

Natural History of the Rocky Intertidal Habitat

The Pacific shores of North America are subject to extremely harsh conditions. Powerful waves formed from prevailing westerly winds and winter storms beat relentlessly against the coast. The tides temporarily cover the substrate with water and then expose the abundant life to terrestrial environmental factors. Despite all of these harsh conditions, life abounds in great diversity throughout the rocky intertidal of the Pacific. The water of the North Pacific inundates the coast with energy and food for the organisms that are able to withstand these conditions. Rocks provide shelter and substrate for thousands of invertebrates and algae. The following provides a brief summary of the rocky intertidal ecosystem.

Abiotic Factors

Many factors are important in determining the nature of the rocky intertidal communities. Abiotic factors are those caused by nonliving things. They can include waves, tides, sun exposure, and changes in salinity. The intertidal is unique in that it is exposed to both terrestrial and marine conditions. The animals have to adapt to a variety of conditions. Wave action against the rocks threatens to crush the animals and plants that live within the intertidal. They can also tear organisms away from their homes and take them to the subtidal regions of the ocean. Tides rise and fall twice each day covering organisms with water and exposing them to the air. During low tide, they are more susceptible to desiccation (drying out), they can be exposed to heavy rainfall or direct sunlight, and are more visible to predators. Rapid temperature changes can occur in these exposed zones of the intertidal. Salinity fluctuations can occur throughout the intertidal. Tidepools in higher zones can acquire freshwater from rainfall or streams or may heat up and increase in salinity as evaporation occurs rapidly on hot, sunny days. The substrate also determines the types of organisms that live in the intertidal. Some species depend on a softer substrate, such as mudstone found at Duxbury Reef in Marin County. These invertebrates can dig or eat into the rock for protection from wave action, predators, and desiccation. Other factors such as rock size and the incline of the shore also determine the type of intertidal life that is present.

Tides

The daily occurrence of tides is a major factor determining the diversity of organisms living within the rocky intertidal. The sea level rises and falls as a tide twice a day on the Pacific Coast of North America. The rise and fall of the ocean is a result of gravitational forces from the Moon and the Sun. The Moon has a greater effect on the tides because it is closer to the Earth. The Moon's gravity pulls on the Earth and creates a high tide on the side that faces the Moon. The opposite side also has a high tide because of the centrifugal force that keeps the Moon and Earth apart. The other two sides have low tide. As the Earth rotates each side will get a high and low tide. These tides are exaggerated during new and full moons, when the Moon is in alignment with the Sun and the Earth. At these phases of the moon, both the Sun and the Moon's gravitational pull work together to create both extreme high tides and extreme low tides, also known as spring tides. Neap tides result when the Moon and the Sun are at right angles to each other. At these times, the difference between high and low tide is smaller.

Zonation

The rocky intertidal ecosystem is divided into a series of zones. Scientists define the zones by the amount of exposure to air and by the amount of time the substrate is submerged under water. Intertidal zones are also identified by the types of organisms that are found there. The following sections will give you an idea of the conditions in each zone and the organisms that are typically found there.

Zones range from the splash zone, closest to the terrestrial environment, to the low zone, closest to the ocean. Each zone is characterized by different abiotic factors and accommodates different communities of organisms. For example, organisms that need to be in water most of the time will not be found in the splash zone, as this area usually only receives splashes from waves at high tide. Each organism has adaptations to help them survive in the zone in which they live. If an animal is moved from the low zone to the high zone, it may not be able to survive in its new environment.

The rocky intertidal ecosystem is home to many different animals and algae. It is easily accessible and provides an excellent opportunity for people to explore the ecosystem and observe the organisms in their natural habitat. Before going to the intertidal it is helpful to know about the organisms that are there and where they can usually be found. This information can help you understand the ecology of the ecosystem.

The Splash Zone

Few species have adaptations to survive within the area that gets only splashes from waves on most days and submerged by water for only a few hours per month. Periwinkle snails, barnacles, black turban snails, and the rock louse live in the splash zone. The snails are able to attach to a rock using their muscular foot, and they seal themselves closed, keeping moisture inside. Barnacles cement themselves to a rock and are closed on top when it is low tide to avoid desiccation. The rock louse, an isopod, is a small crustacean that lives in the wrack line. They must keep their gills moist but will drown if submerged in water.

Enteromorpha, a type of green algae, is among the few species of algae that can survive in the splash zone. It can be bleached by the sun and lose most of its photosynthetic pigment but still regain its photosynthetic abilities once a high tide reaches it.

The High Zone

Twice a day, for a total of only a few hours per day, the ocean water submerges the high zone. A few invertebrates seal themselves up against their substrate in order to survive most of the day without seawater. The lined shore crab (*Pachygrapsus*), survives in this zone by positioning its flat body in rock crevices, out of direct sunlight and hidden from larger predators.

Limpets, chitons, and the black turban snail (*Tegula funebris*), all three mollusks, crawl on top of rocks primarily within this zone and use a sharp tongue called a radula to scrape off short growing algae. They form a watertight seal onto the rocks with their shell to protect themselves from desiccation. Both limpets and chitons can form depressions within certain types of rock, like mudstone, that serve as a home and provide the best possible seal. A chiton's shell consists of eight flexibly attached plates which tightly form to the contours of rock formations.

Although also present in the mid zone, rockweed (*Fucus*), sea lettuce (*Ulva*), and nail brush algae (*Endocladia*), are examples of algae that are able to withstand long periods of time, about 72% of the day, without water in the high zone. Some species such as *Fucus gardneri* have moisture retention adaptations which enable it to survive for many hours exposed to sunlight and air. Others, such as *Ulva fenestrata*, withstand bleaching, losing its color due to sunlight, and is able to photosynthesize once it is wet again. These algae thrive and provide food and shelter for many invertebrates that inhabit this zone.

The Mid Zone

The mid zone is marked by its very high density of living organisms. The brown turban snail (*Tegula brunnea*), the black turban snail (*T. funebris*), the aggregated anemone (*Anthopleura elegantissima*), and the proliferating anemone (*Epiactis prolifera*), are but a few of the invertebrates that reside here. The California mussel (*Mytilus californianus*) also occupies this zone. It uses its gills to extract oxygen and plankton (floating particles of food) from the water. When the tide ebbs, mussels can tightly close their two shells to avoid desiccation. They also form byssal threads that anchor themselves to other mussels and to the substrate, so

they do not wash away with the crashing waves.

Sea stars of the genus *Pisaster* live in the mid zone. Sea stars have tube feet that work like suction cups that allow them to hold tightly onto rocks as waves, gulls, or people try to detach them. Occasionally, one or two of the “arms” are ripped off. However, these invertebrates are able to regenerate their “arms” and tiny tube feet that may be torn off.

In addition to the variety of invertebrates that remain in or visit the mid tide zone, many species of algae thrive in this region. Iridescent seaweed (*Mazzaella*, *Gelidium*, and *Mastocarpus* species) attach their holdfasts, or rootlike structures, to the substrate within this zone.

The Low Zone

Species that survive within the low zone are less resilient to exposure to air and sunlight but more resilient to the submergence under water and waves. These places may be exposed to air only a few times a month. It is in this zone that most life exists within the intertidal ecosystems. The giant green anemone (*Anthopleura xanthogrammica*), and the sunflower star (*Pycnopodia helianthoides*) are two types of larger invertebrates that frequent the lower intertidal and subtidal regions of the ocean. The anemone is attached to the substrate and has stinging tentacles that catch and paralyze prey that drift by in the water. The sunflower star uses its tube feet to travel quickly along the substrate to fulfill its voracious appetite.

The purple sea urchin (*Strongylocentrotus purpuratus*) depends on its tube feet to survive in the low zone. Similar to sea stars, urchins depend on these tube feet for movement and attachment, in addition, sea urchins are able to use these suction cups for oxygen absorption, capturing floating bits of food, and using shells and kelp for shade during low tides. A sea urchin also has five sharp teeth on the underside of its body which enable the animal to graze efficiently on kelp and other algal species.

Of the algal species, sea palm (*Postelsia palmaeformis*) is a common organism in lower regions that receives an abundance of wave action. Surf grass (*Phyllospadix scouleri*) is a flowering plant that grows abundantly in protected rocky intertidal areas. Both species have flexible structures that withstand the forces of waves and are a habitat for small invertebrates.

Tidepools

During low tide, tidepools often form throughout the different zones. This is because of the irregular rocky environment. A myriad of plants and animals live in these pools, because they provide the most protection from desiccation and predation. However, these inhabitants must be able to withstand temperature and salinity changes. At low tide, the tidepool is exposed to the sun, and the water will increase in temperature as well as start to evaporate, increasing its salinity.

Invertebrate and algae species inhabit these pools as well as several fish species. Sculpins, eels, octopi, and nudibranchs can survive only within tidepools or subtidal regions. Sea anemones, sea stars, crabs, and many kinds of algae species may also reside here. Coralline algae species form thin layers on the surface of rocks. The algae may be pink with calcium carbonate which is the same material that composes the hard shell of many invertebrates. This acts as a defense for common grazers like sea urchins and snails.

(Adapted from *PROJECT OCEAN: ROCKY SEASHORE HABITAT GUIDE*)

Glossary of Terms

algae	(singular–alga); aquatic or marine organisms that resemble plants but have no seeds or roots, ranging from one-celled diatoms to multicellular seaweeds
byssal threads	hair-like filaments that mussels produce to bind themselves to rocks and other substrates
desiccation	the process of drying out, which is increased by the wind and the heat from the sun on exposed organisms in the rocky intertidal habitat
chiton	a mollusk with a long, flat foot, hardened shell, and symmetrical double gills; the shell is divided into eight adjoining segments; closely related to snails (Class:Polyplacophora)
ecosystem	an ecological relationship between an organism and its environment
encrusting algae	multicellular algae that covers the substrate instead of growing upright
exoskeleton	an external skeleton, like the “shell” of a crab
filter-feeder	an animal that feeds by passing surrounding water through a filtering device (like barnacle legs, clam gills, etc.) and filtering or straining out small particles of food
grazer	see herbivore
herbivore	an animal that only eats plants or algae
holdfast	the part of an alga that holds it to a firm surface (substrate) by root-like branches called haptera
intertidal	the area of the shore between the highest and lowest tidal levels
limpet	any member of marine gastropods with a simple, conical shell (Order Archeogastropoda)
mobile	moving; unattached to the ocean floor, opposite of sessile
nudibranch	sea slug; any member of marine gastropods without a shell (Order Nudibranchia)
organism	a living thing
photosynthesis	the process by which green plants and algae use energy from sunlight to produce sugar and oxygen from carbon dioxide and water
predator	an animal that kills and eats other animals

prey	an organism that is killed and eaten by other animals
regenerate	to grow back part of the body that has been removed or lost
rocky intertidal	stretches of the shoreline, between the highest and lowest tidal levels, that are rocky—not sandy
seaweed	any large photosynthetic protist, including kelp. They are not true plants but like plants they can make their own food.
sessile	stationary; attached to the sea floor or an object such as a rock, opposite of mobile
substrate	any surface on which an organism lives, ie rock, another animal, or plant
subtidal	below the intertidal, or below the level of the lowest tide
tube feet	an extension of the water vascular system of echinoderms (sea stars, sea urchins, etc.) which aids in locomotion, grasping, and feeding
wave action	the force of the waves crashing on the rocks and organisms
zonation	the distribution of the plants and animals into horizontal bands or zones. In the rocky intertidal, zonation is determined by the tidal height and wave action