## What background information should I know about Intertidal Ecology?

*Not only do the waters teem, but there is no rock too small to harbor some living thing, and no single cluster of algae without its inhabitants. Since these creatures live and thrive in an environment that seems utterly strange to us, it is no wonder that we find interest in their ways of feeding, of breathing, of holding on, on ensuring continuity of their kind - or in strangely different weapons and methods of attack and escape.*

*Rocky shore animals are abundant, easy to find, and spectacular in their bright colors and unexpected shapes. So keen is the struggle for existence here that not only is every square inch of shore surface likely to be utilized, but the holdfasts and stipes of kelp are also occupied; and such forms as sponges, tube worms, and barnacles often take up positions on the shells of larger animals.*

- Ricketts, Calvin, and Hedgpeth, *Between Pacific Tides*

During your visit to the CACS Peterson Bay Field Station, you and your class will be visiting intertidal areas in Peterson or China Poot Bay. This visit will be memorable for your students and an excellent hands-on learning opportunity for the concept of biological diversity. Over the years, visitors to these areas have identified 149 different species of invertebrates and 27 species of seaweed. Beyond providing the sheer experience of seeing, touching, hearing, and smelling diversity, a field trip to this living laboratory is ideal for the study of adaptations to intertidal conditions and of the factors that influence the distribution of plants and animals. To experience the same amount of diversity of conditions and different biological communities on land, you would need to hike up a mountain or cross a broad river valley. The diversity of life in the ocean is similarly difficult to observe in a single short trip. But, in the intertidal zone of Peterson and China Poot Bays, diversity is obvious in a matter of feet and is often revealed or concealed in a matter of minutes as the tide moves.

Kachemak Bay is in a very interesting geographic location from the standpoint of biodiversity. It is far enough south so that the bay and intertidal zone rarely freeze, but far enough north that the rhythms of life are distinctly seasonal with bursts of biological activity during spring, summer, and early fall when light levels are high enough to support photosynthesis by phytoplankton in the water column. Its protected nature and current patterns make it a very different environment from the rest of Cook Inlet. Both on the west side of the Inlet and to the north, the movement of sediments and ice scour away many of the plants and animals that manage to get established in the intertidal zone. The bays on the south side of Kachemak Bay, in particular, harbor diverse arrays of seaweeds and marine invertebrates. The tidal regime and the expanse of different types of substrates are major factors in the conditions for diversity.

## WHAT LIVES WHERE? AND WHY?

### INTRODUCTION

Imagine that you are a mussel. Where would you live in the intertidal zone? What do you think are the most important aspects of the environment that would affect your survival? Or imagine you are a sea star. How will you manage to find as many mussels and clams as you need to eat higher up on the beach without drying out before the tide comes back? Questions of this sort have fascinated scientists, naturalists, and anyone who spends time roaming a rocky beach at low tide. The major and controlling factor in the life of this area is the range and timing of the tides. The action of the tides moves the water's edge up and down the land in a predictable and regular fashion, creating living space for plants and animals and transporting nutrients and food items. Wave action can extend the intertidal zone even higher up on the land or sweep away whatever is not clinging or firmly attached. Plants and animals sort themselves out, either permanently by attaching to a rock or other hard substrate or temporarily by crawling or burrowing, somewhere along an invisible gradient of conditions from the lowest low tide to the highest high tide and splash of salty water.

Scientists have sought answers to these questions through studies on beaches and shores all around the world. The intertidal environment is a dynamic and harsh environment to which plants and animals must have adaptations that allow them to cope and survive. It is more crowded at the lower tidal levels where complex dramas are played out to find space and food while avoiding becoming food.

**The distribution of plants and animals in the intertidal zone appears to be a combination of responses to physical conditions and to biological interactions of competition and predation. Upper limits for plants and sessile (fixed) animals are generally set by their tolerance to physical factors while the lower limits are often set by biological interactions. For mobile animals, however, behavior often provides important adaptations that influence their distribution.**

**Four Physical Gradients**

1. Vertical gradient from terrestrial (land) to marine (ocean) conditions
2. Horizontal gradient of exposure to air and variable temperatures,
3. Gradient of particle size from bedrock to silt (mud) in substrates
4. Gradients of salinity

## SHELTER FROM THE STORM

The degree of shelter from wave action is one of the most important factors in setting the conditions for life in the intertidal zone. Very different adaptations are required to cling to rocks subjected to the force of pounding open ocean waves in the Gulf of Alaska compared to living among rocks on a beach in a protected bay like China Poot Bay. Peterson and China Poot Bays have a variety of shelter conditions which provide opportunities for comparison of plant and animal communities. Within a short walk from Peterson Bay Field Station, it is possible to visit the relatively sheltered beach in front of the Field Station, the more exposed "Outer Beaches" around Otter Rock across the slough from the Field Station, and the more sheltered beaches in China Poot Bay, protected by the gravel bar that extends most of the way across its mouth. Peterson Bay beaches, while relatively sheltered are subject to storms and high winds. As a result, with the exception of Otter Rock, the outer beaches have very low intertidal diversity of living plants and animals, but they accumulate remains of plants and animals as a result of storm and wave action.

## THE LAND/SEA EDGE

The diversity of life on any shoreline is an "edge effect" of the proximity of land and the sea and the combination of terrestrial and marine habitats in a relatively short distance. On land, similar ecological effects often occur in the riparian zone of shrubs and wetland plants around streams and along the edges of forest stand patches adjacent to meadows or other very different types of forest stands. Along ecological edges, animals often feed in one habitat and find cover and rear their young in another habitat. In Kachemak Bay, land otters, mink, harlequin ducks, and pigeon guillemots are all examples of animals that feed in the intertidal zone and rear their young on land.

## BETWEEN THE TIDES

The shoreline is a particularly rich edge because, in addition to what can be thought of as a vertical gradient from terrestrial plant communities to marine and estuarine waters, there is a gradient that runs horizontally in the zone between the highest and lowest reach of the tide providing a range of conditions related to the degree and duration of submersion in water or exposure to drying and temperature variations. A variety of plants and animals have been able to adapt and thrive under these conditions. Exposure to air (emersion) and variable temperatures is stressful to marine organisms; the ocean is always wet and a relatively constant environment with respect to temperature. The number of marine plants and animals that have adapted successfully is thus much higher in the less stressful lower intertidal zone. Mobile animals, however, which range higher in the intertidal zone at low tide to feed on the species that are attached to the substrate have to be able to tolerate the harsher environment throughout the exposure period. Only a few organisms, such a lichens, insects, and arthropods, are terrestrialspecies that are restricted to the upper intertidal zone because they can tolerate exposure to the marine environment. Although diversity is lower in the upper and middle tidal zones, species such as barnacles and rockweed that have been successful in adapting to the severe conditions in this zone are found over thousands of miles of coastline.

## HOW MUCH SALT?

As described in the Introduction, Kachemak Bay is an estuary with a pattern of salinity changes in relation to seawater and freshwater flows. Where fresh water flows directly into the intertidal zone, the diversity of plants and animals is limited by adaptations to water less saline than ocean water. Tide pools that are formed when tidal water is trapped in a rock depression in middle of the tidal zone can fluctuate widely in salinity level as the pools dry up or rain dilutes them. Salinity gradients play a large role in the distribution of intertidal plants and animals in Kachemak Bay as a whole and in individual bays from the head to the outlet, but are observable only on the small scale of fresh water seeps across the intertidal areas in China Poot and Peterson Bays.

## ROCK OR SAND OR MUD?

The type of substrate is also another factor in plant and animal adaptation and survival. The third gradient that sets the conditions for life in the intertidal zone is the size of the particles in beach sediments ranging from bedrock cliffs to fine mud. Rocks of various sizes provide a variety of niches (under rocks, in crevices, tide pools, sides and tops of boulders) to provide attachment sites to withstand the force of tides and waves or to shelter from dessication and temperature extremes. Some seaweeds and animals can modify the beach substrate when they attach to rocks or other hard substrates and grow in dense concentrations. Where dense stands of seaweeds, mussel beds, and tube worm colonies become established, these stands can provide shade, prevent dessication, and provide shelter from water movements for individuals and for other species such as worms and small crustaceans. Seaweeds and mussel beds can also trap sediments that provide a substrate for burrowing animals.

Finer sediments accumulate in flatter areas with less current, especially at the mouth of streams and rivers into often-vast tideflats. As particles get progressively smaller, however, the habitat area available in and on the substrate is reduced. Eventually, in muddy areas, no space exists for oxygen a short distance below the surface between the particles. Sand and mud provide habitat only for animals able to withstand burial by shifting sediments. Adaptations include burrowing and building tubes below the surface.

Animals who live below the surface in mudflats

**Rocky Beaches of Peterson and China Poot Bays**

**Bedrock Outcrops/Large Boulders:** Otter Rock and Octopus Rock - rock faces and a diversity of rocky shore niches in crevices, depressions, and various aspects of the boulders

**Mixed Cobble/Mud Beaches:** China Poot Bay and Peterson Bay in front of Field Station - mixtures of large and small boulders and cobbles, semi-cemented together with sand and mud (one of the best combinations of habitat stability and diversity to support the largest number of plant and animal species of any type of beach.)

**Unstable Cobble Beaches:** Outer Beaches west and east of Otter Rock - grinding during storms prevents survival of most plants or animals that manage to become attached or seek shelter under the rocks. Interesting places to look for a diversity of shells and other plant and animal remnants that are washed up by storm tides.

must also be adapted to tolerate low oxygen conditions.

The type of substrate is an indicator of the stability of the beach sediments. Wave action deposits sand and fines, but also moves these sediments and scours the beaches. Cobble and boulder beaches can also be unstable - water runs quickly off beaches with coarse, rocky substrates, so even moderate wave action can rearrange cobbles and boulders frequently. Rock cliffs, bedrock outcrops, and large boulders are the most stable substrates.

Mudflats generally have a lower diversity of species compared to rock and combination-type intertidal areas, but the abundance of small numbers of species can be high and important to non-resident predators. The seasonal abundance of a few species of worms and clams in Mud Bay and Beluga Slough provides a critical food supply for migratory shorebirds and waterfowl.

**North Shore Beaches for Comparisons**

**Bishop's Beach** - areas of cobble, cobble/mud, and sand areas, and some isolated boulders.

**Mud Bay** - diversity of mudflat habitats

**Beluga Slough** - combination of mudflat and salt marsh habitats.

## FRIENDS AND ANEMONES

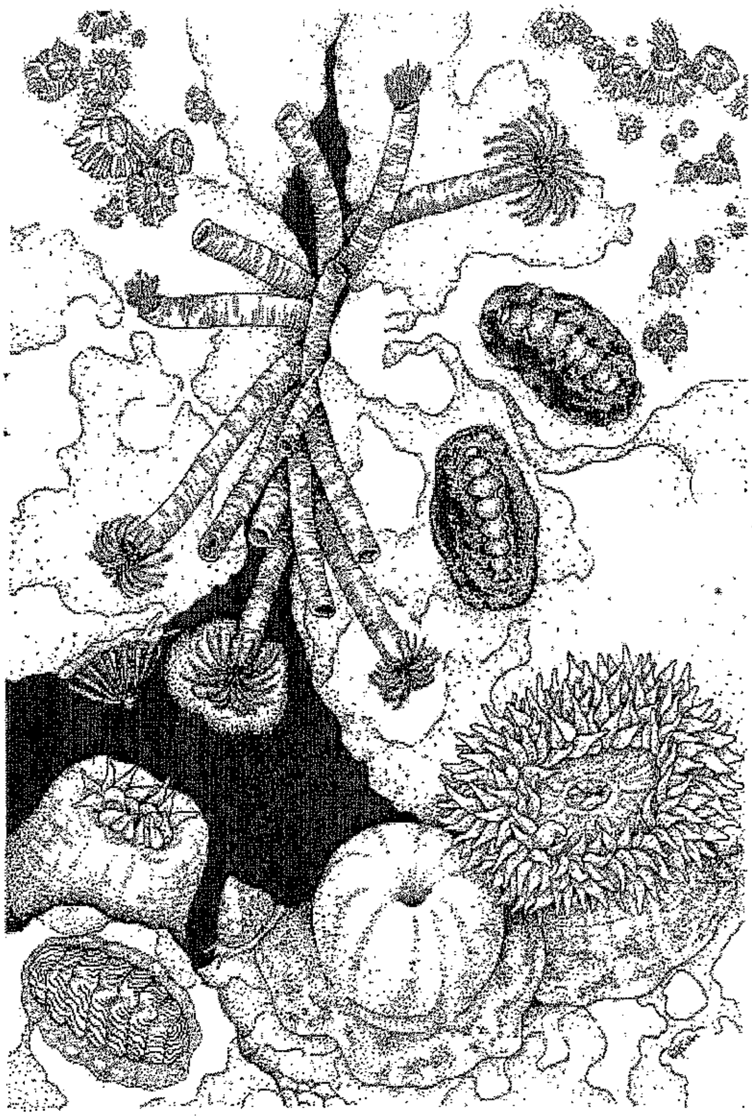
In addition to physical factors, relationships between and among organisms also affect and often control survival at any specific site. The crowded conditions of the lower intertidal zone are thinned by competition, grazing, and predation. Behavior patterns of different animals also help explain where some are found or not found. Mobile animals, such as limpets and sea stars, rarely move so high up in the intertidal zone that they are exposed to conditions that they can't tolerate. Barnacle larvae have chemical sensing capabilities and settle in areas where the scar of a dead barnacle is present rather than on bare rock. Small sea stars, worms, limpets and snails move to the underside of rocks as the tide goes out where they are in a wetter micro-climate. Brittle stars clump together under rocks as do larger sea stars on the surface, which helps conserve water more than if the individuals were alone. Animals find shelter under seaweeds from drying and extreme temperatures.

Figuring out behaviors and ecological relationships and interrelationships that affect the distribution of plants and animals in the intertidal zone has been a rich and fascinating topic for scientific research. Several studies in areas other than Kachemak Bay have unraveled complex stories about the dramas being played out. On rocky shores, the stories have to do with how organisms compete for space to attach themselves to avoid being washed away, how prey animals defend themselves from mobile predators, or how plants and animals can actually add structure to the environment and modify it for other plants and animals.

A classic study of sea stars and mussels in Washington demonstrated that, if Ochre Stars (*Pisaster ochraceus*) are removed from an area, California Mussels (*Mytilus californianus*) will grow lower in the intertidal zone than when the ochre stars are present. Scientists concluded that the sea stars were able to determine the lower limit of the mussels and thus the width of mussel beds, through predation in the intertidal zone.

Another example is from Southeast Alaska, where shield limpets are found higher in the intertidal zone than plate limpets. Both limpets are preyed on by the ochre star. The plate limpet can move faster than the shield limpet. From these observations, scientists believe that the ochre star is influencing the behaviors and distribution of the two limpets: the shield limpet avoids predation by its behavior of staying higher in the intertidal zone than the ochre star can forage while the plate limpet stays lower down and escapes predation by running away from the sea star.

The study of the sea star/mussel relationship involved species that are rare or not present in Kachemak Bay and took place in areas with different conditions. The northern geographic location of Kachemak Bay adds complicating factors of seasonality and temperature extremes that may be more controlling than biological interactions. So questions about whether these types of relationships may exist for similar species in Kachemak Bay are very interesting ones. Scientists have observed a ribbon kelp (*Alaria crispa*) that grew well and formed a canopy in the lower part of the Gull Island intertidal zone only when it could attach to a colony of thatched acorn barnacles (*Semibalanus cariosus*). The kelp canopy provided shade and moist conditions for the crumb-of-bread sponge and also seemed to provide shelter from predators. When the barnacle colony was eliminated by a disturbance, both the kelp and the sponge were absent and all three species recovered together in two years.



## PUTTING IT ALL TOGETHER: LIFE IN THE ZONE

The diversity that you will observe on beaches in Peterson and China Poot Bays has some obvious patterns of bands or zones of biological communities parallel to the shoreline. **Zonation** is a concept in intertidal ecology that is often used to relate the distribution of various species to distinct upper, middle, and lower zones of the intertidal area related to their abilities to withstand the duration and frequency of time out of the water that characterizes each zone. Zonation is generally easily observed on rocky beaches where plants and animals are either on top of rocks or under them rather than burrowed into sand or mud.

Both Peterson and China Poot Bays are rocky beaches, but provide good examples of the variety of conditions that can occur which make a "neat" zonation description inaccurate. Large rocks, such as Otter and Octopus Rocks, have crevices that accumulate fine sediment. Erosion and deposition patterns have intermixed large boulders and smaller cobbles in many areas with finer sand or mud. The addition of new habitat niches under and on smaller rocks and in sandy and muddy pockets increases habitat diversity and results in a larger species diversity (number of different types of species that can find suitable habitat) compared to that of a "typical" rocky beach habitat. However, the plants and animals that may be found at each tide level is less predictable as plants and animals respond to variable local substrate conditions as well as to other factors. This is true of animals that hide under rocks when the tide goes out and animals that burrow in areas where sand and mud have accumulated.

In light of the variable conditions on the beaches your class will visit, a single grouping of the plants and animals that they can expect to find in each zone would be inaccurate and confusing to the students. Instead, zonation can best be presented in terms of:

❶ A very broad classification of high, middle, and low intertidal zones (see next page)

❷ A focus on only a few plants or animals as characteristic of each zone.

❸ Predicting the relative position of other plants and animals in relation to their habitat requirements and adaptations

## Upper or High Intertidal Zone

Covered by water only when the tide is high or nearly high. Plants and animals are rarely covered by salt water or covered for only a short period of time. This provides a predator-free zone for barnacles and periwinkles. Above this zone is the splash zone where organisms are affected by splash from the waves.

**Characteristic species:**

| | |
|---|---|
| **Splash Zone:** | Black Seaside Lichen (forms an almost continuous band) |
| | Orange Lichen |
| **Upper Intertidal:** | Periwinkles |
| | Acorn Barnacles |

## Middle Intertidal Zone

Exposed about 2.5 hours after high tide. Bands of mussel and rockweed define the boundaries of this zone. Plants and animals are adapted to periods of both submergence and periods of exposure to drying.

**Characteristic species:**

| | |
|---|---|
| Rockweed - distinct band | Pacific Blue Mussel - distinct band |
| Periwinkles | Barnacles - Acorn Barnacle and Northern Rock Barnacle |
| Six-rayed Star | Limpets - Mask Limpet, Shield Limpet, and Plate Limpet |

## Lower Intertidal Zone

Area below lower edge of mussel or rockweed beds to extreme low tide exposed approximately 0-1.5 hours after low tide. This area is often covered in lush growths of algae, especially red and brown and has the greatest diversity of invertebrates. Plants and animals can tolerate daily periods of exposure.

**Characteristic Species:**

| | |
|---|---|
| Red Algae | Kelps/Brown Algae |
| Crumb-of-bread Sponge | Thatched Barnacle |
| Christmas Anemone | True Star |
| Black Katy Chiton | Leather Star |
| Lined Chiton | Green Sea Urchin |

## Extreme Lower Intertidal Zone

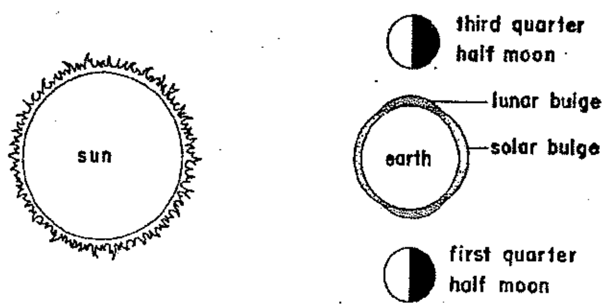
The upper edge of the Subtidal Zone is exposed only briefly at the very extreme, minus tides. Plants and animals are primarily subtidal but can tolerate short periods of exposure occasionally. Animals from upper tide zones may retreat to this area to avoid exposure as tide goes out.

**Characteristic Species:**

| | |
|---|---|
| Coralline Algae | Dunce cap Limpet |
| Nudibranchs - various species | Gumboot Chiton |
| Sea Cucumbers | Tunicates |
| Sunflower Star | |

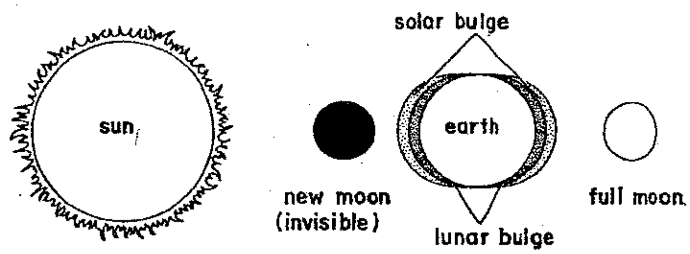
## TIDES

The movements of the tides create the conditions for life in the intertidal zone as they carry nutrients and food items along with larval forms of many animals that spend their adult life in the intertidal zone. Kachemak Bay has two tide cycles daily and a very large tidal range. The tide cycles are unequal with a high low and high tide and a low high and low tide over the two cycles. Because of the high latitude, Kachemak Bay, like all of Alaska's coastal areas have a large tidal range, with the maximum being 28.5 feet and the average 15.4 feet (Upper Cook Inlet has an even greater tidal range of up to 38 feet because the tides are constricted by the geography of the inlet north of Kachemak Bay. This constriction creates the fast-moving tidal bore that moves up Knik and Turnagain Arms, the second largest tidal bore in North America after the Bay of Fundy).




To understand the way the tides affect conditions for life, its important to understand that tidal range is measured vertically, as if on a cliff. If a pole was placed in the intertidal zone, the water would move up and down along the pole a total of 28.5 feet over the course of a year. Another important concept for understanding how tides are measured is the concept of the zero-tide level, which is the average (mean) of the low tides over the course of a month.

The tide level above or below zero in relation to the tidal range provides an indication of the amount of the total intertidal zone that is exposed at a particular place at a particular time. For example, a




-2.0 tide at China Poot Bay (with an extreme low tide level at around -5.0) would expose only a portion of the

# INTERTIDAL FOOD WEBS

## PRODUCERS

Phytoplankton and seaweeds are the producers in the intertidal zone. Phytoplankton are small, unicellular organisms capable of photosynthesis and light enough to float in the upper layer of the water which receives enough light to support photosynthesis. Phytoplankton include microalgae, one-celled monerans, and bacteria. Diatoms and dinoflagellates are common phytoplankton in Kachemak Bay. Some diatoms are sessile, or attached, and appear in large numbers as a slimy scum on intertidal rocks.

Phytoplankton are either captured by zooplankton and other small animals in the water column (many of which are the larval stages of animals that eventually settle and attach themselves to rocks in the intertidal zone such as barnacles and mussels) or filtered from the water by suspension feeders such as the clams, mussels, and barnacles.

Macroalgae, or seaweeds, are more similar in form to flowering plants, but they attach and glue themselves to rocks and other hard surfaces (even the shells of mollusks) with holdfasts rather than rooting in mud or sand, have a stipe instead of a stem, and have blades instead of leaves. They reproduce by microscopic, floating spores rather than by seeds. The distribution of seaweeds in the intertidal zone is related to their ability to photosynthesize at varying light levels and exposure to desiccation. Seaweeds are consumed by grazers such as limpets, some snails, chitons, and sea urchins.

Seaweeds are classified as green, red, and brown. (The color of the plant doesn't always match the classification because the grouping is based on the life cycle, not the color.) As a general rule, green algae are more often found in the upper intertidal zone while red and brown algae are found in lower zones. Kelps that are annuals, in particular, are among the fastest-growing organisms in the world during May and June, as an adaptation to keep their blades floating near the surface of the water column.

## SUSPENSION-FEEDERS (INCLUDES FILTER-FEEDERS)

A number of intertidal animals consume organic material, including phytoplankton, zooplankton, and detritus (dead material). Their feeding method is collectively called suspension feeding because they are feeding on what is suspended in the water column or in sediments. The filter-feeding method of animals such as sponges, clams, mussels involves passing water through their bodies using siphons, pores, cilia and other structures, capturing particles in mucus and moving the food particles to their mouth or place where food is digested. But other methods are also used - worms ingest sediment and sort out the organic particles, sea cucumbers extend tentacles covered with mucus and contract them one at a time into their mouth to clean off the particles, and brittle stars move across the substrate and use their tube feet and mucus to pass particles to their mouth.

## GRAZERS

Grazing occurs at both micro- and macro-levels. Several species of mollusks like periwinkles and limpets are microherbivores, using their radula (whip-like tongue with teeth) to scrape off films of diatoms and microalgae on rocks on other hard surfaces. Sea urchins and larger mollusks such as chitons can bite or rasp off chunks of seaweeds. Seaweeds have few defenses against grazers because they are fixed in place. Some grow in dense patches and tend to lose less mass to grazers. Others are encrusting species that adhere tightly to rocks; the calcification of the coralline algae limit the grazers to just a few species who are microherbivores. Some species have noxious substances which grazers avoid. Rockweed, for example, contains chemicals that make it indigestible by most species, so is rarely grazed. There is even an Acid Kelp (*Desmarestia* spp.) that produces and secretes sulfuric acid that can damage nearby seaweeds and erode cavities in the teeth of sea urchins hungry enough to feed on the seaweed.

## PREDATORS

Intertidal predators also come in all sizes, from the microscopic zooplankton and larva in the water column that capture phytoplankton to the Giant Pacific Octopus that can grow to be 100 feet long in deeper waters. Most are mobile so have a large advantage over the many animals which are sessile, but some remain in one place, like the sea anemone that relies on its stinging cells to attack prey that happen to come in contact with their tentacles. Slow-moving predators may have adaptations to open the shells of bivalves (the tube feet of sea stars) or to bore into their shells (radula of whelks and moon snails).

Intertidal prey species have evolved a variety of passive responses to predators, including spines, thick shells, tough exoskeletons, noxious chemicals, and camouflage. A periwinkle that withdraws into its shell, closes its operculum, and seals the door with mucus can survive being swallowed and digested by a sea anemone for 20 hours! Prey have also developed behavioral responses such as the chemical detection of predatory sea stars by several bivalves, followed by rapid movement away.

Prey can escape predation if they can develop refuges either temporally (shift activity to a time when the predator is not active such as nighttime, time larval settlement to a time when predation or competition is lower) or spatially (adapt to a zone out of the reach of predators). Or they can grow so fast that they escape in size by becoming too large for a predator to successfully attack.

## SCAVENGING AND DECOMPOSING

While a large amount of detritus is recycled by the suspension-feeders, other animals feed on larger chunks of dead matter. Several types of crabs and amphipods are the clean-up crew in the intertidal zone, but sea urchins, usually an herbivore, will also feed opportunistically on dead matter. Detritus passes through what can be thought of as a series of sieves in the intertidal zone. Crabs eat big chunks, beach hoppers eat minute particles or break up large pieces into small ones, sea cucumbers and brittle stars buried in the substratum sweep surfaces with tentacles, limpets and periwinkles sweep the rocks, other animals like brittle stars, sea cucumbers, and annelid worms eat dirt and sand to extract nourishment. The smallest particles are attacked by bacteria and recycled into nutrients that phytoplankton and seaweeds can use in photosynthesis.

## What background information should I know about Forest Ecology?

The forest accessible from Peterson Bay Field Station is an example of Alaska's coastal forest. It is near the northern and western edge of this type of forest which stretches from northern California to the south, Kodiak to the west and about the middle of the Kenai Peninsula to the north. Because it is so close to the edge of this biome, Kachemak Bay is a transitional area, with a mixture of elements from the coastal Sitka spruce-western hemlock forest and those of the boreal or white spruce-paper birch forest to the north.

The majority of spruce forests on the uplands surrounding Kachemak Bay are dominated by Lutz Spruce trees that are hybrids of White Spruce and Sitka Spruce. Forests near Cook Inlet on the south side of the bay around Nanwalek and Seldovia are pure Sitka spruce, then the relative contribution of Sitka spruce to the hybrid mix shifts from a high proportion on the south side of the bay to a low proportion on the north side. A smattering of western hemlock trees are found in south shore forests.

### TEMPERATE RAINFOREST?

The coastal forest is often referred to as the coastal temperate rainforest, but some scientists draw the boundary line for this forest based on a rainy but relatively mild climate influenced by being on the seaward side of coastal mountain ranges. By this definition, since the south side of Kachemak Bay is sheltered in the rainshadow of the Kenai Mountain Range, it is not rainy enough. Other researchers would define the Bay's forests as sub-polar temperate rainforests. Regardless, there many characters the forests of this area have that are considered characteristics of temperate rainforests.

**Due to the lack of massive rainfall, many scientists don't define Kachemak Bay forests as true rainforests, however the bay forests have several other characteristics of temperate rainforests:**

1. Rarity of fire
2. Evergreenness (at the ground level during winter)
3. An abundance of epiphytes (plants that live on the surface of other plants such as hanging lichens and mosses)
4. A complex structure with several canopy layers
5. A range of tree sizes and ages within a patch of forest
6. A dense, shrubby understory
7. Dominance by conifers

## SPRUCE BARK BEETLE

The coastal forests in Alaska are relatively young since they developed following glaciation as recent as several hundred years ago. The forests developed as a climax stage to primary succession on thin soil layers on top of glacial till. The thin soils can be observed in the root wads of fallen, dead trees and on the top of cliffs above the beaches. In some areas around the Field Station, secondary succession has been initiated by disturbances such as the cutting of trees for a powerline corridor and high winds that created a windthrow area. Recently, the trees that were infested or killed by spruce bark beetles were cut down around the Field Station to minimize the danger from falling trees and the spread of fire. These areas provide outdoor laboratories to observe secondary succession.

In some areas, water collects in low-lying areas and soils are too saturated to permit the growth of trees. A short hike from the Field Station provides an excellent example of a bog and the variety of plant adaptations that allow survival in this distinct environment. Lost and Found Lake is an example of a fresh water lake that formed in a depression left by a remnant large piece of glacial ice.

A spruce bark beetle epidemic is causing obvious and relatively rapid changes in Kenai Peninsula forests — in terms of both infestation and death of individual trees and human responses to dead trees. Management of the forest presents a dilemma for land owners and public land managers - balancing the inevitable effects of ecological change with human concerns for safety and economic benefits of harvesting timber. The key management question is whether or not to leave infested trees alone to die in place and eventually rot or to cut down trees that are likely to be infested or that are already infested or dead. This curriculum packet includes a reference to the Forest Management Dilemma activity revised from the Alaska Wildlife Curriculum Alaska's Forests and Wildlife volume. The revision is specific to the situation on the Kenai Peninsula and incorporates recent scientific information and land management actions.

**ETIQUETTE GUIDE TO FOREST EXPLORATION**

1. Keep everyone on the trails, even through wet and muddy spots.

2. No collection of plant specimens (unless for a specific CACS educational project) or other souvenirs, with the exception of ripe berries.

3. Bears have the right of way at all times. Avoid bear encounters and leave no trace of food or garbage on the trails.