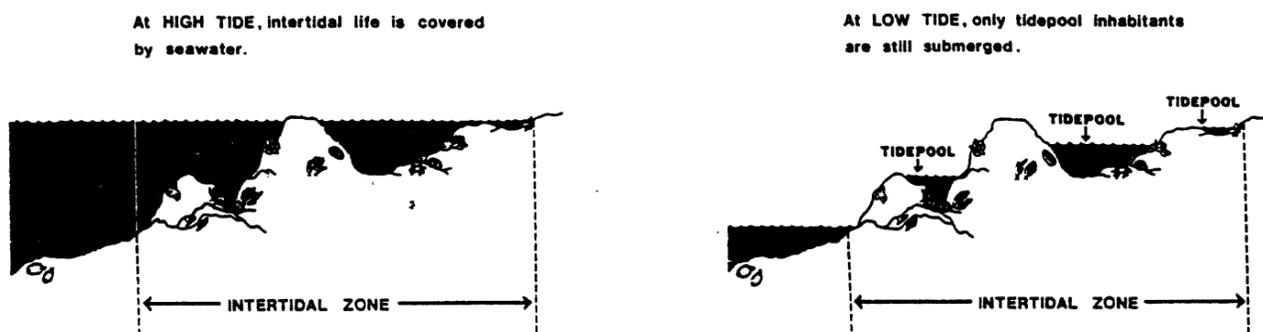


THE ROCKY SHORE ENVIRONMENT

The rocky shoreline of Southern California is a region of crashing waves, changing tides and a wide variety of plants and animals found nowhere else along the Pacific coast. The rocky shore is the border of two environments: the land and the sea. Conditions along the shoreline change continuously; as the **tide** goes in and out, the shore is alternately covered by water and exposed to all of the conditions on land. Within a twelve-hour period, inhabitants are both baked by the sun and subjected to the crashing waves. The portion of the coast that falls between the range of the **tides** is called the **intertidal**. This narrow strip of land is home for a wealth of different plants and animals.



When the tide is high, waves wash over the shore, bringing fresh nutrients and waterborne food into the **intertidal**. The churning water also supplies fresh oxygen for the animals. Covered by only a few feet of water, plants in the **intertidal** have plenty of sunlight for **photosynthesis**. It may sound like an ideal **habitat**, but the rocky intertidal is a rigorous environment. Organisms that live on and among the rocks must withstand the sheer crushing force of the waves. To avoid being dislodged, many animals have a strong anchoring device, which holds them tightly onto the rocks. Other animals have tough exteriors or shells, which prevent them from being crushed by the waves. Those animals too fragile to withstand the wave action find shelter in cracks and crevices.

As the tide goes out, the marine conditions slowly disappear. Often, water is retained between rocks or in depressions called **tidepools**. However, the rest of the shore is exposed to the sun, wind, and all of the elements. The intertidal is an extension of the marine environment; the plants and animals have evolved from marine creatures. Therefore, they depend on salt water for survival! At low tide, without water cover, many animals cannot move, feed or obtain oxygen. When the shore is exposed, temperatures can soar and **desiccation** or loss of body water becomes a severe problem. Many animals have a thick body covering to reduce water loss. Other



animals trap water to keep their vital organs damp at low tide. **Tidepools** are like miniature oases on the shore. These water-filled depressions are full of a variety of plants and animals unable to withstand the extremes of drying out. Although **desiccation** is not a problem for **tidepool** animals, they must adjust to drastic changes in the salt content of the water due to evaporation or rainfall. Together, these varying conditions create an environment where only the hardest species can survive.

The changing tides create a wide range of conditions on the shore. The conditions at a given location are dependent on how long and how often that section of the shore is exposed or covered by water. Rock ledges just a few centimeters apart can receive dramatically different water cover. Many coastal plants and animals are limited to living in specific locations depending on their tolerance of physical extremes and interactions with other organisms. This results in distinct bands of life throughout the intertidal known as **zonation**. Imagine how plant and animal species change dramatically as one moves from the desert floor to a mountain peak (depending on rainfall, exposure, temperature, etc.) Rocky shore organisms also exhibit **zonation**; however, it is generally seen on a much smaller vertical scale. The upper portions of the beach receive very little water cover. There, only the organisms able to withstand radical extremes can survive. As one moves down the **intertidal** toward the sea, the change in water cover becomes immediately apparent. Rocks are covered by green algae and more and more animals are visible in the cracks, on rocks and in **tidepools**.

COMMON INTERTIDAL ANIMALS AND THEIR ADAPTATIONS

The high intertidal seems like a dry, barren desert. However, if you look closely, examining between the rocks and in crevices you will see clusters of tiny **periwinkle snails**. These animals take advantage of the fact that moisture is retained in the depressions between the rocks, creating a damp **microhabitat**. By aggregating close together, the snails reduce the amount of moisture lost by the group. In addition, the snail can close itself up inside its **shell**, retaining water on its gills and sealing itself off from the world. When the tide comes back in, these animals hold on to the rocks with a strong muscular foot.

Scanning the rocks, they appear to be covered with very tiny volcanoes! These small structures actually house live animals known as **barnacles**. The **barnacle** permanently cements itself to the rock. It is covered with a tough exterior and can be shut off from the environment by closing two plates across the top. The **barnacle** can withstand high temperatures and lack of water for long periods of time. When the tide is high and the animal is covered with water, the plates open and specialized feeding appendages come out to gather food from the water.



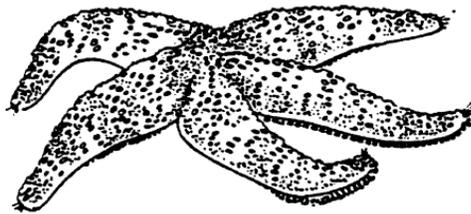
Virtually motionless at low tide is the single-shelled snail known as the **limpet**. The **limpet** prevents itself from being washed away by clamping down onto the rocks with a strong muscular foot. Its low profile offers little resistance to the waves. The **limpet** uses its tough, file-like **radula** to scrape algae and encrusting animals off the rocks for food.

The **mussel** is a bivalve that makes a semi-permanent home on the rocks. It secretes strong, slender attachments known as **byssal threads**, which contain a cement at the tip to hold the animal onto the rocks. On the rocky shore one will find "mussel beds" -many mussels grouped together which provides each animal more protection from the environment. The mussel's tough shell often serves as space to house smaller, encrusting creatures. Look closely at the mussel's shell and you will see a variety of barnacles, sponges and other tiny animals. When the tide goes out, the mussel clamps its shell shut, trapping water on its gills to keep them moist.



Covered with spines to protect it from animal enemies, the **sea urchin** attaches itself to the rocks with hundreds of **tube feet**. The flexible **tube feet** have suction cupped ends, which are used for movement and to gather food. Often, the **sea urchin** is found in a "custom-made" hole on the rocks. These animals use their powerful, beaklike jaws to wear away the rocks! The urchin lives in the hole, which retains moisture, safe from the force of the crashing waves.

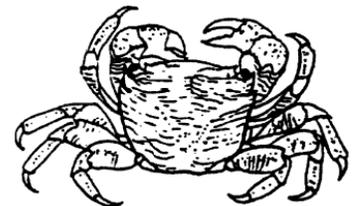
Related to the jellyfish is the beautiful **sea anemone**. This flowerlike animal firmly attaches itself to the rocks by its base. The **sea anemone** has a fleshy body that will quickly dry out if the animal is high in the **intertidal**. It often finds refuge from the harsh environment in **tidepool** waters. The sea anemone is a passive predator; it does not pursue its prey. Its **tentacles** are lined with thousands of microscopic stinging cells, which contain **nematocysts**. When an unsuspecting prey swims into the tentacles, the stinging cells are released to paralyze or kill the prey, which is then passed into the anemone's mouth.



The popular **sea star** is an active predator. Its thick skin and high mobility allow it to search throughout the low intertidal for food. The star's powerful rays are lined with hundreds of suction-cupped **tube feet**. Like the sea urchin, the star's tube feet are used to hold it firmly onto the rocks, for movement and to gather food. To feed, the star covers its prey (usually a mussel or clam) with its body. Attaching its suction-cupped **tube feet** to

the bivalve shell, the star can slowly pull the shell apart. Once a small opening is made, the star extrudes its stomach and begins to digest the prey in its own shell!

The flattened body and short legs of the **purple shore crab** enable it to move quickly or cling tightly to the wave-swept **intertidal**. The shore crab is a scavenger, foraging for food at night and when the tide is high. At low tide, during the heat of the day, the **shore crab** seeks out damp, dark crevices to avoid exposure.



As you can see, the rocky **intertidal** is filled with many unusual animals. It is an area of constant change — affected by conditions at sea and on shore. In this harsh, **wave-swept** environment, only those organisms capable of withstanding exposure and wave action can survive! When out in the intertidal one must ask several questions about these organisms:

How does it move? How does it feed? Can it survive exposure? How does it protect itself? How does it stay on the rocks?

When these questions are answered, you will understand how these animals exist in the realm between the tides.

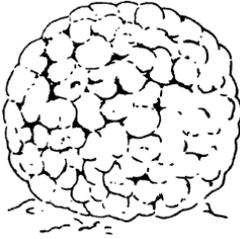
SAVE OUR SEASHORES

Although unique and exciting, the intertidal is a delicate, natural environment. The plants and animals living there can withstand many extremes in temperature or exposure. However, human impact on our seashores is devastating! As the tide recedes, it exposes a wealth of sea life. People can overrun the intertidal, often damaging or destroying fragile life in their wake. By following a few simple rules, our seashores can remain a beautiful, bountiful environment for generations to come:

1. **Walk carefully**; do not crush animals or plants.
2. **Gently touch** intertidal organisms; do not damage them.
3. **Never move any organism** in the intertidal; a misplaced plant or animal may not survive in a different location.
4. When in the intertidal, if you **turn over a rock**, be sure to **replace** it exactly as you found it! The organisms living on the underside of the rock cannot withstand exposure.
5. Almost all collecting of animals and plants on the seashore is prohibited by law. If you must collect, be sure to obtain the required licenses and obey the collecting rules. To preserve the seashores for future generations, collect animals and plants only when necessary. (Collection permits can be obtained from the California Department of Fish and Game.)

L. Elliott--Cabrillo Marine Aquarium--Sea Search

Rocky Shore Animals



ORANGE PUFFBALL SPONGE
Tethya aurantia



ROUGH LIMPET
Lottia scabra



HERMIT CRAB
Pagurus sp.



AGGREGATING ANEMONE
Anthopleura elegantissima



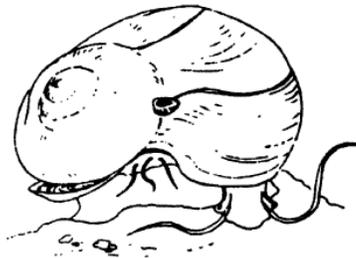
MUSSEL
Mytilus sp.



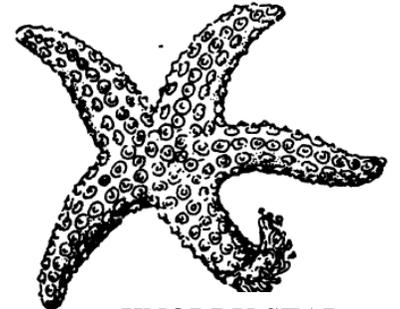
THATCHED BARNACLE
Tetraclita squamosa



BAT STAR
Asterina miniata



SMOOTH BROWN TURBAN
Norrisia norrisi



KNOBBY STAR
Pisaster giganteus



SNAKE SKIN BRITTLE STAR
Ophioderma panamense



PURPLE SEA URCHIN
Strongylocentrotus purpuratus



WARTY SEA CUCUMBER
Parastichopus parvimensis

Rocky Shore Vocabulary

adaptation	modification of traits, characteristics or behavior of an organism in structure, behavior or function in adjusting to a new condition
algae	aquatic plants of fresh or sea water from microscopic in size to 200 ft. giant kelp; simple, photosynthetic plants with unicellular organs of reproduction
beach cast (beach wrack)	organic matter and debris washed up on the beach by waves
breakwater	an offshore structure used for reducing wave action
burrow	to make a passageway beneath a surface
camouflage	any device, structure, behavior, action, disguise or coloration that serves to hide or conceal an object or animal in patterns merging with the background
current	continuous movement of water in a certain direction
ecology	interactions of plants and animals with the environment
entanglement	being entwined in something difficult to escape from
erosion	the weathering away of earthy or rocky material
gills	a respiratory structure in aquatic organisms through which gaseous exchange takes place
habitat	natural home or dwelling of an organism. The environment in which specified organisms live
intertidal	area on shore between high and low tides
migrate	to pass periodically from one region to another for purposes of feeding or breeding
nocturnal	animals which are active at night
pollution	a contamination of water, soil and/or air from the discharge of wastes, gases or chemicals
predatory	living by killing and eating other animals
radula	a belt of chitinous teeth used by marine snails to scrape food from the substrate

scavenger	an animal which devours dead animals or feeds on dead organic matter
shell	the hard, rigid exoskeleton or covering of an animal as in mollusks and crustaceans
siphon	a tube like structure for drawing in or expelling fluids
substrate	the solid material upon which an organism lives or is attached
tentacles	flexible processes near the oral region of an organism. They function as sensory, food getting, defense or attachment structures
tidepool	a reservoir of water, usually a depression in the rocks, remaining when the tide goes out
tides	daily rise and fall of ocean waters produced by gravitational pull of the earth by the moon and sun
waves	a moving flow of energy through air or water which causes the up and down movement called swells, generally caused by wind
zonation	the location and distribution of organisms in definite zones

Rocky Shore Curricular Extensions

- Brainstorm as a class or in small groups to identify animals and plants that might be found on the rocky shore. Animals that the students have seen when they have visited the beach previously can be included. This activity can be repeated after the visit to show a comparison.
- Locate San Pedro and Pt. Fermin on a map. Have the students map the route to the museum from school using a freeway or local map. Note rivers and streams in the Los Angeles Basin.
- Review the water cycle. Map a path that water follows from the mountains to the ocean and discuss what blocks the sand that the water would have brought to the ocean (dams, cemented rivers, etc.).
- Fill two containers, one with fresh water and one with salt water. (The percentage density of salt in ocean water is approximately 965 grams fresh water and 35 grams salt per liter.) Add a variety of objects to determine if they float. Discuss how/where objects float in saltwater as compared to fresh water. Continue adding salt to the fresh water until the objects float at a higher level in the water.
- Place a shallow container filled with salt water in the sun. Allow the water in the container to evaporate. Record the air temperature, how much water was used, and how long it took the water to evaporate. Check to see what is left in the pan. Investigate how salt is developed for consumer use.
- Graph the high and low tides each day for a two-week period. Compare the changes with the changes of the phases of the moon. (Find tide information in a newspaper or sporting goods store or on the Internet.)
- Create waves using a slinky or rope to show wave motion. Observe and discuss what happens when the wave is interrupted by hitting a slope or what could be a reef.
- Examine the properties of different rocks and rock formations.
- Discuss how animals adapt to a particular environment and that these adaptations ensure survival.
- Examine predator-prey relationships and discuss what would happen if one were eliminated from an area.
- Have students design a new animal species for the rocky shore habitat. Have them include what some of the physical characteristics of the chosen animal are as well as any adaptations the animal would need for survival.

- Have students cooperatively write a crossword puzzle, trivia pursuit or other game focusing on the animals in the rocky shore habitat.
- Discuss prefixes used in oceanography (hydro, zoo, bi, aqua, sub, phyto, chloro, uni).
- Have students write an interview with a rocky shore animal or research an animal so they can be interviewed by other students. Include descriptions of special features and behaviors. This could be "a day in the life of _____" (animal selected).
- Present the students with an opportunity to imagine the rocky shore environment (tapes of waves or sea birds could be used, could be through guided imagery). Encourage the students to recall the details of what they imagine including colors, actions, smells, sounds, etc. Then write a poem (Haiku, Cinquain or Diamante work well).
- Read literature that incorporates the rocky shore environment (*Pagoo, A House for Hermit, The Island of the Blue Dolphin, etc.*)
- Have students create a rocky shore environment mural with animals the students have seen. Include any biological or physical features or add human impacts like storm drains, harbors, jetties, etc.
- Using a familiar tune, have students change the words to reflect a rocky shore theme.
- Explore the products that use kelp or kelp derivatives (alginate, carrageenan, agar, etc.)
- Have students further explore the ways people use the ocean and the effects on the sea life including recreation, fishing, harvesting kelp, aquaculture, etc.
- Investigate biomedical research using rocky shore invertebrates (sea hares studied by neurophysiologists, coral to help heal broken bones, barnacle cement to repair teeth, etc.)