Chapter 15

The Intertidal Environment of the Rocky Coast

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Introduction

The Rocky Coast is the dominant New England intertidal environment north of Cape Cod. This intertidal environment is regularly exposed to air, creating extreme physical conditions to which the inhabitant plants and animals must adapt. Despite its harshness, the rocky intertidal is home to a wide variety of marine organisms, whose communities and their distribution are controlled by a complex interplay of physical and biological factors. It is an ideal area for studies of marine biology and ecology because of its accessibility and richness of its marine life. Students can observe and investigate marine organisms and their interactions without leaving their own terrestrial world. The many studies conducted in this community have added greatly to our understanding of marine biology and biological processes in general.

In this workshop our plan is to do two things: One is to introduce you to this unique environment by providing background information about pertinent biological and physical factors, our second goal is to present a set of field studies which can be used to introduce students to the ecology of the rocky intertidal environment.

Description of the Rocky Coast Environment

Structure and Formation:

The rocky shore is considered a young, or primitive, coast in that it is the least altered of all coasts; not having time to erode and form sediments. It is often the result of a relatively recent geologic event. The rocky coast of New England was formed during the last ice age about 18,000 years ago. The bare rock of the continental shelf was exposed when huge sheets of ice scraped away the overlying sediments. At first the tremendous weight of the ice actually sank the coast down into the mantle.

The coast slowly rose when the ice melted leaving a coastline of exposed, mostly granite, rock, which has over time been flooded and weathered as a result of rising sea levels. The rock face has been sculptured by the force of the waves forming crevices, caves, ledges, arches and depressions. A wide variety of habitats, ranging from sheltered to exposed, has been created due to the irregularity of the rock surfaces. These irregularities are very important to organisms of this shore whose lives are spent on the exposed surface of the rock.

Tides and Tidal Cycle:

The physical nature of being covered and uncovered by seawater is crucial in determining the types of communities on a rocky shore. Exactly which plants or animals are present depends upon the amount of exposure that can be tolerated. The Massachusetts coast experiences two tides each day, two highs and two lows. This tidal cycle is called semi - diurnal with the two high tides, as well as the two lows, being similar. The actual height of each tide varies with a range on the New England coast averaging from 6 to 8 feet. These tides are caused by the gravitational attraction of the moon and the sun on the oceans of the earth. Our highest highs (and lowest lows) occur when the sun, moon, and earth are in alignment. These are called spring tides. When the sun and moon are at right angles in relation to the earth we have more moderate tides called neap tides. During the monthly lunar cycle we experience two spring tides and two neap tides.

The Intertidal Zone—Conditions and Challenges

The intertidal zone (also called the littoral zone) can be defined as the area that lies between the highest high and the lowest low. This zone is one of extremes, alternating between almost complete submergence in seawater and almost dry terrestrial conditions. Nearly all the inhabitants of this area are marine, therefore the exposure at low-tide to terrestrial conditions is a time of great physiological stress. The organisms of the rocky intertidal live directly on the surfaces and, except for irregularities in the rock, are directly exposed to widely ranging environmental conditions. At low tide they must be able to tolerate desiccation, extremes of temperature, rainfall and ice (in the winter). On a hot summer day, for example, an organism might experience a temperature change of 30° C within an hour. Strategies must be developed in order for organisms to survive such extremes. Mobile organisms can move down with the tide or into a sheltered area. Others can "clam-up" to prevent drying out until the tide returns. Most inhabitants of this area have adapted to tolerate the wide range of conditions, for example, the *Littorina* living high in the intertidal can survive temperatures as high as 49° C (120° F). Our local rockweeds such as *Fucus* can withstand a 80% water loss.

With the returning tide conditions moderate and normal physiological processes are restored: food and nutrients arrive, dissolved oxygen is replenished, and wastes are washed away. However, the returning tide also brings exposure to the force of the waves. The amount of exposure to wave force is a critical environmental factor due, not only to the force, but also the angle of attack. There are great differences in the communities on an exposed shore versus a protected one. The amount of exposure exerts numerous environmental challenges to organisms in the rocky intertidal zone.

In the upper intertidal, where organisms are exposed for the greatest lengths of time, the physical factors are crucial in determining the inhabitants. In the less exposed lower intertidal the competition for space and predation becomes major factors. One of the characteristic features of these coasts is the zonation of living organisms.

Zonation

The rise and fall of the tides create a gradient of submergence and exposure along the vertical slope of the intertidal zone. Species tend to occupy different levels, or zones, each having its own tolerance for wave action, exposure to air, temperature variations, or desiccation. In the intertidal one sees a well-defined series of horizontal bands sometimes extending along a great length of coastline. Each zone may be sharply defined from adjacent zones by the color, texture and general appearance of the species living there. The make up of plant and animal populations may differ from place to place, however zonation is a visible unifying feature of rocky shores.

Considerable effort has been expended in devising schemes to identify each zone and its characteristic inhabitants. The following is a general description of the zones of the rocky intertidal and the various species found there.

Upper Intertidal:

The upper intertidal and the area just above it are sparsely populated. The conditions here are adverse and difficult for marine organisms; only the hardiest species can survive since conditions are nearly terrestrial. It is wetted only infrequently by extremely high tides and splash from waves. In the bare space between the terrestrial environment and the upper intertidal one finds a few species of terrestrial lichen that are able to tolerate sea mist.

Directly below this upper zone can be found a lichen species that is transitional between terrestrial and marine. This lichen *Verrucaria* forms an asphalt-like crust on the rocks and is tolerant of both spray and mist. The upper limit of the intertidal is defined by the "Black Zone" where black tar like splotches on the rock are the blue-green algae *Calothrix*. This species is embedded in a gelatinous mass that enables them to resist desiccation and, also, makes the surface very slippery when wet!

In moist areas several species of algae may be found: the green algae *Ulothrix* and *Enteromorpha*, or the filamentous red algae *Bangia* and the sheets of laver *Porphyra*. Grazing on the sparse vegetation is a small snail, the rough periwinkle *Littorina saxatilis*. This periwinkle is well adapted to the harsh conditions and is almost terrestrial in some of its functions. It can breathe air through moist membranes and retains its embryos within its shell until they are fully developed and capable of surviving on the rock. Another hardy grazer found in this area is the limpet *Acmaea testudinali*. Its cone shaped shell deflects the waves and it can clamp securely to the rocks by wearing down a "home" spot that precisely fits the margins of its shell.

The Middle Intertidal

The middle intertidal, unlike the upper intertidal, is always submerged by the tides twice a day. The seawater brings plant nutrients, dissolved oxygen, and planktonic food into this zone. A wider variety and number of organisms are able to survive here; there is competition for the limited space and predators are more numerous. The complex interactions between physical and biological factors often result in variable communities from different locations along the shore.

The upper boundary of this area is dominated by *Balanus balanoides* , a small crustacean called a rock barnacle. These plankton feeders, whose calcareous shells are firmly cemented to the surface, form a horizontal white band known as the "Barnacle Zone". The barnacles dominate in an area where their upper limit is controlled by exposure and their lower limit by predation and competition.

Below the barnacles is an area dominated by brown algae and mussels. The brown algae *Fucus*, being particularly tolerant of desiccation, is found just below the barnacles, while further down the slope and intermixed with the *Fucus* is the most prevalent brown algae of a moderately exposed coast, *Ascophyllum*. During exposure at low tide these overhanging algae fronds provide refuge for a wide variety of small invertebrates. Beds of the blue mussel *Mytilis edulis* underlie the algae or occur in patches amongst the seaweed. Bits of green algae such as the sea lettuce *Ulva* may also be mixed in this zone. *Ulva* could outcompete the browns except for the heavy grazing of *Littorina littorea*, a periwinkle that is abundant here. *Mytilis* is also a formidable competitor for limited space but it is controlled by predation of the carnivorous gastropod *Nucella lapilis* and by the sea star *Asterias*.

The Lower Intertidal

The lower intertidal is submerged most of the time and is habitat to the most diverse communities, especially on shores with some protection from wave action. Here one can find members of all the major phyla and several minor phyla. Algae dominate - greens, browns, and reds. Barnacles and mussels are not found here since the longer submergence time allows heavier predation mainly by sea stars who are not tolerant of the exposed conditions of higher zones. Again, grazing by periwinkles reduces the amount of green algae and the most abundant algae of this zone is commonly the red algae *Chondrus crispus* or Irish Moss, a commercially important species. It is not tolerant of exposure and lives in areas which remain wet even at low tide. *Chondrus*'s range extends to the lower edge of the intertidal where it is limited by sea urchin grazing and competition from other seaweeds. The kelps mark the lower limit of the intertidal zone and extend into the sub-tidal. The seaweeds of the lower intertidal are hosts to a variety of small animals hiding from predators and remaining moist even during the lowest tides.

Variations in Zonation

Through extensive study we are beginning to understand the various interactions that result in differences in zonation between areas. For example, there are noticeable and predictable differences in the zonation patterns between protected and exposed shores. The zonation described above is most typical of a relatively protected shore. In more exposed situations such as headlands one notices the absence of *Aschophyllum* which has difficulty getting established in a high surf environment. In its place one often finds a mixture of *Fucus* and green algae species, as well as mussels. The greens become prevalent because increased wave action removes the periwinkles that normally graze on green algae.

Even more exposed shores are almost totally covered by mussels due to the exclusion of their predators such as *Asterias* and *Nucella* by the pounding surf. In studies where sea stars have been artificially removed the mussels out compete other species and form dense beds. Their upper range has been found to be controlled by desiccation and food supply, while their lower limit is controlled mainly by predation.

Variations in zonation are the result of different factors. The factors which are most influential depend on the tidal height. In the higher intertidal the adaptations of each species to tolerate the harsh conditions of prolonged exposure determine its residents. In the middle and lower areas the elements of competition, predation, grazing and larval settlement are critical factors that control the composition of populations. At these lower levels there exists intense competition for space even amongst members of the same species. Barnacles, for example, can undercut each other forcing their neighbors off the rock. Algae, barnacles, mussels, and others are in competition for the available attachment space. The dominance of one group is often determine by the amount of predation on a competing species. The presence or absence of predators may be determined by physical factors like wave action or exposure.

Disturbance and succession are two other factors that play a role in the composition of intertidal communities. Disturbance can be caused by the action of predators or by physical causes such as clumps of organisms being torn off the rock by wave action, drifting logs or ice scouring. Whatever the cause, the result is a patch left on the rock into which organisms migrate often in a regular sequence. This process of species replacement can follow various paths and is somewhat dependent on who gets there first. Usually the first stage is a film of bacteria and microscopic algae. This is followed by barnacles, algae or mussels. Mussels can outcompete the other two but predation may restrict their ability to colonize. For example, if the patch should occur at times of abundant barnacle larvae and few seaweed spores the barnacles may be the colonizer. These processes help maintain the diversity of species in an area by making room on a crowded shore for new colonizers. It creates a mosaic of patches composed of different sets of organisms within a successional sequence.

Microhabitats

Protected areas such as tidepools, crevices, and overhangs often contain a different group of organisms than the surrounding rock, adding to intertidal diversity. Crevices and overhangs provide enough protection from desiccation to allow a species to inhabit an area where exposure on the open rock is more than they can tolerate.

Tidepools are areas of standing water within the intertidal, which create a mini-ecosystem with an assemblage of plants and animals quite different from those on the surrounding rock platform. There are also differences in the types and diversity of organisms found in pools located at different tidal heights. The upper pools have more extreme conditions and their water is only infrequently refreshed by the tides. They can reach elevated temperatures in the summer, while evaporation can increase salinity, and rainfall can decrease it. In these upper tidepools you will find a small variety of tolerant species. The lower pools are regularly flushed by the tides and conditions are much like the ocean. Here one finds a wonderfully diverse collection of marine organisms including coraline algae which carpets the floor with various shades of pink, anemones, hydrozoans, hermit crabs, and a variety of marine algae. The same kinds of interactions involving grazing, predation and competition occur among tidepool organisms and affect the variety of species found in each pool. Because of their isolation within larger environment tidepools have provided investigators more easily controlled environments to study and manipulate. Much has been learned of interactions of marine organisms through these experiments. For further reading see Amos and Amos (1989), Berrill and Berrill (1981), Castro and Hubard (1992), Smith (1992), Sumich (1988); for an excellent video see Gerber (1993).

Materials

Each *group* should have the following:

Meter sticks (2)
Graph paper, arithmetic (1)
Clipboard (1)
0.5m × 0.5m quadrat (1)
DO meter (1) or sample bottles for Winkler titration (2)
pH meter (1), pH paper, or sample bottles for laboratory pH meter reading (2)
Refractometer (1) or hydrometer (1)
Field guides

Student Outline

Field Investigations of the Rocky Coast

Vertical Transect Studies

A. General Survey

In groups of four we will study separate transects of the intertidal zone. The area of study is located in Nahant, MA at the Marine Science Center of Northeastern University. Each transect should extend from the water's edge to the splash zone. Follow these guidelines:

1. Use a line level or estimate by eye the general profile of your transect. Plot the profile of your transect on the graph provided. Remember to estimate the height of each area from the water as well as the distance of the slope up the rock.
2. Identify and study the dominant organisms found along your transect. Plot their location using an identification number for each species, for example:
   a. *Balanus balanoides*
   b. *Littorina littorea*
   c. Unknown - collected for ID

   If you cannot identify it in the field, collect it to bring back for identification. Label collecting bottle or bag with plot # for that species. Remember to take your time and look closely. Examine areas under rocks (replace in original positions), ledges, and even under algae.
3. Collect information which may be helpful in understanding the role of the plant or animal in the intertidal community: factors such as food preferences, feeding behavior and association with other plants or animals.
4. Using the information you have collected answer the following questions for discussion:

   Discuss the general trends of distribution of intertidal plants along your transect.

   Discuss the general trends of distribution of intertidal animals along your transect.

   Did your study show any evidence of zonation?

   What were the apparent dominant organism(s) in each zone?

   Describe any "microhabitats" in your study area. What differences were there in these organisms compared to the surrounding rock slope?

   Give examples of different feeding methods in the animals you observed?

   Propose a food web for the organisms in this environment.

B. Comparison of Exposed Versus Protected Coasts

The first area we studied was located in a sheltered area, protected from the most extreme wave action. We will repeat the transect study in an area that faces the open ocean with little protection from the most extreme wave action. Follow the same procedure you used for the previous transect. Comparing the data collected from each study answer the following for discussion.

Compare the general trends of distribution of intertidal plants along your two transects. Are their differences? What are they?

Compare the general trends of distribution of intertidal animals along your two transects. Are their differences? What are they?

What are the differences in zonation between the two areas both in distribution along the rock and in dominant organisms?

C. Vertical Distribution Analysis

Once you have gained an understanding of the types and general distribution of organisms along the rocky intertidal you can do a more accurate and detailed study. The following study is designed to obtain accurate population density estimates of several intertidal species along a narrow transect. The information can be used as a basis for discussion of the factors that affect the distribution of intertidal organisms. Again, this can be done in one area, or several, to compare distributions in areas of different exposure. This type of survey produces the best results in intertidal areas that are nearly vertical and extend through the entire tidal range. It assumes the you can accurately identify plant and animal species.

For this study each group will need a 0.5m × 0.5m quadrat (area = 0.25 m^2)

Procedure:

1. Working in groups of four you will survey selected organisms in successive 0.5m × 0.5m quadrats along a transect line. Choose 10 common species of plants and animals. Your choices should be based on the species' abundance, its range of distribution, and your ability to easily identify it.
2. Beginning at the highest point of the intertidal place your quadrat along the transect you have chosen. Count the individuals of each selected species found in this quadrat. If the number of individuals in one species is large (Over 100), making counting difficult; count the individuals in a portion of the quadrant.
3. Record the number of individuals you counted for each selected species in that quadrat (or portion of quadrat).
4. Move the quadrat down 0.5m along the transect and repeat the process of counting and recording selected species. Continue this procedure until you reach the water line.

Data Analysis:

1. To standardize the data for comparison convert each species to individuals/m^2 for each quadrat where they were present.
2. Using these density calculations and the vertical range of each species we will plot a distribution and abundance chart for the transect studied (see example). Begin by setting up a graph with the vertical axis representing the vertical range in half-meter increments and the horizontal axis representing the density. Divide the graph into ten vertical sections so the distribution and abundance of each species can be compared on the same graph.
3. Indicate the vertical range of each species with a line on the graph spanning the corresponding vertical distance. For each species: at each half-meter increment of vertical height plot the density with a horizontal line proportional to the density at that height.
4. To complete the chart construct a "kite" diagram for each species by enclosing the lines that indicate vertical range and horizontal density (see Table 1).

The results of this study can be used as a basis for discussion of the distribution of organisms and the biotic and abiotic factors that effect the patterns of zonation. As in the previous exercise it is useful to compare areas with different amounts of exposure. This type of study can also be used for long-term observations of the same area. If classes visit the same areas year after year permanent transects can be marked by driving large bolts or spikes into the rock every meter along the transect. Data collected from one year can be compared to earlier surveys and differences discussed which may involve the factors of disturbance and succession.

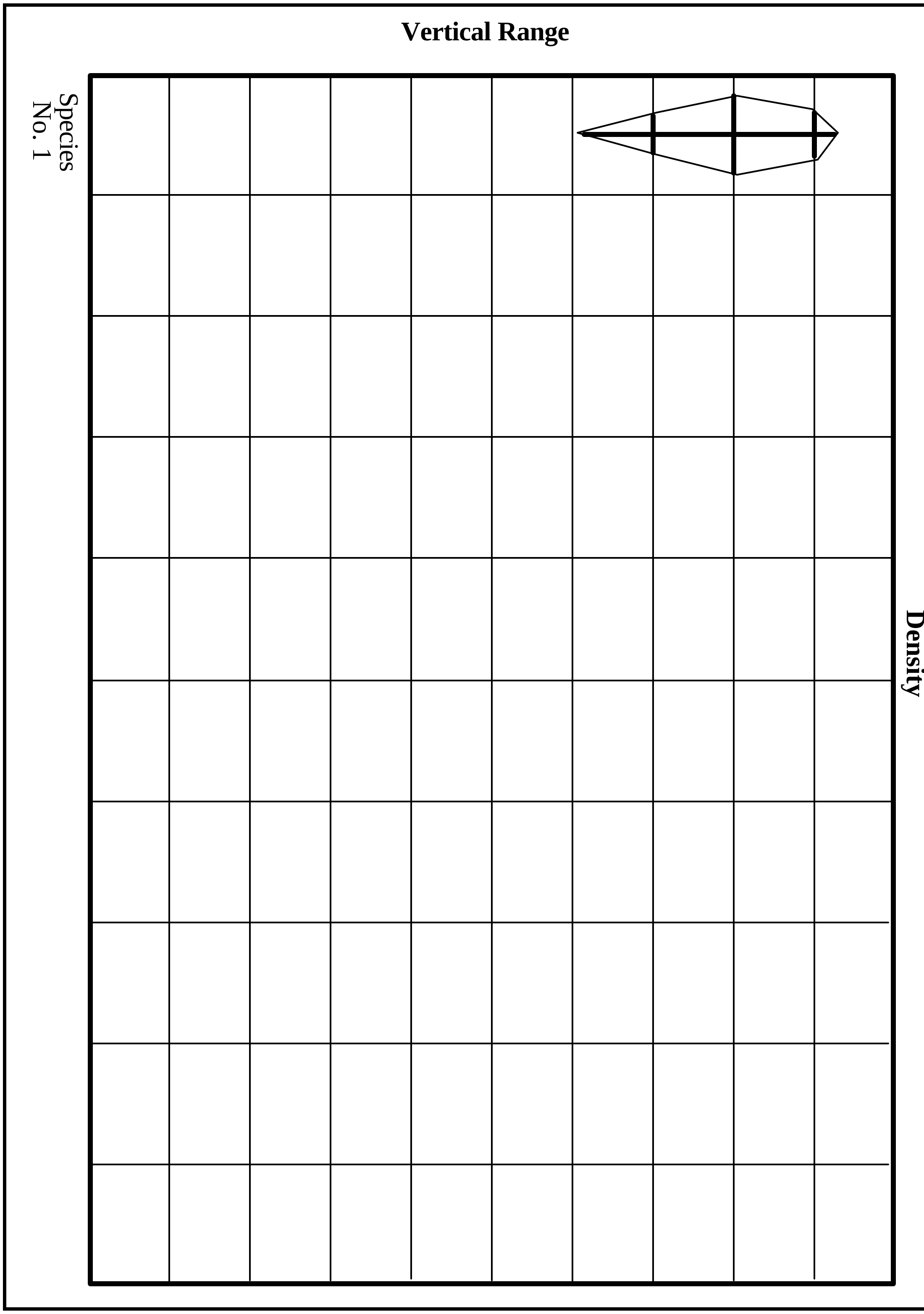

Table 15.1. Distribution and abundance chart.

Tide Pool Study

Comparison of abiotic and biotic factors of two tidepools: one located in the upper intertidal and the other in the lower intertidal.

This investigation can be done along with the introductory transect study. Each transect group should study two tide pools: one close to the water's edge and one high in the intertidal. The pools do not need to be in your transect but find ones nearby. Estimate each pool's height from the water then do the following:

1. Measure the temperature, salinity, dissolved oxygen and pH for each pool and the ocean. Record these on the chart (see Table 2). (If using the Winkler titration method fix samples in the field and they can be kept for titration in the lab for up to 48 hours. The pH samples can also be collected in the field and measured later on a meter in the lab. Make sure all sample bottles are carefully labeled.)
2. Survey the organisms in each pool. List species name and approximate abundance of 5 to 10 species in each pool. Refer to field guides for help with identification.
3. Using the data you have collected answer the following questions for discussion:

Are there any differences in the types and diversity of organisms in the tide pools? If so what are these differences?

What are the differences in the chemical and physical data from each pool? Which is most like the ocean?

What kinds of environmental factors might be responsible for any differences in the chemical and physical factors of the pools compared to the ocean?

Is there any correlation between physical/chemical factors and diversity?

Table 15.2. Physical and chemical conditions of water.

	Pool 1	Pool 2	Ocean
Location			
Temp.			
Salinity			
Dissolve O_2			
pH			

For field guides to use in these studies see Amos and Amos (1989), Gosner (1978) and Kingsbury (1969). For further marine field studies and laboratory exercises see Dudley and Sumich (1984).

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APPENDIX

Guide to Common Flora and Fauna of the Rocky Coast

I. Flora

Phylum Cyanophyta ("Blue-greens")

Calothrix - most common of the blue-green genera that form a black, paint-like stain on the rocks in the spray zone above the high tide level.

Phylum Chlorophyta (Green Algae)

Chaetomorpha - Filamentous, unbranched, bright green; filaments coarse, about as thick as a paper clip; to 300 mm; cells large and visible; attached in pools or on lower intertidal rocks or found drifting in tangles.

Enteromorpha - grass-green, tubular, often containing air bubbles with in the thallus; branched,or not; 3 mm or less in width and to 300 mm long; common in lower intertidal, in higher levels in tide pools and areas of freshwater seepage; wide tolerence of varying and low salinities.

Spongomorpha - filamentous,branched in spongy or ropey tufts of green; filaments hairlike to thickness of a thread and to 150 mm in length; found hanging from rock surfaces between high and low tide lines.

Ulothtrix - Unbranched filaments as thick as cotton fibers to 25 mm in length;on rocks or pilings in upper intertidal.

Ulva - "sea lettuce", bright green, grows in sheets with lobed or ruffled edges to 900 mm; common between tide levels in moderately exposed locations; attached to rock by a short marginal stalk; tolerant and thriving in moderate pollution.

Phylum Phaeophyta (Brown Algae)

Alaria - a kelp with a distinct, sharply edged midrib and short, leafy bladelets at base of stipe; grows up to 3 meters long and 25 mm wide; attaches to rocks in the upper subtidal with a branched holdfast.

Agarum - a kelp that is easily ditinguished by the numerous holes that perforate the blade; grows to 1.8 meters or more; dark brown; found in subtidal but frequently washes ashore.

Ascophyllum - "knotted wrack"; a very common olive-colored weed covering intertidal rocks below the upper band of rockweeds; the long, narrow ribless blades contain air bladders throughout; branching is highly variable; blade length to 600 mm or greater; commonly epiphytized by *Polysiphonia*.

Chorda - a slender, brownish-green, whiplike weed without branches; to 4.5 meters in length but only about 6 mm thick; may be covered with a dense furry coating of fine brown hairs; attached to shells or stones in lower intertidal to subtidal.

Desmarestia - "sourweeds"; bushy, 450 mm to 600 mm; brown fading to yellow-brown; characteristic sour smell; on rocks and pilings lower intertidal to subtidal .

Ectocarpus - a filmy brown seaweed found attached to rocks or larger plants; each plant is an erect branching and rebranching filament no thicker than a human hair.

Fucus edentatus - brownish-green blades that are broad and flat with a strong midrib; blades divide in more or less equal Y-shaped forks; species easiest to distinguish when "in fruit"; has flat, elongated recepacles, usually bifurcate; found in low intertidal and upper subtidal.

Fucus spiralis - Brownish-green flat, twisted blades; lacks air bladders; found in upper interdital.

Fucus vesiculosus - "rockweed"; the most common and widespread species; characterised by paired, pea-shaped air bladders placed at intervals within the blade and a distinct midrib; most abundant in mid-intertidal.

Laminaria agadhii - a long-bladed dark brown kelp with midrib; solid,cylidrical stalk and branched holdfast; blade to 3 meters long and 150 mm to 250 mm wide; subtidal.

Laminaria digitata - blade in mature plant divided into 6-30 or more strapelike "fingers"; stalk stiff and woody; extreme lower intertidal to subtidal.

Leathesia difformis - "sea potato"; grows in rubbery saclike masses; yellow-brown; common among *Chondrus* in lower intertidal; 75 -100 mm across.

Ralfsia - encrusting in tar like patches on rocks; in tide pools or in lower intertidal.

Phylum Rhodophyta (Red Algae)

Bangia - grows in tufts composed of soft, unbranched, slippery filaments; to 200 mm long, about as thick as horsehair; dark red-purple fading to yellow brown; found upper intertidal above the barnacle zone.

Chondrus crispus - "Irish moss"; variable in form; composed of flat branching blades 175 mm to 250 mm; deep red in shade bleaching to yellow-green in the full sun; often appears iridescent under water; very abundant, forming a dense carpet over much of the lower intertidal.

Corallina officinalis - composed of calcified fan-shaped tufts to 38 mm; thallus is hard, jointed, and branching; light pink to deep purple; lower intertidal to subtidal.

Dumontia - 300 meters or more in length; composed of a central axis with numerous large branches distinctly larger than the axis; older branches hollow and inflated or squeezed flat; dull red in color, upper part of branches turn yellowish; in shallow lower intertidal and tide pools.

Girgartina - similar in structure to *Chondrus*; but differs in having curled blades covered with short bumps like terry cloth; grows amongst Irish moss in lower intertdal.

Hildenbrandia - encrusting, uncalcified red algae; forms a thin, but tough film over rocks in tide pools and intertidal rock surfaces.

Lithothamnium - encrusting and calcarious; forms heavy crusts on rock; whitish lavender.

Polysiphonia - bushy plant; common epiphyte on *Ascophyllum*; densely branched, stiff and wiry; to 50 mm in diameter; deep red.

Porphyra - "laver"; large, soft, thin sheet-like blade; purple to brown in color; sometimes epiphytic on other plants but often attached to rocks in intertdal.

II. Fauna

Phylum Cnidaria (Coelenterata)

Class Hydrozoa - small and colonial; found attached to various seaweeds and to undersides of rocks and in crevices.

Class Anthozoa

Metridium senile - an anenome with numerous fine tentacles; usually orange or yellow-brown, sometimes pink or white; to 10 cm tall to 7.5 cm wide, smaller intertidally; found in lower intertidal in rock crevices and in tidepools.

Phylum Bryozoa - form small, encrusting, calciferous colonies on algae and rocks; colonies 1 - 10 cm, individuals smaller than 0.5mm.

Phylum Mollusca

Class Gastropoda

Acmaea testudinalis - the common intertidal limpet; cone-shaped shell, often mottled; usually 25 mm to 50mm.

Crepidula fornicata - "slipper" or "boat "shell; shell has a platform extending about one-half way across opening; shell not coiled, apex is turned to one side; shell pinkish-tan; to 38 mm; attach to any solid surface, often found in stacks of individuals.

Littorina littorea - the most common intertdal periwinkle; a herbivourous snail with a blunt spire and pale columella; usually brownish-gray; to 31mm.

Littorina obtusata - smooth periwinkle; shell globular and smooth, spire very low; color variable: yellow, browns, orange, sometimes banded; found in lower intertidal, often among rockweeds; to 12 mm.

Littorina saxatilis - rough periwinkle; similar in appearance to a small *L. littorea*; spire taller; tolerant to dessication, lives higher on the intertidal; to 12mm.

Nucella lapillus - dogwinkle; common carnivorous snail, feeding on barnacles and mussels; color varies: white,orange or brown, often banded; to 38 mm.

Class Bivalvia

Mytilis edulis - the blue mussel; smooth-shelled with pointed terminal beaks; color outside glossy blue to blue-black; common and abundant in mid-to-lower intertidal often forming dense beds; attach firmly to substrate with tough byssal threads; to 100 mm.

Phylum Arthropoda

Class Crustacea

Subclass Cirripedia

Balanus balanoides - northern rock barnacle; common species in mid to high intertidal forming a distinct white "zone"; shell varies in shape, usually rough and folded; compressed where crowded; to 25 mm.

Subclass Malacostraca

Order Amphipoda - a large group of small (less than 1cm), laterally flattened crustaceans; good swimmers; found intertidally in pools and under algal mats.

Order Isopoda - small crustaceans flattened dorsoventrally; many species; intertidally in pools, crevices and among algae; 3 to 34 mm.

Order Decapoda

Cancer irroratus - rock crab; broadly oval shell with marginal teeth; pinkish-purple with stout claws; under rocks, in crevices and tidepools; to 131 mm.

Carcinus maenas - green crab; shell somewhat broader than long; 5 marginal teeth; last walking leg somewhat flattened; mottled green in males; females more reddish - brown; found in similar areas as *Cancer irroratus*; to 75 mm.

Class Insecta

Order Collembola

Anurida martima - a common springtail found in tidepools; collect in dusty bluishgray aggregates on surface; small (3 mm).

Phylum Echinodermata

Class Echinoidea

Strongylocentrotus droebachiensis - green sea urchin; spines short; common in tide-pools and subtidally; to 75 mm in diameter.

Class Stelleroidea

Asterias spp. - *A. forbesi* and *A. vulgaris* are two similar sea stars common in the lower intertidal; rough skinned and in a variety of colors; *A. forbesi* more common intertidally south of Cape Cod; it has a bright orange madreporite and grows to 125 mm; *A. vulgaris* is common north of Cape Cod and has a pale yellowish madreporite and reaches 200mm.

For illustrations and further information on these species or additional species found on the rocky coast see these gudes: Amos and Amos (1989), Berrill and Berrill (1981), Gosner (1978), Kingsbury (1969).

Rocky intertidal areas along the west coast of North America are some of the richest and most diverse places in the world. Over 1000 species of invertebrates and algae can be found in the rocky intertidal of central California, and this wide variety of life makes exploring the rocky shores fun and exciting. Does this diversity matter to the rocky intertidal?Â â€¢ Climate change: Because rocky intertidal environments lie at the land and sea interface, they are expected to be strongly influenced by climate change. In response to rising air and sea temperatures, we may expect the distribution of species along our coast to change. A rocky shore is an intertidal area of seacoasts where solid rock predominates. Rocky shores are biologically rich environments, and are a useful "natural laboratory" for studying intertidal ecology and other biological processes. Due to their high accessibility, they have been well studied for a long time and their species are well known. Many factors favour the survival of life on rocky shores. Temperate coastal waters are mixed by waves and convection, maintaining adequate availability of nutrients This article describes the habitat of rocky shores in a tidal environment. It is one of the habitat sub-categories within the section dealing with biodiversity of marine habitats and ecosystems. It gives an introduction to the type of biota that lives there, the problems and adaptations the habitat is facing with and the importance of it in the marine environment. Intertidal zones of rocky shorelines host sea stars, snails, seaweed, algae, and crabs. Barnacles, mussels, and kelps can survive in this environment by anchoring themselves to the rocks. Barnacles and mussels can also hold seawater in their closed shells to keep from drying out during low tide. Intertidal zones richer in sediments are filled with different species of clams, sand dollars, and worms. At rocky shorelines, tide pools can form in holes, cracks, or crevices where seawater collects as the tide goes out. Organisms that cannot normally survive low tide conditions, like sea stars, shri