

Life on Rocky Shores
Puget Sound Region - Puget Sound Proper and the San Juan Islands
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I. Some General Habitats Found on Rocky Shores

Many organisms require very special conditions that are met by one or more of the features listed:

- Hardness, chemical composition, texture of the surface (Some invertebrates live in pits or burrows in soft rock; they cannot excavate hard rock. Certain species require smooth surfaces, others need rough surfaces on which to settle and mature.)
- Vertical surfaces, sloping surfaces, flat surfaces
- Protected surfaces, exposed surfaces (Some organisms require exposure to wave action that others cannot tolerate.)
- Surge channels
- Crevices, rock-on-rock situations (These provide tight places that many invertebrates, such as certain sea cucumbers, require.)
- Loose boulders
- Tide pools
- Symbiotic associations - This category covers close associations of two species. It includes mutualism (of benefit to both partners), parasitism (harmful to the host), and commensalism (neither obviously harmful nor beneficial to the host). Commensalism is a rather vague category, probably including many associations that simply have not been shown to be mutualistic or parasitic.
- Epiphytic ("plant-on-plant") associations. In marine habitats, this category includes algae that typically attach to other algae or to eelgrass and basketgrass.

Problems faced by organisms that live on rocky substrata, especially in the intertidal region

Physical factors

- Wave action (low to moderate in the San Juan Islands and Puget Sound)
- Scouring by sand and covering by sand, especially where rocky outcrops alternate with sandy beaches and coves. Seasonal changes in the vertical distribution of sand are common.
- Exposure, during low tides, to ultraviolet light, heat, desiccation, rain, runoff of fresh water from the land. Runoff may change the salinity of a localized area.

Biological factors

- Competition for space
- Competition for food
- Predation (carnivores eating other animals)

- Grazing (animals eating algae or eelgrass)
- Scavenging (animals feeding on dead or dying organisms, which may be algae, eelgrass, or other animals)

Tidal patterns of the region

On the west coast of North America, there are typically two high tides (usually unequal) and two low tides (also unequal) in each period of slightly more than 24 hours. In tide tables, the average of the lower of the two low tides is stated as 0.0. Tides below 0.0 are called minus tides, and are given in tide tables as -1.0 ft., -2.5 ft., etc. Our lowest low tides, coming in May and June, are about -3.0 ft. The highest tides are about +9.0 ft. Thus the amplitude – the vertical range of tides, from highest to lowest – is about 12 ft.

In our region, very low tides occur during daylight hours in spring and summer. In autumn and winter, however, such low tides occur only at night, often at very inconvenient times. But it is possible to have a valuable field trip without having an exceptionally low tide. It will be better, in fact, to make the study of seashore biology a gradual process, beginning with moderately low tides of perhaps +3.0 ft., possible during daylight hours in winter. A first field trip on an extremely low tide can be very frustrating to the teacher and students, because there is so much material to deal with. My advice: start with the upper levels on the first field trips, which can be in autumn or winter. Save the rich fauna and flora of lower levels for field trips in spring.

A few words about conservation

It is unwise to bring animals back to school, where they are not likely to live long unless there are suitable aquarium facilities, with plenty of space, cold water, and oxygen. Rocks, if lifted, should be put back into their original position, and care must be taken not to crush animals beneath them. Before setting a large rock down again, it may be a good idea to move crabs, fishes, and other animals to one side; they'll find their way back to safety. You can also lay down a small rock to support the large rock enough to keep organisms beneath it from being crushed.

II. Some Common Intertidal Species in Our Region, and the Tide Levels at Which They Are Most Likely to Be Found

Species discussed below are illustrated and described in *Seashore Life of the Northern Pacific Coast*, and many are given appropriate common names. (You and your students may wish to make up common names for others.) Most of the species are widely distributed in the region, but some are restricted to shores where there are special conditions, such as strong wave action. The organisms dealt with are grouped according to four zones.

These may not be sharply marked, but they are nevertheless useful for teaching.

Something to remember! On a richly populated beach, such as would be found on the west and southwest portions of San Juan Island and the southwest portion of Lopez Island, there are many hundreds of species living between high and low tide marks. A large proportion of them – diatoms, small encrusting algae, protozoans, bacteria – are microscopic. They are important components, providing food for other organisms, promoting decay, etc., but require detailed and often difficult microscopic study. How many easily visible species are likely to be on such a beach? Well, here's a guess: about 100 species of algae (at least in summer), 500 invertebrates, 15 fishes. You are not likely to encounter more than a small percentage of these, because many of them live in habitats that you won't be sampling intensively. Below, in connection with different intertidal zones, especially common and noteworthy organisms are mentioned, and some are discussed briefly. It may be advisable to concentrate on these first, then gradually add to your repertoire.

Zone 1 (supralittoral fringe), about +10.0 ft to +6.0 ft.

Lichens

A lichen consists of a fungus that harbors cells of a unicellular green or blue-green alga. The algal component, being photosynthetic, makes organic foods from inorganic substances, and it allows some soluble organic products to diffuse away and be used by the fungus. In many lichens, filaments of the fungus penetrate the algal cells and destroy some of them. The fungus absorbs water and inorganic nutrients needed by the algal symbionts, and shields the algae from too much ultraviolet light. Two common lichens of the region, *Caloplaca* and *Xanthoria*, are distinctive because of their predominantly orange or yellow color. Both are rather tightly plastered down on rocks of the splash zone. *Verrucaria* is dark, and commonly forms a wide, blackish band, slightly below *Caloplaca* and *Xanthoria*. *Physcia* is grayish or whitish, and coarser than the other three lichens mentioned.

Green algae

Enteromorpha, a tubular species, is common at levels where there is seepage of fresh water, as on most cliffs.

Barnacles

Chthamalus dalli, a small (1/4 inch), low, smooth, usually somewhat brownish barnacle, is typically highest on the shore. Its survival at lower levels is unlikely, because it is vulnerable to predators, especially snails called whelks (see Snails, in Zone 2). *Balanus glandula* is a larger, taller, and rougher species. It mixes with *Chthamalus* and is also subject to intense predation at lower tide levels. Some specimens of both species may, during certain tide cycles, be left high and dry, except perhaps for spray, for several con-

secutive days. What do these barnacles eat? They use their feathery legs (six pairs) to comb microscopic food from the water. The action is easily demonstrated by placing a small rock covered with barnacles in a dish of sea water. Note that the shapes of the four plates that close the shell when a barnacle is out of water are different in *Chthamalus* and *Balanus*. It is important to appreciate that barnacles, like many other marine organisms, do not settle on rock until they have gone through larval stages in the plankton, and that the lives of larvae are full of risks.

Snails and limpets

The checkered periwinkle, *Littorina scutulata*, and the Sitka periwinkle, *L. sitkana*, are common, but one may be more abundant than the other on a particular shore. Periwinkles graze mostly on coatings of diatoms and other microscopic algae. *Lottia digitalis* (*Collisella digitalis*) is the common limpet at higher levels. Note how far forward the apex of its shell is located. This mollusc, like the periwinkles, grazes on algal coatings.

Zone 2, about +6.0 ft to +4.0 ft.

Green algae

Cladophora, a bright green algae whose growths resemble patches of a moss, is sometimes common.

Red algae

Endocladia muricata, often growing with *Cladophora*, forms mosslike, brownish growths. The sexually reproducing phase of *Mastocarpus papillatus* (*Gigartina papillata*) typically has several warty lobes, about 1 in. wide, 2 in. long, originating from the base. Nearby you are likely to find what looks like a spot of tar. This represents the spore-producing phase of the life cycle of *Mastocarpus*. Before this was understood, the tar spot was considered to be in a different genus, *Petrocelis*. On smooth boulders, watch for oily-looking growths of *Porphyra*. We have several species, one succeeding another through the year. It is a species of *Porphyra* that is cultivated on lines in Japan for producing "nori," used in making "sushi" and various other foods. The crop is converted into a paste, which is then dried in thin sheets that can be wrapped around rice cakes, etc.

Brown algae

Fucus gardneri (similar to, perhaps identical to, *F. distichus* of Atlantic shores) is abundant from late winter to late autumn. It usually dies back to a crust in winter. Note the way the alga branches dichotomously, and the swollen tips, in which eggs or sperm are formed. Many small animals find refuge under its growths.

Barnacle

Semibalanus cariosus, which may be more than 1 in. in diameter, is distinctive because of the way its shell is roughened by ridges that point downward. Once this species reaches a fairly large size, it is resistant to predation by whelks (see below) and sea stars. There may be some *Balanus glandula* and even *Chthamalus dalli* at this level, but most of these smaller barnacles will probably have disappeared because of predation.

Snails and limpets

Two whelks, *Nucella ostrina* (the northern, recently recognized counterpart of *N. emarginata*, which is not found north of the San Francisco Bay region) and *N. canaliculata*, are predators on barnacles in this zone and also at lower levels. They drill through the thin plates that close the shell of a barnacle, then paralyze the animal and suck out its tissue. Mussels are also prey for species of *Nucella*. Together with sea stars that consume barnacles, they have much to do with the zonation of these animals. The reason there are so many more small barnacles at higher levels than at lower levels is because they are not so accessible to whelks and sea stars, which cannot be out of water for long periods. *Lottia pelta* (*Collisella pelta*) and *Tectura scutum* (*Notoacmea scutum*) are abundant limpets in Zone 2. They graze on algae and algal coatings.

Isopod crustacean

Gnorimosphaeroma oregonense (under rocks, especially where there is some seepage of fresh water) looks like a garden sowbug or pillbug, which are close relatives. It can even roll up into a ball like a pillbug. The food of this crustacean is detritus and decaying algal material.

Zone 3, about +4.0 ft. to 0.0 ft.

Green algae

Two species are especially abundant. *Ulva fenestrata*, which forms thin green sheets, often (but not always) coarsely perforated, and *Acrosiphonia coalita*, whose intertwining and interlocking threads form dull green, ropelike growths. *Ulva* is uncommon in winter; *Acrosiphonia* disappears. When prevalent, *Ulva* is an important food of the common shore crabs (*Hemigrapsus nudus*, *H. oregonensis*), nereid polychaete worms, and other herbivores.

Red algae

Odonthalia floccosa and *Neorhodomela larix*, both more brown or blackish than red, are particularly common in tide pools, even shallow ones. When you pick them up, numerous amphipod crustaceans are likely to drip off. The amphipods take refuge in these algae and probably also scavenge on portions that are deteriorating. During late spring and summer watch for

Halosaccion glandiforme, a greenish-brown or brownish sac filled with sea water. Coralline species, hardened by calcium carbonate, may be common in tidepools, surge channels, and shaded habitats. More about these in the next section (0.0 ft and lower).

Brown algae

Leathesia difformis, which forms greenish-brown, brainlike growths, is common in late spring and summer, often growing with *Halosaccion*, especially on level patches of rock. *Hedophyllum sessile*, a very coarse brown kelp, resembling a loose-headed cabbage because of the way its several broad lobes spread from the holdfast, is an important source of food for herbivorous snails and chitons. In quiet water, the lobes usually have a blistered appearance; where the water is rough, they tend to be smooth.

Sea anemone

Anthopleura elegantissima is generally in tight colonies, often partly obliterated by sand. Some interesting biology to deal with here! First of all, each aggregation is a clone, formed by repeated divisions that began with a single individual. An anemone elongates at its base, and gradually the two halves pull apart and reorganize themselves into complete new anemones. After the anemones in two genetically different clones have multiplied to the point that their clones get too close, the individuals at the margins fire stinging threads from lumpy protuberances close to the tentacles. This keeps the clones from encroaching on each other's territory. Often concentrated below rocks that have dense populations of barnacles, the anemones get to feed on fragments of barnacles that fall onto them after being knocked off by floating logs. They also feed on other small animal organisms, mostly crustaceans. In cells lining the gut (which extends into each tentacle), *A. elegantissima* harbors unicellular photosynthetic organisms of two types: a green algae and a dinoflagellate. If you take off a single tentacle, tease it apart in a drop of sea water, and examine the tissue with a compound microscope, you will probably see both types. The green algal cells, called zoochlorellae ("chlorellae living in an animal") are bright green; the dinoflagellates, which lack flagella in their symbiotic phase, are brownish or yellowish and are called zooxanthellae ("yellowish cells living in an animal"). The algae manufacture organic food photosynthetically and share some of it with their hosts. They probably use at least some of the carbon dioxide and nitrogenous waste produced by the anemones. As stated above, both types of unicellular symbionts are usually found in each individual, but the proportions vary. In anemones that are very green, like those often seen at Cattle Point, San Juan Island, the symbionts are mostly if not almost entirely zoochlorellae; in those that are more or less olive-green, zooxanthellae predominate. The pink color of the tentacles is a product of the anemones themselves.

Mussels

Mytilus trossulus, the small (up to about 3 in.) smooth-shelled blue mussel or bay mussel is common. Occasionally one finds, on the west side of San Juan and Lopez islands, where wave action is sometimes fairly intense, the larger *M. californianus*, or California mussel, which has a larger, thicker, and ribbed shell. Both mussels, like nearly all bivalve molluscs, are filter-feeders that trap microscopic food in mucus on their gills, then move the mucus toward the mouth, where a pair of structures called labial palps deliver particles of suitable size and consistency to the mouth.

Chitons

Two general types of chitons are abundant. One type is represented by *Katharina tunicata*, whose smooth, black mantle tissue covers most of each of the eight shell plates embedded in it. This chiton feeds on a variety of algae. The other type is represented by species of *Mopalia*, in which much of each shell plate is exposed, and in which the mantle has hairs. If these hairs are thick and stiff, you have *M. muscosa*; if they are slender and flexible, you are probably looking at *M. lignosa* or *M. ciliata*. Mopalias graze partly on algae, partly on small attached animals that grow as low colonies on rocks.

Snails

There are three common snails. *Nucella lamellosa*, a predator on barnacles and mussels, feeds in the way described above for *Nucella ostrina* and *N. canaliculata*. *Lirabuccinum dirum* (*Searlesia dira*) scavenges on dead and dying animals. Species of *Lacuna*, which resemble periwinkles found mostly at higher levels on the shore, feed on coatings of diatoms and other microalgae, as well as on larger algae and leaves of eelgrass.

Isopod crustacean

Watch for *Idotea wosnesenskii*, which looks like an elongated sowbug. (It is in the same general group as terrestrial sowbugs.) This is an herbivore, feeding on living or decaying algae and eelgrass, and its coloration – usually green or brown, sometimes pinkish-red – comes mostly from what it has eaten.

Crabs

The two predominant species are the purple shore crab, *Hemigrapsus nudus*, and *H. oregonensis*. At low tide, both are commonly found under rocks. Please be careful not to crush them when returning a rock to its proper orientation. But at night they leave their hideaways to forage on algae (especially *Ulva*), on snails, and even on each other (large ones may attack small ones). *Hemigrapsus nudus*, almost always easily recognizable because of its mostly dark reddish color, purple-spotted pincers, and nearly hair-

less legs, is generally found where the salinity is close to that of offshore sea water (about 3 percent); *H. oregonensis*, grayish green, without prominent spots on the pincers, and with very hairy legs, is usually most common where the salinity is lowered by seepage from the land. The two mix, however.

Anomuran crabs

This category includes hermit crabs and a variety of other crablike crustaceans whose abdomens are odd in one way or another (soft, asymmetrical, twisted, etc.) and whose prominent second antennae are lateral to the eyes, rather than between them. The two common anomurans in this zone are the hairy hermit, *Pagurus hirsutiusculus*, and the porcelain crab, *Petrolisthes eriomerus*. The hairy hermit occurs in tidepools and under rocks, and is unusual in occupying shells into which it cannot withdraw completely. (Is there anything that can be said in favor of this?) The porcelain crab is largely limited to under-rock situations. Both of these anomurans are primarily deposit feeders, consuming particles of organic detritus and adherent microorganisms.

Sea star

The large purple or orange-brown sea star sometimes found in this zone is *Pisaster ochraceus*, whose food consists mostly of barnacles and mussels. As pointed out above, its predatory habits have much to do with the vertical distribution of barnacles on the shore. On most San Juan shores, there are relatively few *P. ochraceus*. This species is more abundant on the open coast than in Puget Sound or the San Juan Islands.

Fish

The most common fish in this zone is the tidepool sculpin, *Oligocottus maculosus*. It is practically restricted to tidepools, usually staying close to the edges of these or loose rocks at the bottom. It feeds mostly on amphipods and other small crustaceans. Eel-like fishes called gunnells and blennies will be found under rocks at lower levels of this zone.

Zone 4, about 0.0 and below.

The organisms living at low tide levels are not exposed for more than a short time each day. There is a frustratingly rich fauna and flora here. This is one reason careful study of higher levels of the shore will be helpful preparation for tackling lower tide levels. Only a small selection of organisms that are especially common and conspicuous is offered here. It will help a beginner to get off to a solid start.

Flowering plants

The only flowering plants found on rocky shores of our region are *Zostera marina* (eelgrass) and *Phyllospadix scouleri* (surfgrass, basketgrass). Eelgrass

has at least two different growth forms. On mudflats in bays, its leaves may be nearly a half-inch wide and more than a yard long; on rocky shores, the leaves are much narrower and shorter and could be confused with those of surfgrass. Surfgrass, whose leaves are slightly thicker and even narrower than those of narrow-leaved eelgrass, is found only on wave-swept shores. It is uncommon in our area, but there is a little of it on the west side of San Juan Island and Lopez Island.

Green algae

Codium fragile is common in spring and summer, and distinctive because of its dark green color and cylindrical, dichotomously branching thallus.

Red algae

Coralline types, hardened by calcium carbonate, are abundant at lower tide levels. Some form pink encrustations. Others have branching, segmented thalli; flexible joints between segments minimize breakage of the otherwise brittle branches. Coralline algae occur in crevices, tide pools and surge channels at higher levels, but they become especially abundant and diversified at lower levels. Many other red algae are also present below about 0.0.

Brown algae

There are many of these, but four are especially distinctive species common in spring, summer, and early autumn. *Costaria costata* has large, broad, blistered blades. The elongated main blade of *Alaria marginata* is smooth and has a prominent midrib; there are small blades, where spores are produced, coming off both sides of the stipe near the base. *Egregia menziesii*, called feather-boa kelp, has a broad (1 in.) flattened stipe from which small blades and bladders grow out. *Nereocystis luetkeana*, or bull kelp, is attached mostly to rocks in deep water, and has a bulbous, gas-filled bladder that keeps its blades close to the surface, where there is light for photosynthesis. Bull kelp, huge as it is (sometimes more than 100 ft. long), is an annual. It starts growing from a fertilized egg in late winter, and dies in late summer or early autumn. Spores are produced in light areas on the blades, and germinate to form microscopic, filamentous structures that produce eggs or sperm.

Sponges

These, being fragile and not surviving long exposure, are mostly limited to levels of 0.0 or below. They do occur, however, in tidepools and crevices, where they are protected from exposure. *Ophlitaspongia* is easily recognized; it forms thin, orange-red encrustations on rock. Other common sponges form appreciably thicker greenish, grayish, pinkish, or lavender encrustations. By ciliary activity, they move water through a system of extremely small pores, canals, and outlet openings. The outlet openings are sometimes large enough to be visible. Certain cells lining the canals of a sponge take up bacteria and tiny algal cells.

Sea anemones

Urticina crassicornis is perhaps the most common large anemone at lower levels. Its food consists mostly of crustaceans, including shrimps; these are captured with the help of mucus and stinging capsules. *Anthopleura xanthogrammica* and *Metridium senile* are other larger anemones that occur in this zone. The former, like *A. elegantissima*, has symbiotic zoochlorellae and zooxanthellae; it is otherwise a carnivore, feeding mostly on crustaceans. The latter, with numerous small tentacles, consumes only small animal organisms, using cilia on its tentacles and oral surface to direct food to the mouth.

Polychaete annelid worms

Most conspicuous of these is *Eudistylia vancouveri*, the feather-duster worm, evident from its thick, somewhat gritty tubes that are anchored in crevices. At low tide, the worms withdraw into the tubes; when immersed again, they expose their crowns of tentaclelike structures called radioles, used for feeding and respiration. Each radiole is branched and has cilia that circulate water and move mucus. Microscopic food particles are trapped in the mucus and carried down a main groove that leads to a collecting groove at the base of the crown. From this, food reaches the mouth. Coarse and heavy particles are rejected before they enter the mouth. Many of them become incorporated in mucus that hardens to form more tube material; thus the tube is lengthened. On floating docks, such as those on marinas and boat yards, you can usually see *Eudistylia* and also *Schizobranchia insignis*, a smaller species, under water. Note how quickly they withdraw their feathery crowns when a shadow passes over them or when they are touched. This quick action protects the worms from fishes and other predators looking for something to nip off.

Chitons

Tonicella lineata, whose food consists of encrusting coralline algae, is an especially beautiful species. Occasionally *Cryptochiton stelleri* is encountered. This is the largest chiton in the world, and unusual in that all of its eight shell plates are covered by reddish brown mantle tissue. It feeds on algae and algal coatings. Species of *Mopalia*, partly herbivorous, partly carnivorous, are abundant at lower levels, too.

Snails

Amphissa columbiana and *Lirabuccinum dirum* (*Searlesia dira*) are scavengers on dead and dying animals. *Calliostoma ligatum* feeds partly on algae materials, partly on growths of small colonial animal organisms.

Keyhole limpet

Diodora aspera, related to abalones, has an opening ("keyhole") at the apex of the shell. Water for respiration comes in from the sides of the anterior

portion of the shell, and leaves by way of the opening. The anus and kidney openings are close to the opening, so wastes are carried out with the current. The keyhole limpet grazes to a considerable extent on sponges.

Limpet

Acmaea mitra, which eats coralline red algae and is usually overgrown by them, is limited to lower levels of the intertidal region.

Sea slugs

Archidoris montereyensis and *Anisodoris nobilis* are large, mostly yellow species that feed on sponges. The small *Rostanga pulchra* gets its red color from the sponge *Ophlitaspongia*, its only food.

Crabs

Cancer productus is the largest species likely to be encountered. It is a carnivore that uses its strong pincers to crack shells of snails and other molluscs; it will eat other animal material, too. *Pugettia gracilis*, a long-legged, somewhat spidery species, usually has algae and other organisms growing on the carapace; it is one of the “masking crabs” that camouflage themselves. *Pugettia producta* is larger and only rarely has anything growing on its carapace.

Sea stars

Leptasterias hexactis, typically with six rays, feeds mostly on snails and limpets. *Henricia leviuscula*, comparatively smooth and usually orange-red, feeds to a large extent on sponges.

Sea cucumbers

Cucumaria miniata, up to about 8 in. long, is difficult to extricate from the tight crevices it occupies. The beautiful orange tentacles around its mouth are coated with mucus, which collects small particles of food. The animal sticks a tentacle into its mouth, and as it withdraws the tentacle, the food is licked off. *Eupentacta quinquesemita* is a more slender, cream-colored cucumber up to about 4 in. long. It is often found under loose rocks. It feeds in the same way as *Cucumaria*.

Sea urchins

The large red urchin, *Strongylocentrotus franciscanus*, is sometimes common at low tide levels, as well as in deeper water. It is primarily an herbivore that uses five teeth associated with a complicated jaw apparatus to chew up seaweed. But it eats some animal matter, and it can pass food that lands among its spines to the underside to the body, where the mouth and jaw apparatus is located. The purple urchin, *Strongylocentrotus purpuratus*, which lives intertidally on rocky shores where there is strong wave action, is uncommon in the San Juan Islands; the green urchin, *S. droebachiensis*, is mostly subtidal, but occasionally encountered intertidally.

Fishes

Blennies and gunnels, which resemble eels (there are no true eels here) are common under and around rocks. The clingfish, *Gobiesox maeandricus*, is an especially interesting component of the fish fauna. Its ventral fins are modified to form a suckerlike structure with which it attaches itself to the smooth undersides of rocks. It feeds mostly on amphipod crustaceans.

III. Epilogue

Numerous important animals, seaweeds, and concepts have been left out of this little guide, which concentrates on organisms that are abundant and easily recognized. Serious omissions are ascidians, many annelid worms, nemerteans, flatworms, certain crabs, shrimps, and various small crustaceans, especially amphipods. One important amphipod, however, can confidently be identified if found in its usual habitat. This is *Traskorchestia traskiana*, a beach hopper that lives in piles of seaweed drift left at high tide levels on sandy beaches, and also around mudflats and salt marshes. It is an important scavenger on decaying algae, hiding during the daytime, emerging at night. On San Juan Island, it is abundant high up on the beach at Eagle Cove, on both sides of which there are rocky shores where some good teaching can be done.