

ROCKY INTERTIDAL ECOSYSTEMS

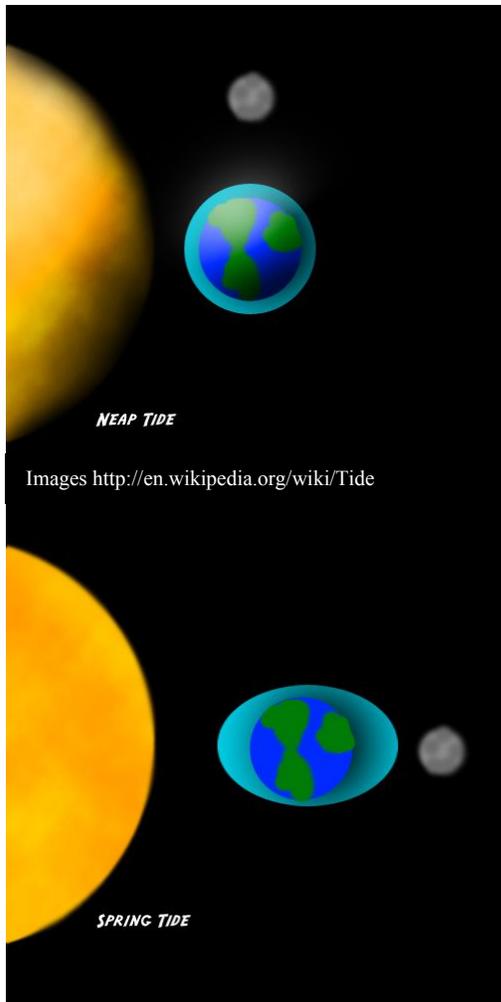
Tides

Although a detailed description of the complexity and mechanics of tides can not be covered in this workbook, it is essential to understand the basic principals of tidal changes as they directly influence the distribution of intertidal marine organisms. The key forces that act to create tidal variations are the gravitational and centrifugal forces at work between the earth, moon and sun (Ricketts et al 1985).

Gravitation is the attraction between two masses and is influenced by both the size and the distance between the two masses. Our moon has the greatest effect on tidal changes due to its close proximity to earth. The moon's gravitational pull causes the water on the earth's surface directly opposite the moon to "bulge" away from the earth (Niesen 1982). Centrifugal forces, caused by the spinning motion of the two masses, either keep masses separate or push them apart. On earth, the centrifugal force from the rotation is equal everywhere in magnitude and the direction of the force is away from the moon. Centrifugal forces therefore cause the water on the earth's surface farthest away from the moon to also "bulge."

When the earth revolves around its axis, every spot on the planet will experience both types of "bulges" during a twenty four hour rotation. If the moon was the only mass influencing tides, each spot on the planet would experience two high tides of equal magnitude and two low tides of equal magnitude every lunar day (24 hours and 50 minutes). However the sun has an important modifying effect on our system (Niesen 1982).

The moon orbits the earth once every 27.5 days; during this orbit the moon is in a different position in relation to the sun every day. When the sun, moon and earth are in a direct line with each other, and the moon is new or full, the combined forces cause our most extreme tides. These extreme tides create our lowest lows and our highest highs and are referred to as "spring tides" (which has nothing to do with the time of year, but is derived from an Anglo-Saxon word "to jump"). When the earth, sun and moon are at right angles to each other and the moon is in the first quarter or third quarter, the suns gravitational pull works to minimize the moon's force and the result is tides of a minimum range referred to as "neap tides".



There is considerable variation in tidal height and frequency in different geographic locations. The location, shape of the ocean basin, and a host of other local factors create modifications to tidal changes around the globe. In southern California we experience a mixed semi-diurnal tide which consists of two unequal high tides every day and two unequal low tides every day. The time of these highs and lows change by about 53 minutes every day.

Geology (Substrate)

Tidepools occur where the sea meets the land and rocky substrate is available for marine species to create communities. The type of communities and organisms found can depend on the type and quality of the rocky substrate. It is important to have a general understanding of the rocks that provide suitable habitat for organisms to exist in tidal influenced areas. In Orange County two geological formations exist at the interface of land and sea that help compose the tidepools in our MPAs; San Onofre Breccia, and Monterey.

Formations

The study of rock layers is done at a local level and then joined with information from surrounding areas to get a complete geological picture. The finest level of geologic rock division is called a formation and describes rock units exposed at local rock outcrops. A formation is a distinctive series of strata that originated through the same geological process. Formations provide a mapable rock unit that has definitive boundaries in its abundance and certain characteristics by which it may be identified from place to place. Formations names generally consist of two parts, for example San Onofre Breccia. San Onofre is the locale where the formation was first described or is most completely exposed and Breccia indicates the dominant rock type in the formation (Tarbuck and Lutgens 1996).

San Onofre Breccia formation

This formation is unique to Orange County with the exception of a few locations on the Channel Islands. The dominant rock type is breccia, which is described as a sedimentary rock composed of angular fragments that were lithified. The breccia consists of a conglomerate of sandstone and mudstone that contains clasts of



harder metamorphic rocks such as, dacite, porphyry, quartzite, amphibolite and Shist (Boles and Landry 1997). When eroded from wave and weather exposure the softer sedimentary layers erode, leaving the harder metamorphic conglomerate to provide pools and substrate for intertidal organisms. This breccia formation can also create huge boulder fields such as Dana Point when the cliffs erode and the metamorphic rocks pile up in the intertidal zone.

Orange County intertidal areas composed of San Onofre Breccia formation

Dana Point

Laguna Beach

Monterey formation



The Monterey formation is seen throughout California and is characterized by the layering of thinly bedded siltstone and sandstone. Based on foraminifera identification the Monterey formation of Orange County was deposited in a shelf environment that deepened to outer shelf (Boles and Landry 1997). The layering provides

ample microhabitats for intertidal colonization, and the erosion of softer portions of the formation can create tidal pools.

Orange County intertidal areas composed of the Monterey formation

Crystal Cove
Corona Del Mar

Wave Exposure

Besides tides, the physical factor that has the most dramatic effect on the distribution of intertidal plants and animals is the effect of wave force. The intertidal area is the chief and final focus of waves, bringing powerful surf crashing against the rocks and sand. Scientist and naturalist have long classified intertidal environments according to the wave exposure a site will experience (Hinton 1987). These environments include:

- 1) *Protected Outer Coast* – Semi-sheltered coast, protected by the shape of the coastline, offshore reefs or kelp bed.
- 2) *Open Coast* – Unprotected outer coast, often characterized by headlands (i.e. Dana Point) that receive high wave exposure.



- 3) *Bays and Estuaries* – Enclosed bays and sloughs with minor wave exposure (Ricketts et al 1985).

On open coasts animals and plants must withstand the impact of tons of water breaking over them. The organisms of the open coast are characterized by hard bodies and have strong attachment mechanisms. Many of the organisms that occur in sheltered outer coasts or bays are not equipped to take the battering and shearing force of heavy surf. As a result more sheltered areas are often rich in species abundance and distribution, in comparison with the neighboring open coast habitat (Ricketts et al 1985).

Intertidal Zonation Patterns

The rocky intertidal is the portion of a rocky coastline that is periodically covered or exposed by daily tidal changes. This interface is a complex environment where species are well adapted to the changing habitat conditions. Conditions are more terrestrial higher in the intertidal and correspondingly more marine in the lower intertidal area, depending on the



amount of exposure the area receives. This range of environmental conditions influences the species that are able to adapt to changing habitat variables. These environmental conditions are in part responsible for the unique zones within the intertidal that are highly visible by the dominant species that occur in each area or “zone.” These dominant species create stripes that take the color and texture of the dominant or “characteristic” organism of that zone (Niesen 1982).

Each of these zones has a dominant group of species that “characterize” that area of rocky intertidal. The four zones that are most commonly used are:

The Splash Zone

The Splash Zone is the area above the high tide water line and mainly depends on sea spray and mist for water coverage. The characteristic species of the splash zone are the Little Acorn Barnacles (*Cthamalus dalli*), Sea Lettuce (*Ulva sp.*) and the Periwinkle Snail (*Littorina sp.*). All species are adapted to withstand long periods of exposure.

The High Zone

The High Zone is the area of intertidal that is covered by most high tides. This zone is characterized by the larger Acorn Barnacle (*Balanus glandula*), but a large number of Limpets and Chitons also call this “zone” home. At our local sites two species of rockweed *Selvetia compressa* and *Hesperophycus harveyanus* are commonly observed in the high intertidal zone.

The Mid Zone

The mid zone is characterized by the three highly recognizable intertidal species the Seastar (*Pisaster sp*), the Mussel (*Mytilus californianus*) and the Gooseneck Barnacle (*Pollicipes polymerus*). The Mussel beds provide the characteristic band for this zone.

The Low Zone

The low tide zone is mixed with organisms that can be found in both the intertidal and subtidal habitats, but is characterized by the large fleshy brown algae that begin to appear in this zone. Several algal species are common but the characteristic browns are the Feather Boa (*Egregia menziesii*) and the Sea Palm (*Eisenia arborea*). The low intertidal zone provides more food, shelter and protection from desiccation than the other intertidal zone and is therefore inhabited by a greater number of species.

Desiccation, Temperature, Salinity and Zonation



Intertidal zonation is primarily caused by the upper limitation of the characteristic organisms. For an organism the height on the shore determines the total amount of time it will spend submerged in water or exposed to air and also the maximum and minimum time the organism will be exposed without interruption. It therefore makes sense that the higher a marine organism is found on the shore the more stressful the environment will be due to three related factors, desiccation, temperature and salinity. Desiccation potential is

the possibility of an organism drying out with exposure to arid conditions. Intertidal position on the shore generally sets the length of exposure to conditions of drying out which determine the desiccation stress. It is this stress that often establishes the upper limitation an organism can have in vertical intertidal range (Ricketts et al 1985). Temperature and salinity also have an influence on what organisms are found living within certain zones. When submerged, organisms experience relatively consistent environmental variables, but when exposed to air or the shallow waters of a tidepool they may be subjected to wide fluctuations in temperature and salinity (Ricketts et al 1985).

Microhabitats

A microhabitat is a topographic change in the rocky habitat that becomes more suitable for organisms that are not normally found in a particular tide zone due to changes in



environmental conditions. Microhabitats exist all over the intertidal habitat and the three most common are tidepools, boulders and channels/crevices.

Tidepools

Tidepools are microcosms of marine life formed by the depression of the rocky substrate that fills with water on an outgoing tide (Niesen 1982). These pools often provide habitat for organisms that on bare rock could only occur much lower in vertical distribution.

Boulders

Boulders create a wide range of conditions for inhabitants. The sides, tops and bottoms of a single boulder can have a wide range of different communities. Just as in terrestrial systems the sides of boulders are exposed to different weather conditions and therefore the same intertidal organism might be found higher on the shadier side of a boulder. In intertidal areas of high human use, boulders are sometimes referred to as “monk caps”, due to the bareness of the top of the rock from humans constantly stepping here.

Channels and Crevices

Channels and crevices provide protection from desiccation and provide organisms increased time for feeding that often reflects an increase in the vertical distribution of species.

Ecological Principals

Along with the complexity of the physical environment the interaction of organisms in the rocky intertidal makes it a living classroom for ecology. Competition for space, adaptation and evolution, consumption, disturbance, species versus area, and reproduction strategies are easily studied in this complex marine environment. It is here that the activities of this booklet focus and further study and research should be done by the teacher and student alike.