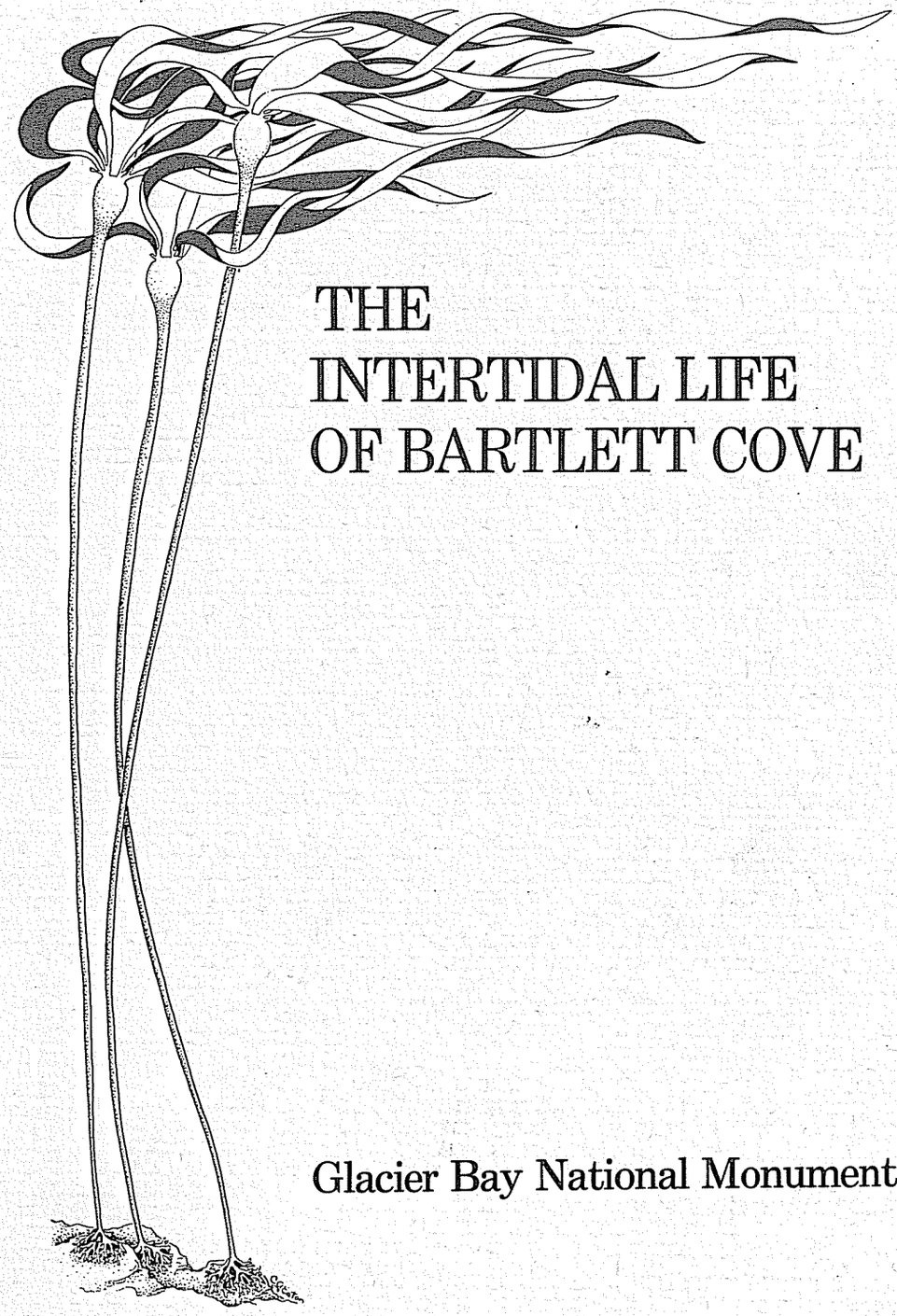
As the nation's principal conservation agency, the Department of the Interior has basic responsibilities for water, fish, wildlife, mineral, land, park and recreational resources. Indian and territorial affairs are other major concerns of America's "Department for Natural Resources." The Department works to assure the wisest choice in managing all our resources so each will make its full contribution to a better United States—now and in the future.

GPO 1979 696-630



THE INTERTIDAL LIFE OF BARTLETT COVE

Glacier Bay National Monument

PREFACE

The authors wish to thank the National Park Service for giving them the opportunity to work in Glacier Bay National Monument and are particularly grateful for the concern that the Park Service has shown for maintaining the integrity of Glacier Bay's nearshore marine communities. We gathered notes for this publication while working on an ecological study along the Monument's western boundary. Both of the authors are about to receive PhD degrees from the University of Washington where they have studied Ecology, concentrating upon marine benthic communities.

The illustrations were prepared by Cathy Eaton in close collaboration with the authors.

The authors would particularly like to thank Bruce Paige, Greg Steveler, Charles Eaton and Megan Dethier for reviewing the text and making valuable comments.

D.O.D.
Friday Harbor Marine Labs
University of Washington
May, 1979

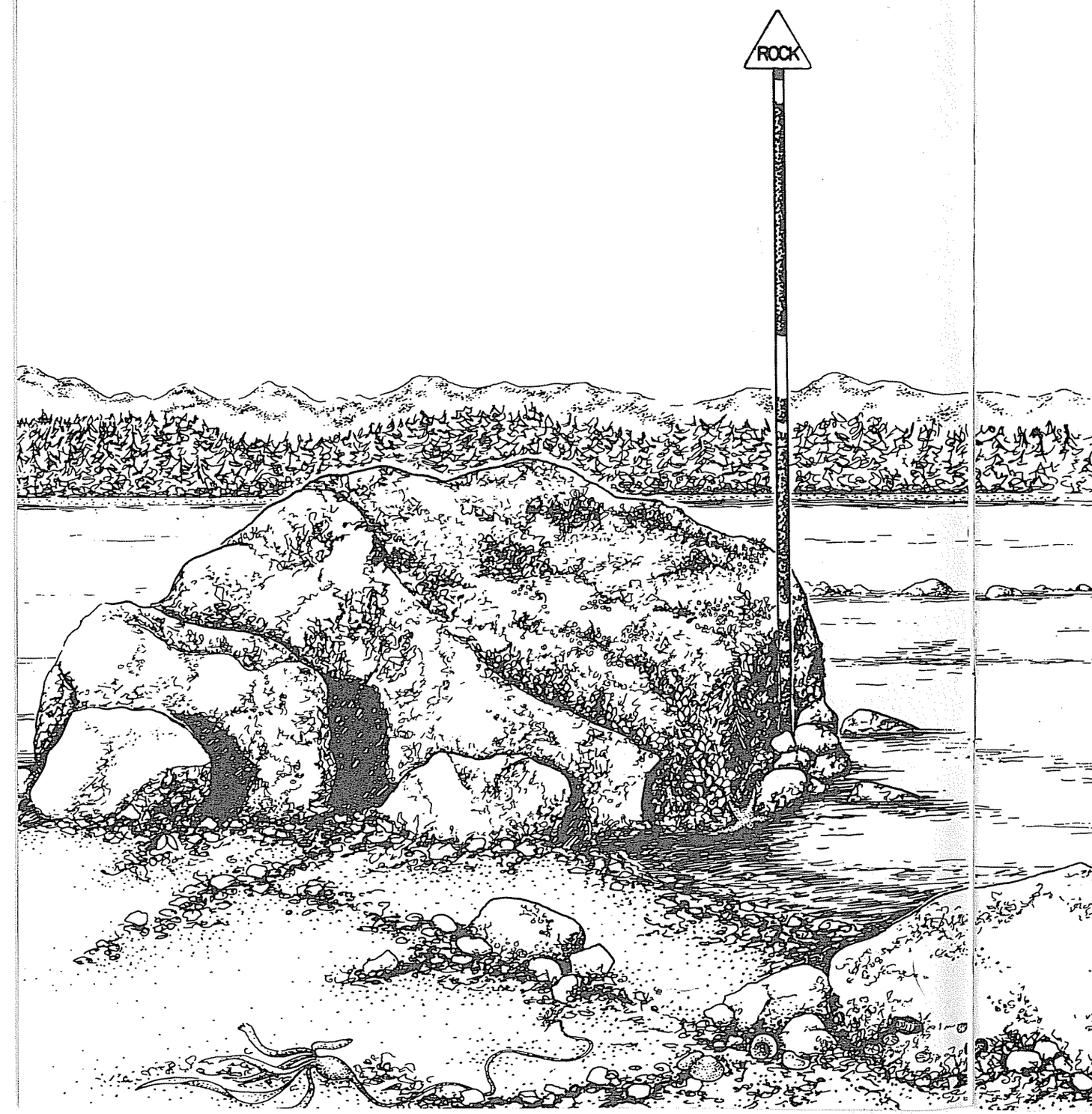
Cover

bull kelp **Nereocystis luetkeana**

THE INTERTIDAL LIFE OF BARTLETT COVE

Glacier Bay National Monument
Gustavus, Alaska

by David Duggins
James Quinn



Coordination. . . . . J.A. "Rocky" Richardson
Illustrations. . . . . Cathy Eaton
Editing. . . . . Robert A. Mowrey
Design. . . . . Harold W. Street

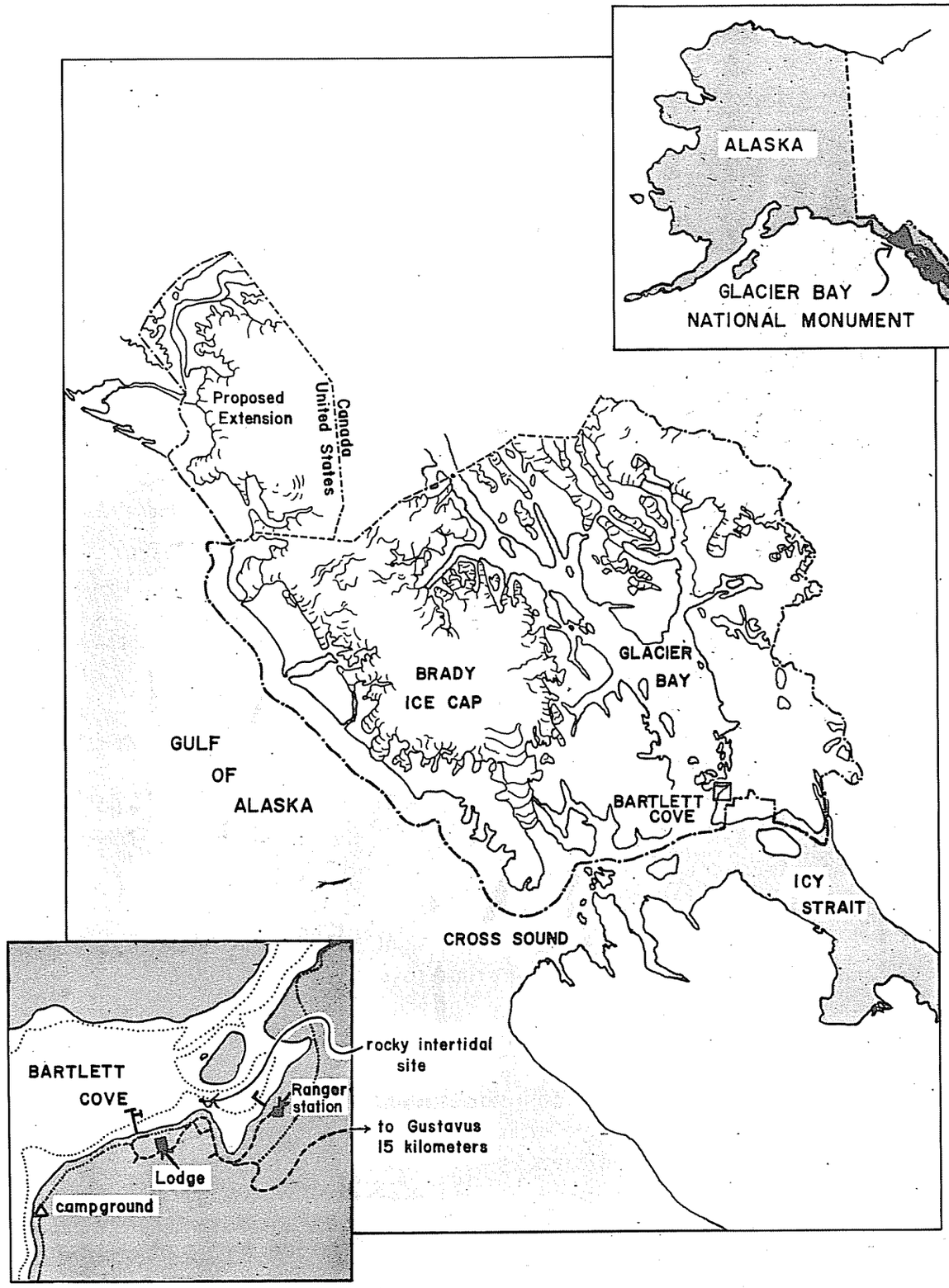
BARTLETT COVE AT LOW TIDE

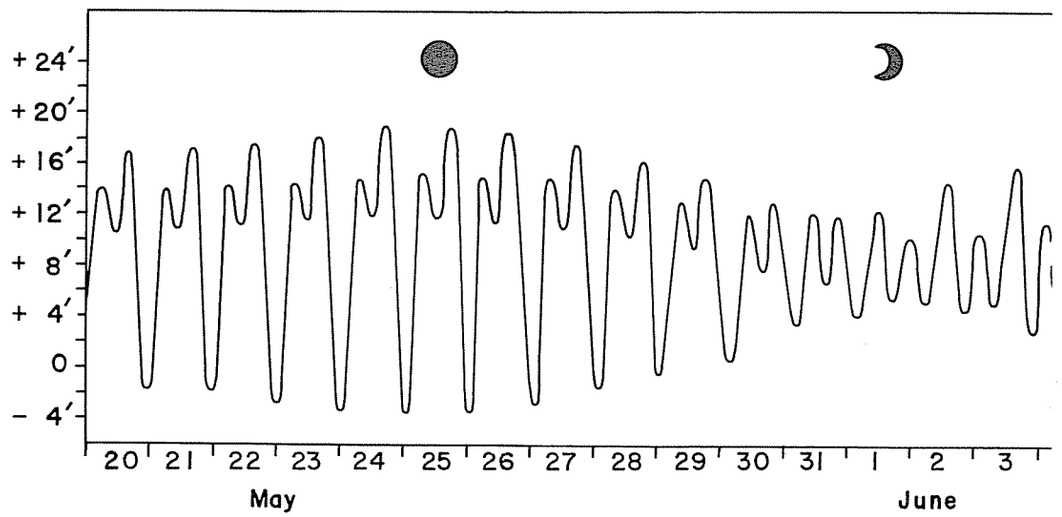
The information assembled in this field guide is intended to provide a brief introduction to the organisms and ecology of that area of shore uncovered by low tides in the Bartlett Cove area of Glacier Bay National Monument, Alaska. This portion of the marine environment is referred to as the "intertidal zone". It is, of course, not possible in this brief treatment to do justice to all of the many species and interactions that may be seen in the course of an intertidal walk. Therefore, emphasis will be placed on some of the major organizing ecological principles and the most conspicuous species that are found in this living community. Most of the plants and animals likely to be seen here are widespread along the Pacific Coast of North America, and a number of excellent books are available in the Bartlett Cove library which provide much more extensive information on them. Refer to the selected references in the back of the field guide.

The shores of Bartlett Cove can be visited during any low tide, but the level of a low tide varies greatly from day to day. On some days, even at low water, many of the most interesting organisms will be submerged. However, about every two weeks the tides cycle through their greatest range. The lowest tides occur during this time.

In summer, the lowest tides always occur in the morning and this is the best time to see many of the most interesting marine creatures. Perhaps the best area to explore is along the channel which runs from the lagoon by the park office out into Bartlett Cove (see map). The lagoon channel can be waded at extreme low tide, but this channel fills quickly as the tide comes in, and one could easily become stranded on Brown Island if not careful!

The channel which leads out from the Bartlett River also has a rich community and is well worth a visit. In addition, the floating docks nearby represent another unique habitat and can be visited at any stage of a tide. Many kinds of interesting plants and animals can be seen attached to the docks just below water line.





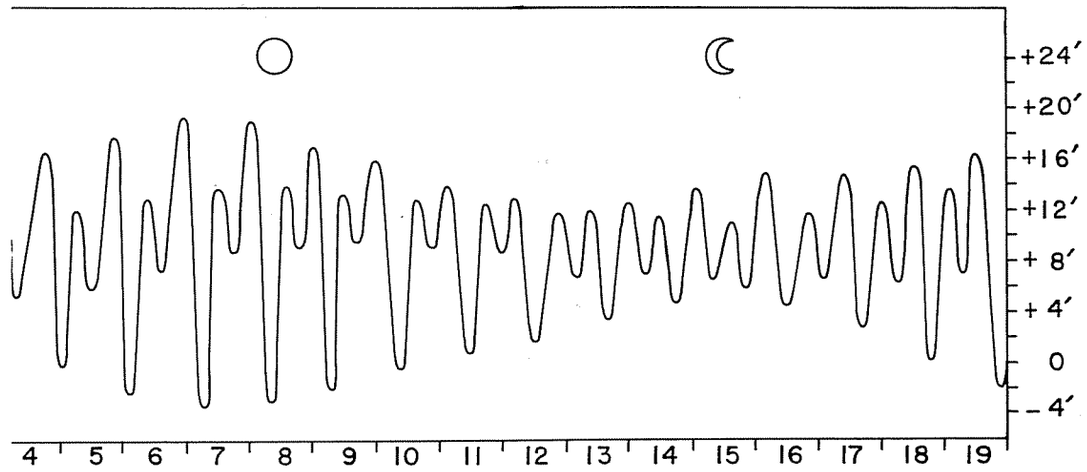
Large numbers of people walking along the same section of a beach are sure to have an impact on the intertidal life. Visitors should always watch their steps, handle the animals gently, and put them back exactly where they were found. Overturned rocks should be put back in their original positions, and the dirt returned to any holes that have been dug.

None of the intertidal animals likely to be found here are known to be dangerous to man. Virtually all of them can be picked up for closer examination without risk. However, a few of the larger polychaete worms may bite, so it is probably best not to handle those.

TIDES

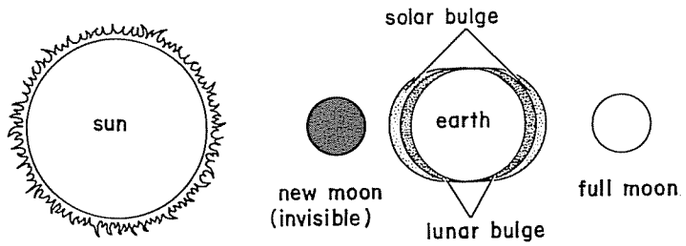
Most marine organisms will die if left out of water for very long, and thus it is the tides that govern how high in the intertidal they will be found. Any organism that lives in the intertidal zone faces a difficult ecological situation. This zone lies between the highest and lowest tide levels, and therefore all of the plants and animals found within it will be exposed to both salt water and air some time during the year. Contact with the air represents exposure to extremes for marine life forms. They can freeze, overheat, dry out, and come into contact with fresh water during periods of rain or runoff.

Species in the low intertidal zone live in a predominantly aquatic habitat where they are exposed to the air only during the lowest tides and only for short periods. By contrast, some

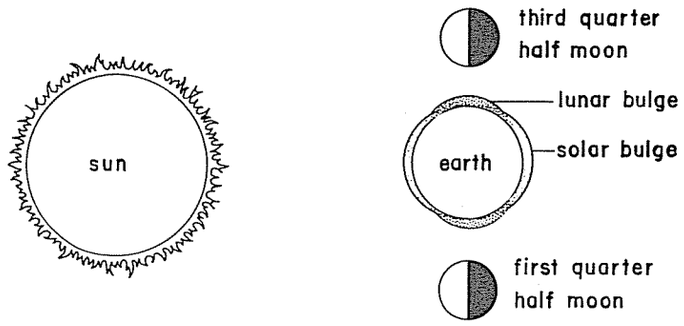


species in the higher zones may actually spend more time exposed to the air than to the water. Some of them are able to move up and down with the tides and so remain under water. However, even such mobile animals as starfish and snails are frequently exposed as the tides ebb. These animals may seek out the wettest areas for protection during low tides. Snails, for example, may move into tidepools, moist crevices, or under rocks to protect themselves from the drying effects of sun and wind. A limpet is able to trap a small amount of water between its shell and the rock substrate. Limpets use this water to keep their bodies and gills moist as they sit it out until high tide returns. The option of moving to find optimum conditions does not exist for sessile animals like barnacles which are permanently fixed to one spot. Barnacles and some snails can close the openings of their shells with a structure called an operculum (opercular plates in barnacles) by which they trap enough water inside to remain moist. Even some fish survive during low tides by remaining in tidepools, under rocks, or buried in mussel beds where water is trapped during low tides.

Tidal movements result from the gravitational attraction exerted on the oceans by the sun and the moon. The moon exerts about ten times the pull of the sun and is the main force driving the tide cycles, which follow the 24-hour 50-minute lunar day. About every two weeks the sun and moon are oriented in such a way so that they reinforce each other's gravitational pull. This happens when sun, moon and earth are in line, which occurs at the full and new moons. During such times the



range of the tides is at its greatest. These are the "spring tides". The range of the spring tides at Bartlett Cove may be as much as 25 feet from low tide line to high tide line. At the quarter phases of the moon, which also occur twice a month, the gravitational attractions of sun and moon are in opposing directions. During these times the minimum tide ranges or "neap tides" result. These may range only 5 to 6 feet at Bartlett Cove.



On the west coast of North America there are two high and two low tides per lunar day. These lows and highs are of unequal magnitude so that in one cycle there is a higher high and a lower high, a higher low, and a lower low. Zero tide level is the average level of the lower low tides. This pattern is referred

While high and low tides fall at different times each day, there are certain patterns which are consistent from year to year. For example, on most of the west coast, including Glacier Bay, the lowest spring tides fall early in the morning during the summer and in late afternoon or evening in winter. During summer the shore life is submerged during the hottest portions of the day when drying would otherwise be most serious. Similarly, during winter they are submerged during the coldest portions of the daily cycle when freezing is most likely to occur. Consequently, species are able to exist in the low intertidal zone at Bartlett Cove that might not survive under a different tidal regime.

The vertical range of the tides varies considerably from place to place. At Bartlett Cove the tidal range can be as much as 25 feet, but in the Gulf of Alaska the maximum range is closer to 12 feet. These ranges are due to differences in the size and shape of the basins in which the tidal action occurs. In general inland waters have greater tidal ranges than open ocean.

SUBSTRATE AND EXPOSURE

There are many other factors which determine what organisms are likely to be found along the shore. Exposure to the pounding of ocean surf and the type of substrate are two factors that are often related. In very exposed sites in the Gulf of Alaska the marine life must be able to withstand the frequent battering of large ocean waves breaking on rocks and beaches.

While there are rocky areas along the shores of Bartlett Cove, the area is primarily mud flats and sand and gravel beaches. This is because exposure to waves is much less than that on the outer coast. Here in Bartlett Cove the fine particles in the water have a chance to settle out on the beaches as the movement of the water slows.

In Bartlett Cove there are considerable differences between the shore life found in muddy or sandy areas and that found in rocky areas. Sandy and muddy areas provide less suitable attachment for surface-dwelling species. However, such areas may harbor vast numbers of burrowing animals including clams, shrimp, and an incredible profusion of worms. Some of these animals filter plankton from the water through siphons or through elaborate burrows. Some are predators and others feed directly on the organic matter in the sediment.

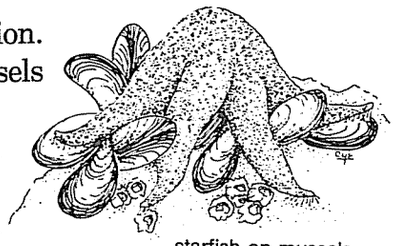
Even within a substrate type, like rocks or sand, the plants and animals vary considerably from place to place. The exposed rocks contain a very different group of species from that found in protected rocky areas. In sandy and muddy areas, the sea life varies not only with exposure, but with particle size, slope and oxygen level—all of which are interrelated. In areas with heavy fresh water inflow, such as the mouth of a river or in front of a glacier, species that are less tolerant of fresh water are unable to survive.

ZONATION

The marine shorelines of the world often exhibit distinct bands or zones with individual species tending to be found only within a restricted range of tidal heights particular to that species. Some are much more tolerant than others to exposure to air and live higher on the shore. However, it may not be so obvious why these organisms are not also found lower in the intertidal where conditions are presumably more favorable.

In general, ecologists believe that the upper limits to species' distributions are ultimately determined by tolerance to physical stress. Lower limits of distribution are frequently set by biological factors—principally the presence of predators or superior competitors. For example, mussels and barnacles need space upon which to attach themselves. Along many shores mussels are able to monopolize all of the space in parts of the middle intertidal zone. Several species of barnacles are able to survive higher in the intertidal than are mussels, the ability of these barnacles to withstand drying being greater than mussels'. The barnacles' upper limits are set by their own tolerance for desiccation, while their lower limits are set by competition for space with mussels (they are overgrown by mussels). Thus, these two animals are competing for a single resource—space in which to live. Space and food are probably the two most important resources for which intertidal organisms compete.

Predators also contribute to shore zonation. Starfish are known to enjoy a meal of mussels and the lower limit of mussels is often determined by the height at which starfish can feed. Mussels that find themselves too low are quickly eaten, and thus the mussel bed cannot become established. Many experiments have been performed in which a predator or superior competitor has been removed from a section of shore. Such removals usually result in the poorer competitor or prey moving down or settling into the lower zone, which is now a safer place to live.



starfish on mussels

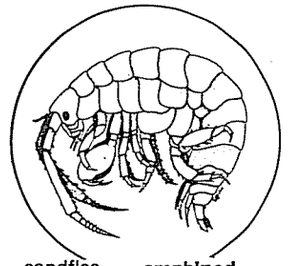
The animal and plant species described below will be organized into a generalized format depicting high, middle, and low zonation patterns. Greatest attention will be given to the most

readily observed life forms. Consequently, many of the organisms which live buried in the sand and mud are ignored. There is actually considerable overlap between these zones, and many organisms will be found in more than one zone. The concept is still a useful one and it will be obvious to anyone who walks along the shore that zonation does indeed occur along the shores of Bartlett Cove.

All plants and animals have Latin scientific names composed of two parts, the genus name and the species name. In the pages to follow, we have used only the genus name in order to make the text less cumbersome. In the keys to the illustrations we use both genus and species when both are known, but only the genus when we are unsure of the species. The ambitious intertidal observer who is interested in the taxonomic "fine tuning" can consult the references found in the Bartlett Cove library.

THE INTERTIDAL ANIMALS AND PLANTS OF BARTLETT COVE

The beach hopper is an organism of the high intertidal zone. It can be found feeding on clumps of algae that wash up on the shore. Often called "sand fleas" because of their ability to jump impressive distances, beach hoppers are amphipods and are related to crabs and shrimp. Small snails called periwinkles *(Littorina)* live in the highest intertidal zone and extend down into the upper part of the middle intertidal zone. They are found under and upon rocks and among the rockweed algae. Periwinkles spend more time out of the water than in it, and, in fact, may drown if kept underwater for very long. One experiment conducted on these hardy snails showed that they could survive out of water for 45 days!

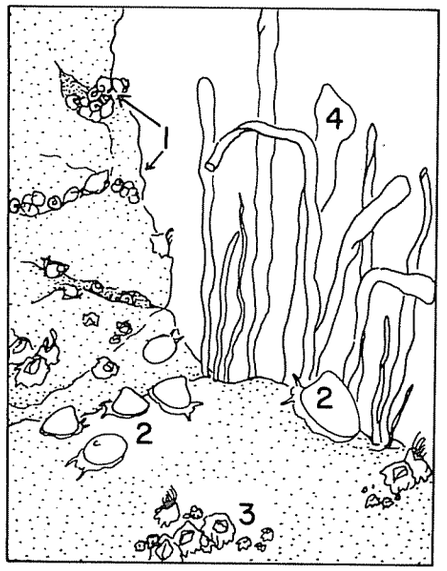


sandflea **amphipod**

Periwinkles feed by scraping small algae and diatoms off the rocks. This food source is also used by limpets and chitons. All of these organisms have a special toothed "tongue" called a radula, which is scraped against the rock to remove the plant material. All snails have a radula, but some are very specialized for gathering specific kinds of food. Periwinkles lay their eggs in a jelly-like mass on the underside of rocks.

Limpets *(Notoacmea, Collisella)* are the "Chinese hat shells." They are found on rocks throughout the intertidal zone. Although their shells are not coiled, they are closely related to snails. There are several species in the Bartlett Cove area, but they are difficult to tell apart. In some cases one must examine the radula with a microscope to be sure. Like periwinkles, limpets feed by scraping algae off the rocks. They survive in the high zone by trapping water underneath their shells. This can be seen by lightly tapping a limpet and watching the water ooze out. Limpets are incredibly tenacious. Unless they are surprised they are very difficult to remove from a rock. The force required to remove one that is only the size of one's fingernail has been measured to be about 70 pounds.

Chitons are found in the middle to low intertidal zone in rocky areas. Chitons are mollusks with flattened bodies. They are oval in shape and have eight plates along their backs. Chitons eat algae and are thus ecologically similar to limpets. Several species can be found in the Bartlett Cove area. The leather chiton *(Katharina)* is a large black chiton and reaches several inches in length. It can be told by its color and the fact that the plates are almost covered by its black leathery girdle. The hairy chiton *(Mopalia)* can be told by the hair-like growths around the margin. A small, very colorful chiton, the lined chiton *(Tonicella)* can be found on pink encrusted rocks in the channels where strong currents occur.



HIGH INTERTIDAL ZONE

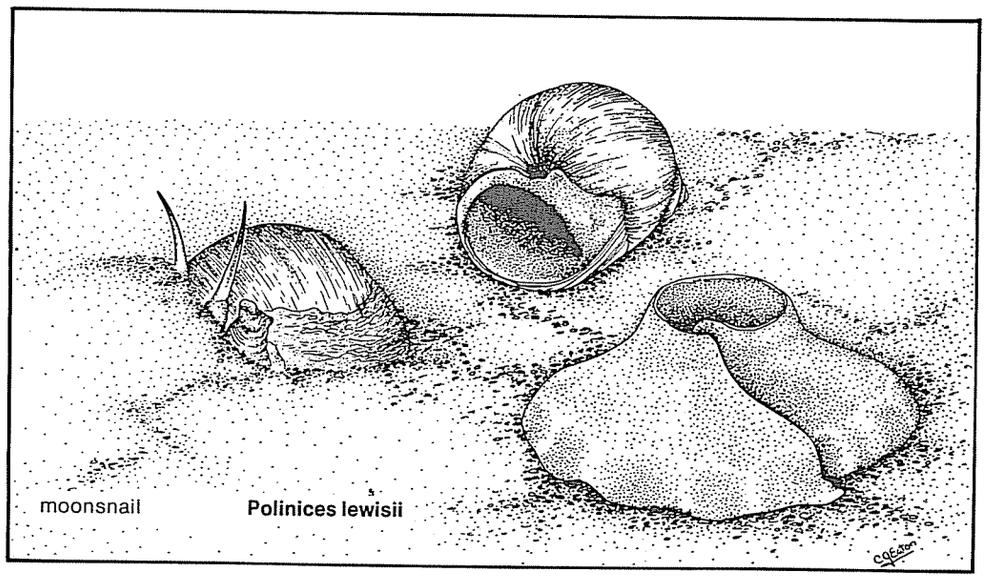
1. periwinkles	**Littorina sitkana**
2. limpets	**Notoacmea persona**
	Collisella digitalis
3. barnacles	**Balanus glandula**
4. seaweed	**Enteromorpha intestinalis**

The dogwinkle *(Thais)* is a common snail in the middle shore zone. It is commonly found around mussels and barnacles which are its preferred foods. It feeds on these animals by drilling a small hole in the shell with its radula. Then its long proboscis is forced through the hole. Digestive enzymes are released, and the soft body of the mussel or barnacle is sucked out through the proboscis. Many of the empty mussel shells in and around the mussel beds have a small round hole in them—a sure sign that they were eaten by a dogwinkle.

Under rocks one will often find the egg masses of the dogwinkle. They are laid in clusters of white to tan cigar-shaped capsules called "sea oats." Each cluster is about one-quarter inch high and contains several hundred eggs. Cannibalism is not uncommon in dogwinkles. The adults frequently eat the egg capsules, and the first snails to hatch within the capsule will generally eat the remaining eggs.

The shells of two large snails can often be found in the intertidal zone where they have been carried by currents or hermit crabs, although the living snails are rarely seen. The ridged whelk *(Neptunea)* reaches a length of about four inches and can be told by the heavy ribs spiraling around the shell. A similar snail, the hairy whelk *(Fusitriton)* has a shell covered with a hairy surface layer when alive. Both species are important predators and scavengers of deep water.

Moon snail *(Polinices, Natica)* shells are white and globular in



moonsnail **Polinices lewisii**

shape and can be up to two inches in diameter. Live individuals are occasionally found on very low tides on muddy or sandy beaches where they may not be recognized as snails. When they are moving about, moon snails protrude so far out of their shells that the shell may be completely covered by folds of the body. This gives them the appearance of grey-white slugs. If touched, however, the snail can contract completely into its shell. The egg cases of moon snails are often found washed up on the beach. They are thin doughnut-shaped collars measuring 4-5 inches across. Initially, they are sandy in color, but soon turn black after being washed ashore.

Barnacles *(Balanus, Chthamalus)* are ubiquitous marine animals that are found along shores throughout the world. They are crustaceans, and thus are related to crabs and shrimp. Several species of barnacles are found in Bartlett Cove. However, they are not easy to tell apart.

Barnacles may dominate in the high intertidal or in areas of low salinity where few other marine species can live. Some particularly hardy barnacles survived one 3-year experiment in which they were submerged in sea water for only one day every three months. There is also a local species which lives only on the skin of humpback whales. In the middle intertidal zone barnacles can get so crowded that they force each other into a tall, thin "pencilform" shape. Another local species found in deeper water can reach 8 inches in diameter and is probably the largest barnacle in the world.

Barnacles feed on plankton in the water and, in turn, are eaten by a number of predators, including starfish, dogwinkles, and ribbon worms. Barnacles are hermaphrodites, that is, each one has both male and female sex organs. However, self-fertilization does not occur in local species. They must mate with their neighbors in order for fertilization of the eggs to take place. Larval stages develop initially within the shell of the parent, then live swimming in the plankton for up to 12 weeks before settling. The final larval stage attaches itself in a head-down position using special suckers and a cement gland. Then it undergoes a metamorphosis into the adult barnacle form. To feed, it sweeps the water with its legs, called cirri, and pulls in

periwinkles **Littorina sitkana**

food and fans out wastes. Barnacles can usually be observed feeding in tidepools or just below the water line.

Among the barnacles on rocks in the low to middle intertidal zones, worms which are long, thin and very smooth can be found. They are usually dark green or white in color, although in muddy areas similar purple worms are common. These are ribbon worms or Nemerteans. They have an extendable proboscis that measures up to half the length of their bodies. At the end of the proboscis in most species is a stinging barb attached to a poison gland. Ribbon worms are predators. The green ribbon worm *(Emplectonema),* which usually has a light underbody, specializes on a diet of barnacles which it stings and paralyzes when the barnacle's plates are open to feed. It then inserts its head into the open shell and consumes the barnacle.

The purple species *(Paranemertes)* and probably the white species *(Amphiporus)* feed primarily on other worms, such as the mussel worm. It is sometimes possible to elicit an attack by the purple ribbon worm by placing a mussel worm close to the ribbon worm in a pool of water. Although the mussel worms can be much larger, and have powerful jaws, the ribbon worm is often successful in paralyzing it with its strike. Ribbon worms sometimes break apart when handled but each part may be capable of regenerating into an entire worm.

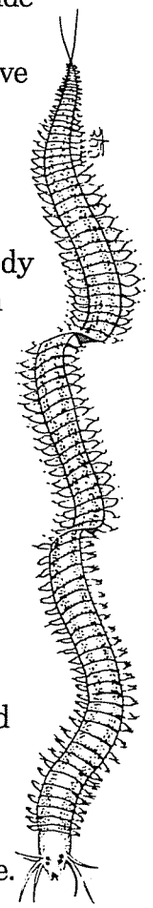
Polychaetes, relatives of the earthworm, are found in just about every type of marine environment from the intertidal zone to the deepest portions of the oceans. There are many species of these segmented worms in the Bartlett Cove area but most are buried in the mud and are difficult to observe. Many of the holes observed in the mud at low tide are the openings of worm burrows, some of which are elaborate sand and mucus structures.

Identifying worms is a reasonably ambitious undertaking. Serious worm watchers will find more information in the selected references in the back of the book. However, there are a few polychaetes which are easily recognized. The most conspicuous, and by far the prettiest, are the feather duster worms. Sessile tube-dwelling polychaetes, feather duster worms, feed by filtering plankton from the water with their flower-like

tentacles. They can be recognized when feeding because they instantly withdraw their tentacles when disturbed. All other flower-like invertebrates withdraw more slowly. Clusters of their straight parchment-like tubes *(Eudistylia)* can often be found at low tide in crevices in rocky areas or under the overhangs of large rocks. Another kind of feather duster worm, the tiny *Spirorbis,* can be found in great numbers on the undersides of rocks. These have white spiraled calcareous tubes generally under one-quarter inch in diameter. Sometimes, the bright red tentacles of the worm are visible.

Another group of polychaetes likely to be seen are scale worms, which are identified by the two rows of plate-like scales running down the back. Some members of the group provide excellent examples of what ecologists call commensalism. Although many are free-living, a number of scale worms live closely with other marine animals. For example, some are found only in the burrows of other host worms or clams. Others live only in grooves on the undersides of starfishes or on the bodies of large sea cucumbers or in the gills of chitons. One such worm lives between the shell and the body of the keyhole limpet, which is found below low tide line in Barlett Cove. A commensal relationship is beneficial to one of the two organisms involved—in these cases to the scale worm—but neither harms nor benefits the host.

The mussel worm *(Nereis)* may grow up to three feet in length. As in most segmented worms each segment has a pair of paddle-like appendages which aid in locomotion. They have powerful jaws, and may bite when mistreated. Look for them in the middle and lower zone mussel beds. Once a year the mussel worm changes completely in appearance in preparation for mating and spawning. The posterior segments become swollen with eggs or sperm and the female turns bright red. Both males and females develop strong swimming appendages and though they are normally crawling animals, during the spawning period, they swim at the water's surface in swarms to mate.

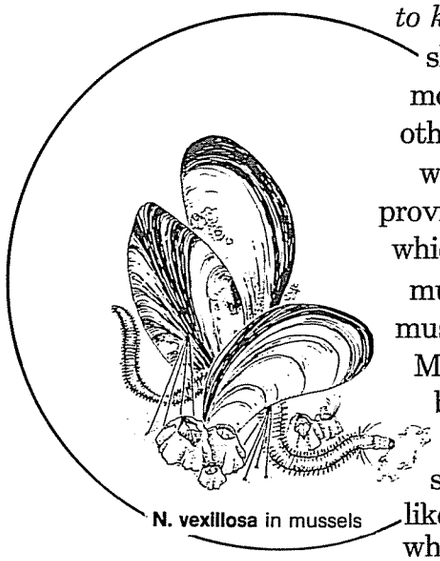


mussel worm
Nereis vexillosa

As they mate, they release eggs and sperm into the water and eventually are eaten by fish and birds.

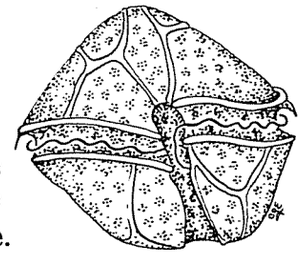
Mussels *(Mytilus)* are relatives of clams and are commonly found in the middle to lower rocky zones attached to rocks by strong threads which the animals secrete. Blue-black in color, mussels are filter feeders. They feed by passing sea water over a filtering structure (the gill) which removes organic particles and small organisms (plankton) and passes them on to the mouth.

The mussels in the Bartlett Cove area are edible. In fact, in Europe, the same species is a prized food item. *However, in the summer and fall they may become poisonous.* One of the tiny organisms that blooms in the plankton is a dinoflagellate *(Gonyaulax)* which secretes a potent toxin. The toxin does not affect the mussels, but they accumulate it and may store it for a month or more. *A single heavily tainted mussel is sufficient to kill a person.* This syndrome, paralytic shellfish poisoning, is a serious danger over most of the Pacific Coast and mussels and other filter feeding clams should be eaten with due care during summer. Mussel beds provide a home for many other organisms which live in the protected spaces between mussels or among the threads by which the mussels attach themselves to rocks.



N. vexillosa in mussels

Mussel beds can become so thick that they overgrow other sessile animals like barnacles. Barnacles which are overgrown are unable to feed and will eventually die.



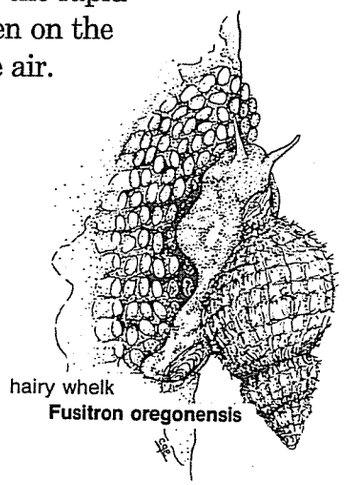
"redtide" plankton
Gonyaulax

Every year each female mussel produces several million eggs and releases them into the water. Fertilization takes place in open water and small larvae develop. The larvae spend up to several months swimming in the ocean. If they are not eaten or washed out to sea, they settle along the shore, attach themselves, and undergo a metamorphosis into the adult form.

Several different clam species live in Bartlett Cove, but usually only the shells of dead clams are noticed at first. Live clams can be found by digging in the mud flats. Many of the holes in the mud are openings through which water is pumped to and from the bodies of the clams. This circulated water brings both food and oxygen to the gills. Most clams are filter feeders. That is, they remove plankton from the water with their gills. Like mussels, the filter feeding clams concentrate the toxin of paralytic shellfish poisoning, and so should not be eaten in the summer unless they are positively known to be untainted.

Cockles *(Clinocardium)* range from the Bering Sea to Baja, California. They can be recognized by the heavy ribs radiating from the hinge of the shell. Unlike other clams, cockles have no siphon tubes. Consequently, they live very close to the surface of a mud or sand flat. An exposed cockle can bury itself very quickly if disturbed and can actually "hop away" from a starfish. It moves by means of manipulating its large muscular "foot"—an interesting process to watch.

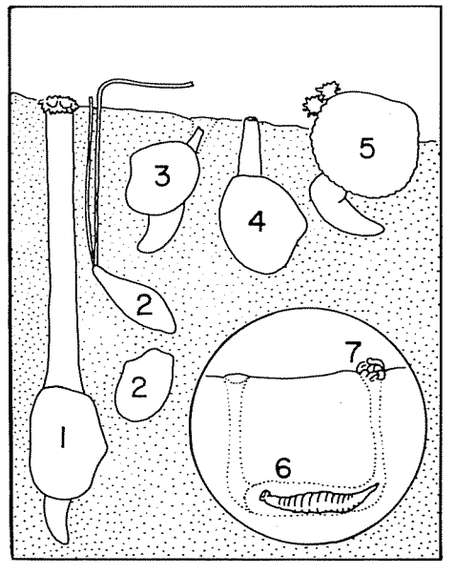
The littleneck clam *(Protothaca)* gets its name from its short siphons or "neck," and is best identified by shell ribs radiating from the hinge and running parallel to the margin. These clams can reach very high densities and are perhaps the best tasting of the local bivalves. The occasional geyser-like spurts of water, coming from the rapid contractions of these clams, are often seen on the beaches and can shoot several feet in the air.



hairy whelk
Fusitron oregonensis

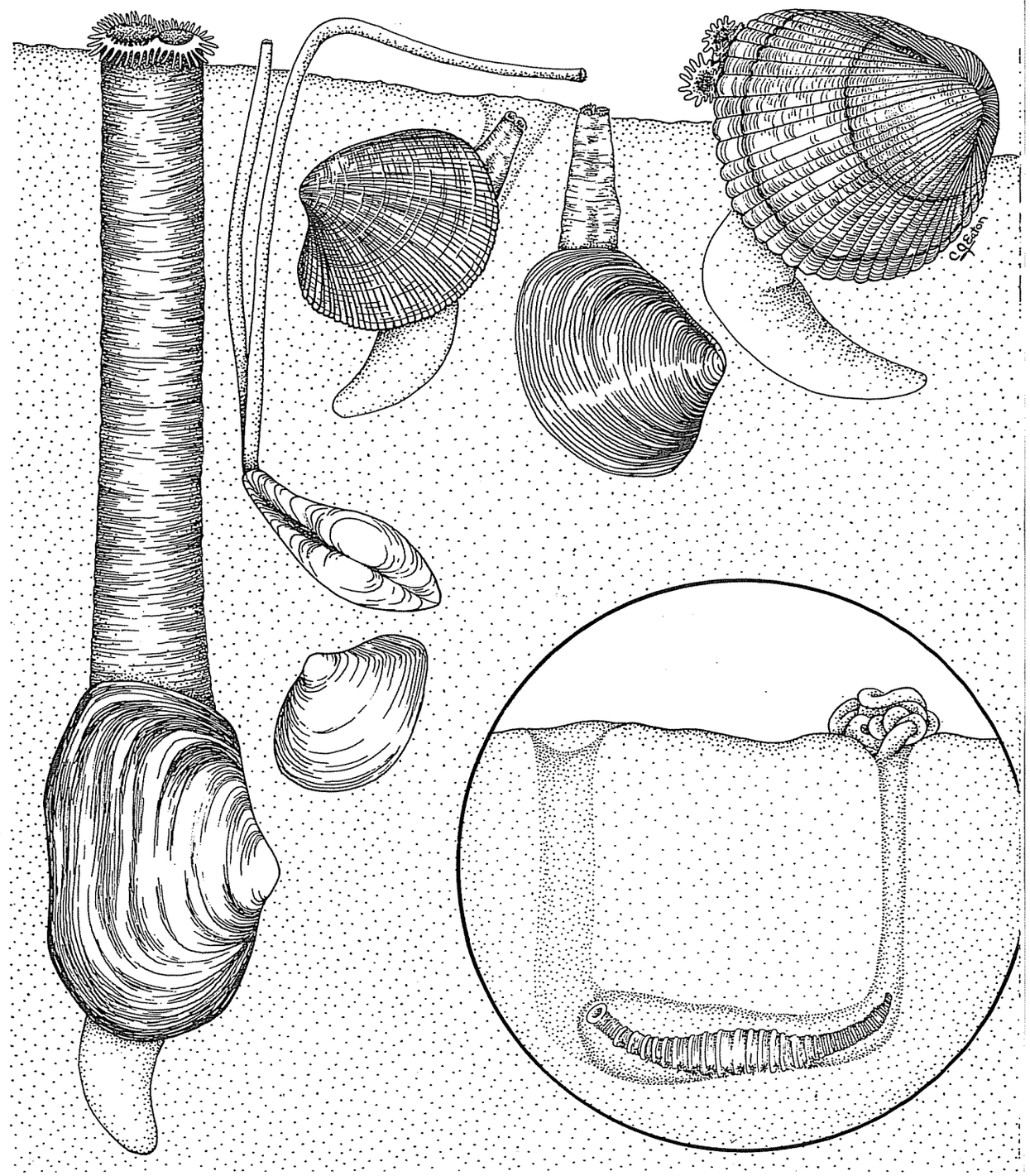
Butter clams *(Saxidomus)* are common large clams with thick shells showing fine ribbing parallel to the margin. Although very tasty, they store paralytic shellfish poisoning toxin for long periods of time, and should be eaten with due caution.

Bent-nose clams *(Macoma)* are abundant in soft sediment areas. Their thin shells rarely exceed a couple of inches in length and, when looked at from above the hinge, are distinctly bent to one side. Bent-nose clams are often buried at a depth of a foot or more, and feed by sucking sediment from the surface down a long worm-like siphon. Though generally safe to eat, they tend to be sandy.



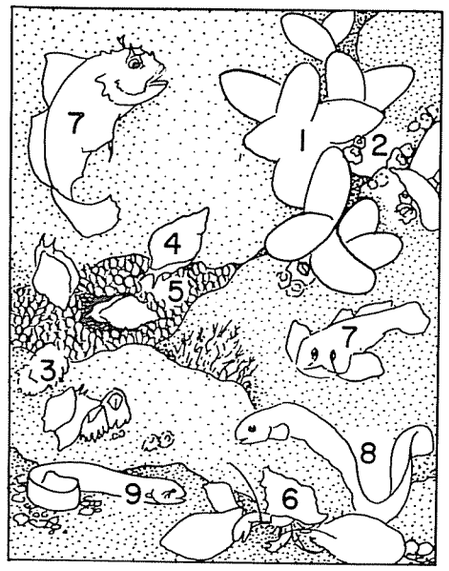
SANDY BOTTOM

1. soft-shelled clam — **Mya**
2. bent-nosed clam — **Macoma**
3. Pacific littleneck clam — **Protothaca**
4. Washington butterclam — **Saxidomus nuttali**
5. cockle — **Clinocardium**
6. burrowing worm — **Abarenicola**
7. castings of burrowing worm



A variety of fish feed in the intertidal zone at high tide, but most withdraw with the receding water of ebb tide. Several species, however, are likely to be seen hiding in tidepools under rocks or in mussel beds. Sculpins, or bullheads, are usually brown or mottled with large heads, wide mouths, a long tapering tail, and pronounced pectoral (side) fins. Most are less than two inches long.

Several kinds of gunnels and pricklebacks are found under rocks, in mussel beds, or partially buried in coarse sand. Collectively, they are referred to as "blenny eels." They are long and thin eel-like fish which thrash wildly when disturbed. Like sculpins, they are generalized feeders. They eat seaweeds, scavenge dead animals, and prey on small shrimp, fish and other animals.

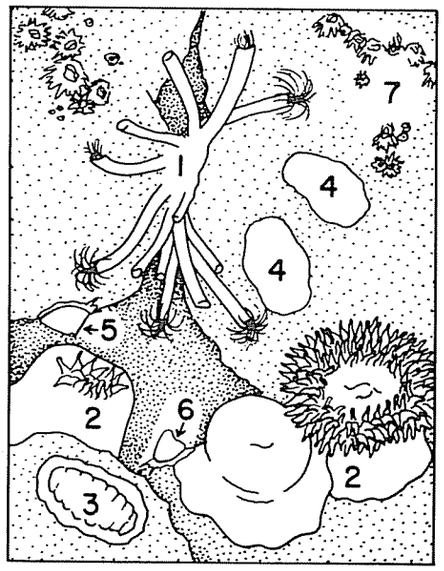


LOWER INTERTIDAL ZONE

1. edible mussels	**Mytilus edulis**
2. barnacles	**Balanus glandula**
3. ridged barnacles	**Balanus cariosus**
4. dogwinkle	**Thais lamellosa**
5. "sea oats"	**Thais** egg capsules
6. hermit crab	**Pagurus**
7. tidepool sculpin	
8. gunnel	
9. prickleback	

Among the most beautiful of marine animals are sea anemones—the flowers of the sea. Sea anemones are predators and related to jellyfish. A ring of tentacles, surrounding a mouth, is covered with specialized stinging cells. When touched, the cells eject microscopic harpoon-like barbs called nematocysts which usually are poisonous. In this way food items are held tightly, usually paralyzed, and then brought to the mouth by the muscular tentacles. None of the local anemones are capable of stinging a person. However, the barbs can be felt as a sticky sensation when the tentacles are touched.

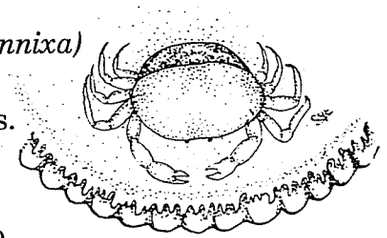
One species of anemone *(Tealia)* is found in low rocky areas. It is typically red and tan in color, and has thick and strong tentacles. It feeds on large prey, such as mussels, snails, and sea urchins that have been dislodged by the current or by predators. The feeding behavior of these anemones can be watched by dropping a mussel on one of the tentacles. *Anthopleura,* which is smaller than *Tealia* and green in color, is typically found in aggregations on rock surfaces where sand, shells and pebbles have accumulated. When the tide ebbs, the anemones contract into blobs covered with bits of gravel and shell, blending well into the background. If sat on or walked upon, the pressure causes water to squirt from their mouths and through pores in their body walls.



LOWER INTERTIDAL ZONE

1. tube worms	**Eudistylia**
2. anemone	**Tealia crassicornus**
3. lined chiton	**Tonicella lineata**
4. black leather chiton	**Katharina tunicata**
5. keyhole limpet	**Diodora aspera**
6. dunce cap limpet	**Acmea mitra**
7. ridged barnacles	**Balanus cariosus**

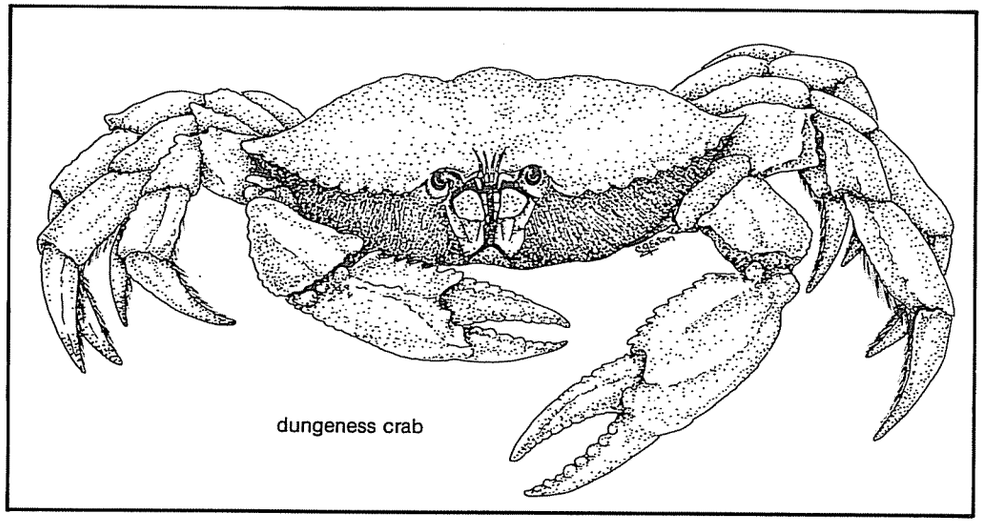
There are a number of small pea crabs *(Pinnixa)* living commensally with other organisms in burrows or even inside the shells of some clams. However, the crab species of greatest interest to the Monument visitor is likely to be the Dungeness crab *(Cancer).* It may be difficult to find Dungeness crabs except at the lowest tides, and even then they will usually be buried in the sand or mud. The greater number of these crabs in deeper water is attested to by the large number of molts found along the beach. A molt is an old discarded shell or exoskeleton. A mature crab will molt only once a year, but younger ones may molt as many as six times in one year.



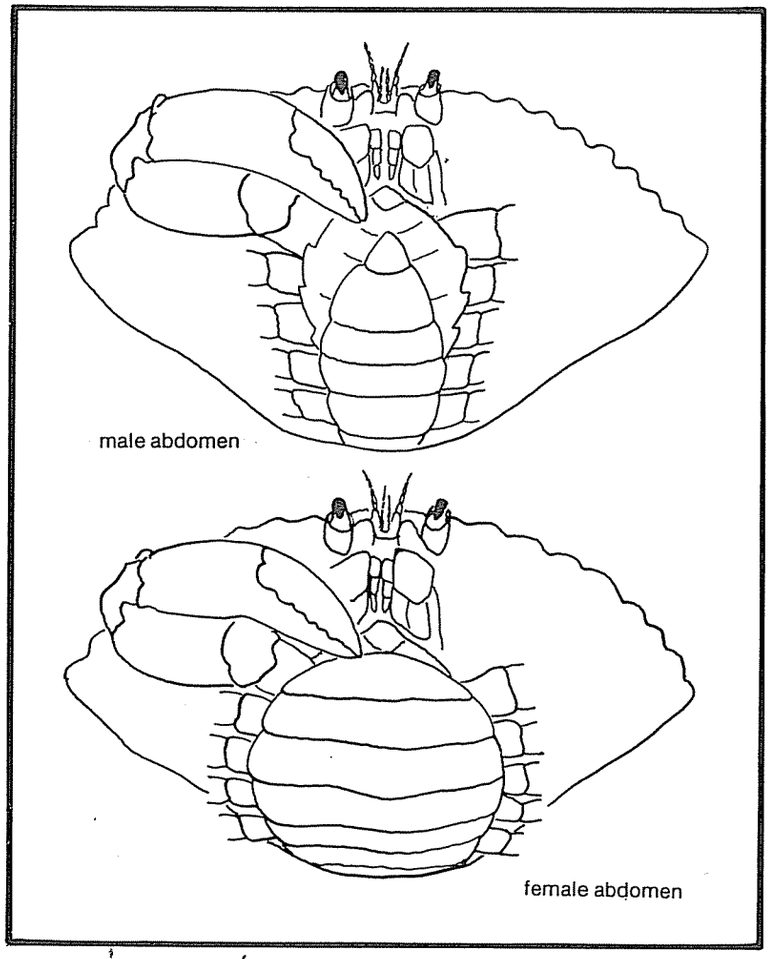
pea crab in a cockle

Male crabs can be distinguished from females by the size and shape of the abdomen or "tail" which is folded underneath. The abdomen of the male is long and thin, at least twice as long as it is wide. The female has a smaller and wider abdomen under which it carries its eggs. Only male crabs are permitted to be taken for commercial or private use, and they must be at least six and one half inches across the back.

Mating in crabs is a rather involved process. The male crab first embraces the female tightly. The two crabs may remain like this for several days or until the female is ready to molt. Molting of the female must take place before mating can occur. The female signals to the male that molting is about to begin by stroking the male's eyestalks with her large claws. The male then switches his position so that he rests on top of the female's back. The male may actually help the female shed her old shell, and mating then takes place. The female stores the male's sperm in a receptacle in her body until she is ready to lay her eggs, at which time the sperm is released, and the eggs are fertilized. The female will carry the eggs under her abdomen for up to 10 months and may carry as many as one and one half million eggs at one time.



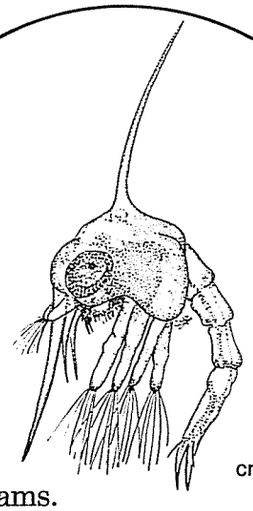
dungeness crab



male abdomen

female abdomen

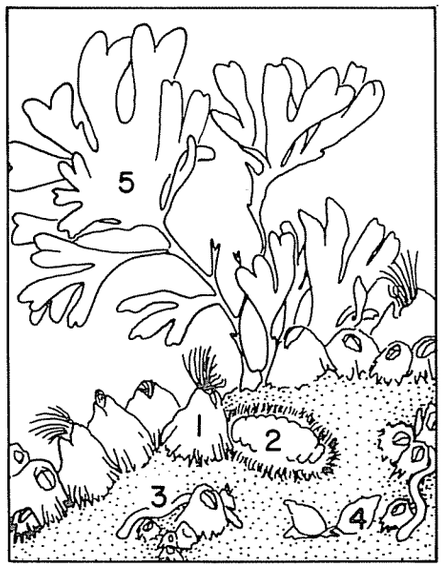
After hatching, the young crabs swim in the plankton for about five months. They then undergo a metamorphosis through several intermediate stages. When the adult stage is reached, the crabs settle to the ocean bottom and bury themselves in the sand. They are very vulnerable to predators at this stage. Crabs are also vulnerable to predators after molting. Their bodies are soft, so they remain buried for several days while their new shells harden.



crab larva

Crabs are predators. They feed on many kinds of animals buried in the sand—especially clams. A crab uses its large claw to capture and manipulate its prey and to chip open clams. Crabs are in turn eaten by octopuses, bottom fish such as halibut, and, of course, man.

The plant life found along the beach follows zonation and exposure patterns like those that govern the distribution of animals. Although there are many species of marine plants, only a few of the most common will be mentioned. Algae, or seaweeds, are classified on the basis of the photosynthetic pigments they use. Green algae use chlorophyll like terrestrial plants. The red and brown algae also use chlorophyll, but its color is masked by other photosynthetic pigments.



MID INTERTIDAL ZONE

1. ridged barnacles **Balanus cariosus**
2. hairy chiton **Mopalia ciliata**
3. ribbon worm **Emplectonema**
4. dogwinkle **Thais emarginata**
5. rockweed **Fucus distichus**

The most common brown seaweed is rockweed *(Fucus),* which is found attached to rocks throughout the middle intertidal zone. Gas-filled bladders at the tip of each branch help keep the plant floating near the surface when the tide is in, and thus increases the amount of light available for its energy needs. Light is filtered out rapidly as it passes through water. Rockweed also secretes a mucus-like substance which helps keep it moist during low tide.

In the lowest reaches of the intertidal zone are found a few large brown algae which belong to the group commonly referred to as kelp *(Alaria, Costaria* and *Laminaria).* These are perhaps best observed attached to the floats at the main dock. At the entrance to Bartlett Cove, at the south tip of Lester Island and just off Halibut Point, will be found large beds of these kelps. One of the kelps seen in these beds is the bull or bulb kelp, *Nereocystis luetkeana.* One of the fastest growing plants on earth, this kelp may grow as much as six inches in length a day.

Alaria is also found in these large beds and on the dock floats. It is distinguished by a blade up to 20 feet long, with a central rib. It has a short stem with many shorter reproductive blades at the base. It also has a root-like holdfast by which it attaches itself to solid surfaces.

A common red seaweed is *Porphyra.* This is found in the middle and upper zones, sometimes growing on *Fucus.* It is a very thin seaweed and composed of only one or two layers of cells. It will completely dry out during a low tide, but when the water comes back in it quickly returns to its healthy state. *Porphyra* is a major source of food in Japan, where it is cultivated on aquatic farms. Another common red seaweed is *Gigartina.* Found on rocks in the mud and low zones, it is dark red in color and its roughened blades are covered with small palp-like reproductive structures.

Several types of green algae will be seen in rocky and muddy areas. In the middle and lower zones the sea lettuce *(Ulva* or *Monostroma)* will be found. These algae are bright green with thin broad blades, about 6 inches long, sometimes perforated with many holes. Very common in the high intertidal, particularly in areas of fresh water runoff, is the long narrow and tubular *Enteromorpha,* up to 5 inches long but only ¼ inch wide. All these marine algae are discussed in Abbott and Hollenberg (1976).

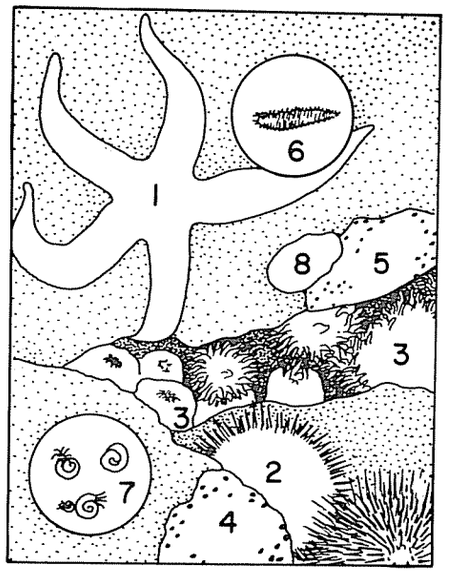
Starfish are among the principal predators of the intertidal zone. Although several species are found locally, almost all that are seen in the Bartlett Cove area are the five armed mottled starfish, *Evasterias.* Starfish are echinoderms, related to sea urchins and sea cucumbers. When exposed at low tide a starfish will be inactive, but if it is picked up and turned over, it is frequently possible to see what it has been eating. A starfish feeds on such animals as mussels and snails by everting its stomach through its mouth and into the shell of the prey. Digestion takes place outside the starfish's body.

In many places starfish play a very important role in the ecology of the shore. By feeding predominantly on mussels, one species of starfish clears enough space (which would otherwise be choked by mussel beds) to allow a variety of other species to live in the area.

On the top side of the starfish, the side away from the mouth, are many tiny pinching organs. These perform several important functions, including aggression toward other starfish. The pinchers can usually be felt by placing the back of the hand on the starfish's upper surface. Hold the hand in that position for several seconds, then withdraw it slowly. The pinchers can be felt tugging on the hairs of the hand. On the bottom of the starfish, in the conspicuous grooves, are hundreds of appendages called "tube feet." Each has a suction cup at the end. The tube feet are used for locomotion and for holding onto prey and rocks.

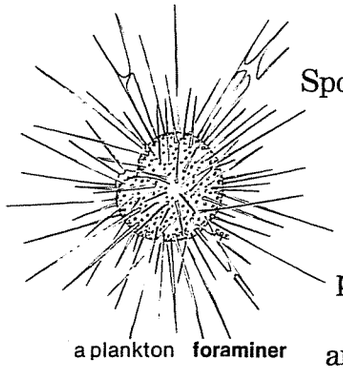
Sea urchins *(Strongylocentrotus)* are sometimes exposed at very low tides in Bartlett Cove. During such tides large numbers of urchins can be seen in the lagoon channel just below the low tide line where they dominate large areas. Sea urchins, relatives of the starfish, are plant eaters and account for the absence of algae from the channel or the adjacent areas. Sea urchins play very important roles in the marine environment by determining the amount and type of plants that are present in many areas. Some larger algae will be observed in the quiet waters of the lagoon near the channel. These algae probably survive because sea urchins don't like the still muddy water outside of the fast-flowing channel.

The sea urchin uses its spines for protection, locomotion, and to transport plant material to its mouth which is located on the underside of its body. Like a starfish, the sea urchin has pinching organs between its spines, and tube feet which it uses for locomotion and attaching itself to the substrate. The internal skeleton of a sea urchin is called a test. Many such tests will be observed in the lower intertidal, and close examination will reveal them to be fascinating structures. The large hole in the bottom side is where the mouth used to be. The many small knobs covering the test are where the spines were attached, and the hundreds of very small holes are where the tube feet passed through the test.



LOWER INTERTIDAL ZONE

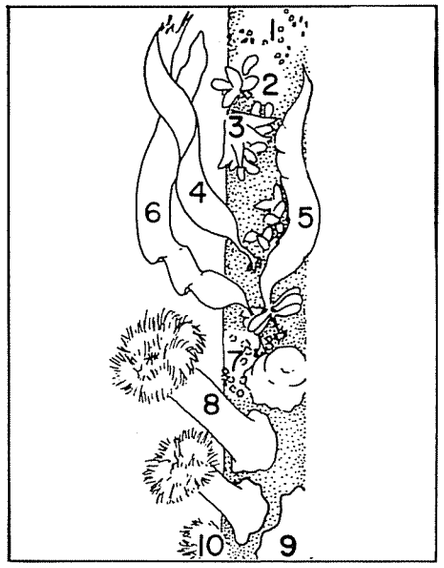
1. mottled starfish — **Evasterias troschelii**
2. green sea urchin — **Strongylocentrotus droebachiensis**
3. pink-tipped sea anemone — **Anthopleura elegantissima**
4. sponge — **Haliclona**
5. "bread crumb" sponge — **Halichondria**
6. scale worm
7. spiral tube worm — **Spirorbis**
8. black leather chiton — **Katharina tunicata**



a plankton **foraminer**

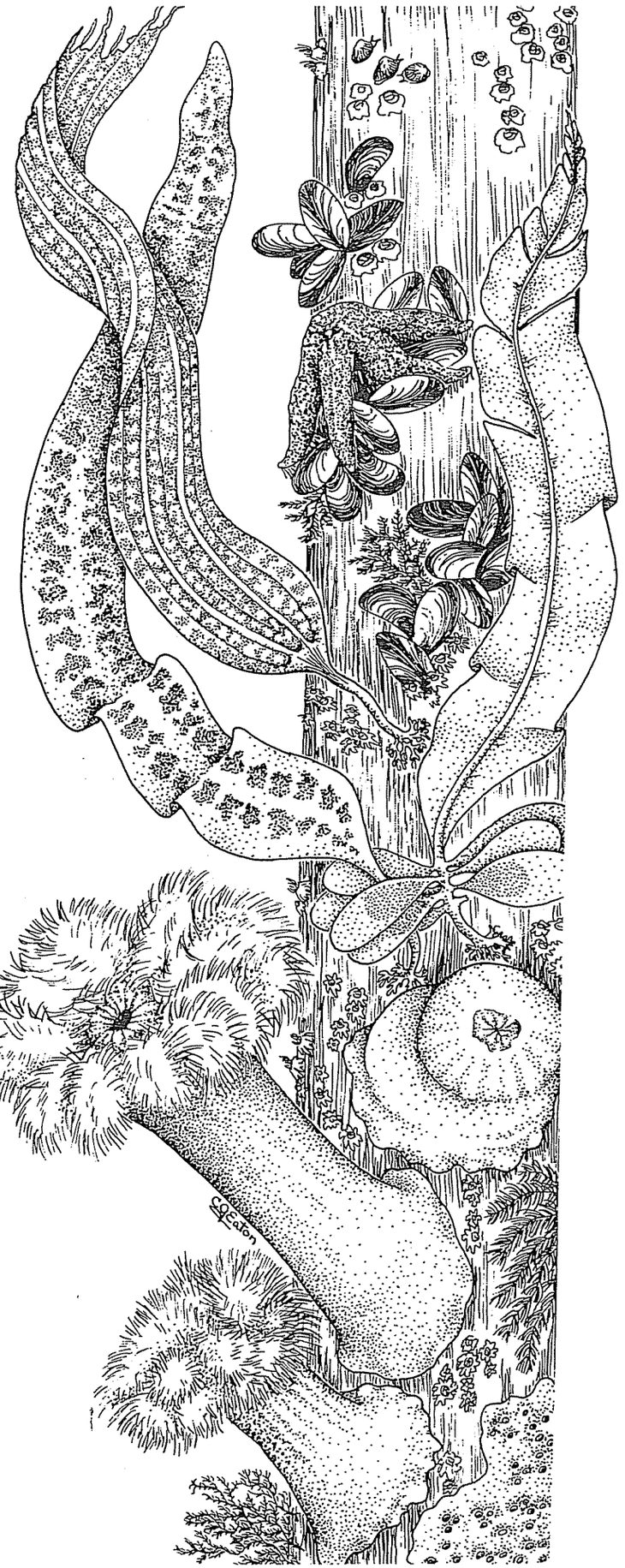
Sponges are generally considered to be among the most primitive of animals. They have no organs, but are rather an assemblage of several kinds of specialized cells. A sponge feeds by moving water in through small pores on its surface into chambers where plankton is trapped by specialized collar cells. The water is then pumped into larger chambers and expelled through large pores. Both of the common sponges in Bartlett Cove are encrusting forms, which means that they spread over the surfaces of rocks in a relatively thin layer. The bread crumb sponge *(Halichondria)* is greenish in color, up to an inch thick and has a very distinctive odor. Another sponge, *Haliclona,* is thinner and smoother, with conspicuous volcano-like pores. *Haliclona* is frequently a deep shade of purple or pink.

Floats and pilings offer a wide assortment of plants and animals, many of which are also found in the rocky intertidal zones. Floats that rise and fall with the tide make a convenient place to study marine life at all levels of the tides. Also, this action allows the animals and plants on the floats to live close to the water's surface, yet not be in danger of exposure. Barnacles, sponges, seaweeds, mussels, starfish and sea urchins can be found here. Small fish and shrimps swim in and out of the heavy growth.



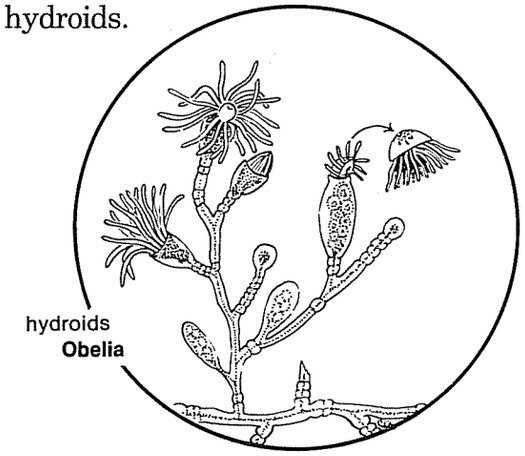
PILINGS

1.	barnacles	**Balanus glandula**
2.	edible mussel	**Mytilis edulis**
3.	mottled starfish	**Evasterias troschelii**
4.	seaweed	**Costaria costata**
5.	seaweed	**Alaria marginata**
6.	seaweed	**Laminaria saccharina**
7.	ridged barnacles	**Balanus cariosus**
8.	anemone	**Metridium senile**
9.	sponge	**Haliclona**
10.	hydroids	**Obelia**



The sea anemone *(Metridium)* is most conspicuous on the docks and pilings, although smaller individuals are found on rocks in the channel. *Metridium* is either orange or white, reaches up to two feet in length, and can be told by its delicate, feathery tentacles. It feeds primarily on planktonic animals which get caught in its tentacles as water flows past.

The floats and pilings are also a good place to observe hydroids. Hydroids are relatives of jellyfish and sea anemones. They feed on plankton and live in colonies—each with hundreds of individuals. Hydroids have an alternation-of-generation life history, meaning that they have very different body types associated with different sexual stages. The hydroid is the asexual stage. It buds off free-swimming jellyfish which are sexual. It is these jellyfish which produce eggs and sperm which unite and develop eventually into hydroids.



hydroids
Obelia

CONCLUSION

The marine intertidal community is a well defined, diverse and important assemblage of plants and animals. Many of the organisms found in the Bartlett Cove intertidal can also be found as far south as California. In most cases the ecology and natural history of these organisms are similar over their geographic ranges, and consequently, what we have learned by observing intertidal animals in Bartlett Cove can be applied to other areas of the northwest Pacific coast.

While unique, the intertidal zone is not an isolated community and even a casual observer will note that many terrestrial organisms frequently come into the intertidal to forage. Perhaps the most obvious of these are the many shore-birds which depend upon the intertidal as a source of food. The patient observer will also note that several terrestrial mammals forage regularly in the intertidal. Over the last five years, while working in and around Glacier Bay National Monument, we have watched river otters, sea otters, short-tailed weasels, mink, coyote, black bear, and wolf work through the intertidal in search of food. Disruptions to the ecology of the intertidal zone could have serious ramifications to all these animals. Lastly, man himself is a major consumer of intertidal organisms. Ninety-five thousand people descended upon the ocean beaches of Washington on the opening weekend of clam digging season in 1979. Crab, abalone, mussels and clams are commonly sought by humans, and the gastronomically adventuresome claim to enjoy chitons, limpets, barnacles and sea urchins. Sea urchins are exported in large numbers to Japan where the roe is considered a delicacy.

The effects that even small numbers of people may have on a small area such as Bartlett Cove's intertidal could be significant. It is our hope that organisms will be left undisturbed by monument visitors so that those who follow us into this interesting community will find it to be an enriching experience.

SELECTED REFERENCES

Abbott, Isabella A., and George J. Hollenberg. 1976. *Marine Algae of California.* Stanford University Press, Stanford, Calif.

Kozloff, Eugene N. 1973. *Seashore Life of Puget Sound, The Strait of Georgia, and the San Juan Archipelago.* Univ. of Wash. Press, Seattle. 326 p., Illus.

Rickets, Edward F., and Jack Calvin. 1968. *Between Pacific Tides.* Stanford Univ. Press, Stanford, Calif. 4th ed., Illus.

Smith, Ralph I., and James T. Carlton, Eds. 1975. *Light's Manual: Intertidal Invertebrates of the Central California Coast.* Univ. of Calif. Press, Berkeley, Calif. 3rd ed.