speculate as to their adult form?

4) Write a brief paragraph explaining the role of plankton in the oceanic food chain. How do you think plankton abundance changes with yearly shifts in currents, upwelling, and the occasional El Niño event? (You may write your answer on the back of this page.)