The *Biology of Seashores* - Image Bank Guide

Shore Types

Low tide, rocky shore, sandstone shelves ,The amount of beach exposed at low tide depends both on the level the tide will reach, and on the gradient of the beach.

Low tide, granite boulders, The geology of intertidal areas varies widely. Here, vertical faces of exposure are mixed with gentle slopes, providing much variation in rocky intertidal habitat.

Low tide, muddy bay, Bodega Bay, California. Bays protected from winds, currents, and waves tend to be shallow and muddy as sediments from rivers accumulate in the basin. The receding tide leaves mudflats.

Low tide, muddy bay. In some bays, low tides expose vast areas of mudflats. The sea may recede several kilometers from the shoreline of high tide

Low tide, sandy beach. Sandy beaches also vary widely in gradient. Gently sloping beaches expose large expanses of sand at low tide.

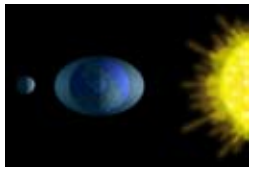
Low tide, sandy beach, clam diggers. Knowing the time and extent of low tides is important for people who collect intertidal organisms for food.

Low tide, Salt Point, CA, mixed sandstone and hard rock boulders. A rocky beach at low tide. Rocks in the background are about 15 ft. (4 meters) high.

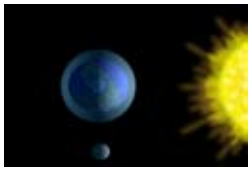
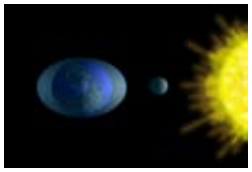
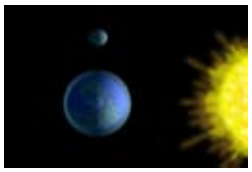
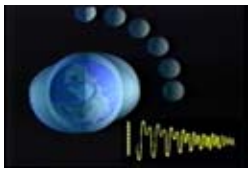
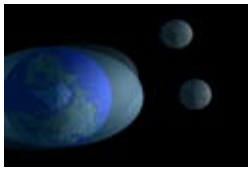
Split frame, showing low tide and high tide from same view, Salt Point, California. Identical views of a rocky intertidal area at a moderate low tide (left) and moderate high tide (right). Tidal variation between these two times was about 9 feet (2.7 m).

High tide, Salt Point, mixed sandstone and hard rock boulders. Same beach as previous two slides, note the absence of exposed algae on the rocks.

Tides



Slide 1 of 4, Tidal bulge variation at different phases of the moon. Full moon. Gravitational pull from moon and sun are directly opposed, emphasizing tidal bulges.

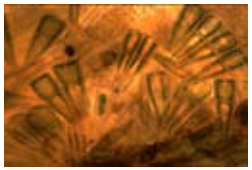
	**Slide 2 of 4, Tidal bulge variation at different phases of the moon. 3rd quarter moon.** Gravitational pull from moon and sun at roughly right angles. Tidal bulges are least pronounced.
	**Slide 3 of 4, Tidal bulge variation at different phases of the moon. New moon.** Moon and sun gravitational pulls combine on one side of the earth. Tides at new moon tend to be slightly more extreme than tides at full moon.
	**Slide 4 of 4, Tidal bulge variation at different phases of the moon. 1st quarter moon.** Gravitational pull from moon and sun at roughly right angles. Tidal bulges are least pronounced.
	**Variation in the tidal cycle over 7 day period - new moon to first quarter.** Note the pattern of daily tides as the moon moves from "in line" with the sun to the "right angle" position. A seven day cycle shows trends that will be reversed in the following 7 days. Trends over 14 days will repeat in the 28-day lunar cycle.
	**Tides are about 51 minutes later each day due to movement of the moon in its orbit.** Actual published tidal chart data will confirm this effect.

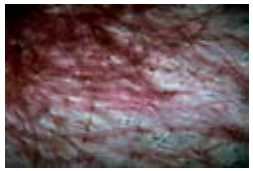
Competition for Space

	**Competition for space by algae, British Columbia Coast, semi-protected rocky shore.** The large-boulders in this low tide zone area are packed with algae. Dominant species include: the dark, finger-like green alga, *Codium fragile*; the leaf-like green alga, *Ulva* (sea lettuce); the rock weed, *Fucus*; and, in the water, the giant kelp, *Macrocystis*.
	**Competition for space by algae, British Columbia Coast, semi-protected rocky shore.** Dominant species include *Leathesia*, the leather alga; Turkish towel, *Gigartina* (a red alga seen in the left foreground, that has been bleached); and a filamentous green alga.
	**Sponges competing for space on low intertidal rocks under overhang.** In dark habitats, encrusting organisms such as sponges compete for space with coralline red algae. Of all the intertidal or shallow water algae, the encrusting corallines seem to be most able to tolerate low light conditions.
	**Competition for space - plumose anemone, *Metridium senile*.** This anemone occurs in low wave-shock areas, deeper substrates, and on docks.
	**The aggregating anemone, *Anthopleura elegantissima*** Like many cnidarian species this anemone can divide asexually creating genetically uniform clones. Large clones can build up over time and when one clone contacts another, individuals at the contact zone actually battle for space using specialized, potent stinging cells.
	**Under-rock: tunicates, sponges, bryozoans, flatworm.** Encrusting animals occupy almost every surface in the lowest intertidal areas, especially in spaces under rocks.
	**Low tide: tunicates, sponges, bryozoans, tidepool sculpin.** The red social tunicate shown here is competing for space under a rock with bryozoan colonies and small calcareous tube worms.

	**Mid tide zone, exposed rocky coast, barnacle competition, thatched barnacles, *Semibalanus cariosus.*** Competition for space on the surface of exposed rocks can be fierce. This rock on an exposed, wave-swept beach is packed with barnacles. Most of the clear spaces are occupied by mussels.

Production

	**Pennate diatoms that form surface scum.** Pennate diatoms secrete a sticky mucilage that aids in movement and sticking to the rocks.
	**Green algae: *Codium fragile* (dark green finger-like) and sea lettuce, *(Ulva* or *Monostroma).*** There are fewer species of green algae on rocky shores than red or brown algae, but as this slide shows, they may compete so successfully in some areas as to dominate the flora.
	**Green algae on rocks: sea lettuce, *(Ulva),* and *Spongomorpha.*** Both *Monostroma* and *Ulva* are thin sheets of algae, the former one cell thick and the latter 2 cells thick.
	**Red algae: Turkish towel, *(Gigartina)* and *Iridaea.*** *Gigartina* forms thick blades roughened by small warty growths, giving it a texture like a rough towel.
	**Red alga, sea bladders, *(Halosaccion).*** Red pigments in these examples have been bleached in the sun. The sacs hold sea water which helps to prevent dehydration.

	**Red algae at the rim of a tidepool in the mid to upper zone: *Prionitis.*** Some species of this genus are characteristic at the rim of tidepools in northern temperate coasts. They tolerate freshwater floating on tidepools during rains.
	**Filaments of red algae that form a coating on rocks.** Many species of red algae form coatings on rocks. Some of these are alternate generations of larger erect species found nearby.
	**Coralline red algae, *Bossiella* (central clump) and *Calliarthron*.** Coralline red algae contain quantities of calcium carbonate to stiffen them and make them unpalatable to some herbivores.
	***Leathesia difformis.*** Called the brain alga or leather alga due to its form.
	**Feather boa kelp, *Egregia menziesii.*** The stipe of the feather boa kelp may be 3cm wide and up to 10 meters in length. Thin blades are attached densely along both margins of the stipe, with some blades inflated to form floats.
	**Sea cabbage, *Hedophyllum sessile.*** A common brown algae on rocky shores. This is the only kelp with no stipe.

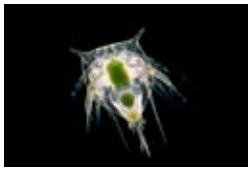
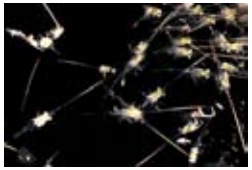
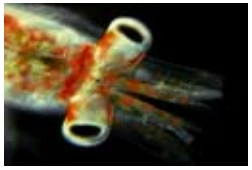
	**Sea palm, *Postelsia palmaeformis.*** Found only on shores washed by strong waves, this species competes with mussels and gooseneck barnacles for space.
	***Laminaria setchellii.*** A strong flexible stipe holds up the narrow blades of this perennial alga. It thrives on wave-battered shores.
	**Bull kelp beds, *Nereocystis.*** This kelp, with its long tubular stipe tipped with a flotation bulb, requires a rocky substrate for attachment. Small *Nereocystis* kelps may be found growing in the lowest intertidal areas, but it is largely a subtidal species.
	**Giant Kelp, *Macrocystis.*** Large beds of giant kelp support extensive communities of life just below the lower edge of many intertidal areas.
	**Surf grass, *Phyllospadix scouleri.*** One of the few flowering plants living in the sea, surf grass lives in the lower regions of intertidal areas with wave action.
	**Surf grass, *Phyllospadix,* medium view.** The roots of this plant form dense fibrous mats occupied by many animals. Leaves are narrow (<0.5cm).

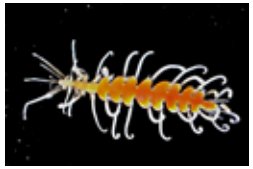
	**Eel grass, *Zostera marina.*** Eel grass is a flowering plant that lives in shallow areas of muddy bays.
	**Eel grass, *Zostera marina* medium view.** The wide leaves (1-2 cm) and roots of this species provide important food and habitat.

Phytoplankton

	**Composite of four phytoplankton species clockwise from upper left: the dinoflagellate, *Noctiluca*; the diatom *Chaetoceros* and *Ditylum*; an unidentified dinoflagellate.** Dinoflagellates and diatoms are the dominant microphytoplankton (20-200 μm) of temperate cold waters. *Noctiluca* is a bioluminescent species.
	**Scanning electromicrograph (SEM) of centric diatom.** The picture shows the sculpted glass frustrule.
	**Centric diatom, photomicrograph, *Triceratium*, 5-pointed cells.** Normally 3-pointed, individuals are occasionally found with 4 or 5 points.
	**Centric diatom, *Arachnoidiscus* and small blade of red alga.** At 0.6 mm *Arachnoidiscus* is one of the largest diatoms

Zooplankton

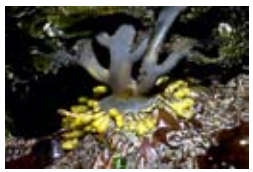
	**Barnacle nauplius larva, the two 'horns' are characteristic.** Green pigments in gut are from phytoplankton food. This is an early nauplius stage.
	**Zoea larvae of porcelain crab.** The long spine structures of these larvae are useful for slowing descent. Many other plankton adaptations function to keep organisms near the ocean surface.
	**Hermit crab zoea.** The head of this larva shows an important feature for zooplankton predators - eyes capable of detecting prey animals. Many zooplankton animals are nearly transparent.
	**Counter-clockwise from upper left: barnacle cypris; brittle star ophiopluteus; unidentified trochophore; snail veliger.** Zooplankton animals present only as larval stages are collectively termed meroplankton. Most coastal invertebrates have planktonic larvae.
	**Mysid crustacean.** Mysids and euphausids are large holoplankton crustaceans, sometimes occurring in dense swimming groups. Mysids serve as food for some baleen whales.
	**Euphausid crustacean.** The krill of Arctic and Antarctic waters, euphausids form dense swarms, especially in areas of upwelling currents.

	**Copepod, bearing eggs or developing larvae.** Copepods are probably the most abundant group of animals on the planet, exceeding even the ants in shear numbers.
	**Planktonic adult mollusc, *Clione,* the sea butterfly.** This odd mollusc swims by flapping the two wing-like structures.
	**Hyperid amphipod.** Large-eyed hyperid amphipods are pelagic, although some species are 'hitch-hiking' commensals on jellyfish.
	**Pelagic polychaete annelid.** Most polychaetes have planktonic larvae and there are a few species planktonic as adults.
	**Ctenophore, Sea gooseberry, *Pleurobrachia.*** The rows of complex cilia give this animal the name, comb jelly. The species is a significant predator on crustaceans, principally copepods, caught with long sticky tentacles.
	**Ctenophore, *Beroe.*** This species feeds exclusively on its cousin, the sea gooseberry.

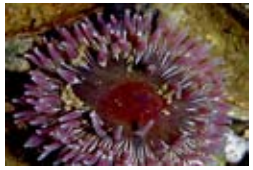
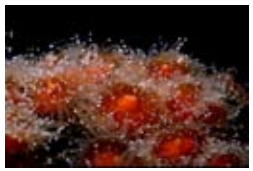
	**Moon jelly, *Aurelia aurita.*** Distributed worldwide in temperate seas, this species grows to 40 cm across the bell. Inset shows horseshoe shaped gonads.
	**Moon jelly, *Aequorea Victoria.*** This common Pacific coast hydromedusa is bioluminescent.
	**Jellyfish, *Placellophora camschatica.*** One of the largest planktonic invertebrates of the North Pacific (up to 65cm bell diameter), this species is distributed worldwide in temperate oceans. It is quite similar to the 'lion's mane' jellyfish, *Cyanea*.

Wave Shock Adaptations

	**Rocky coast showing wave shock, Vancouver Island, B.C.** Outer rocky shores exposed to open-ocean waves experience high wave forces. These forces decrease as the protection from waves increases.
	**Crumb-of-bread sponge, *Halichondria* and ochre sea stars, *Pisaster* .** Near the surface of rocks there is significant reduction in the forces generated by flowing water, due to friction. Encrusting organisms take advantage of these 'boundary layer effects'
	**Shield limpets, *Tectura scutum.*** A shallow, flattened profile is adaptive to strong wave forces, serving to increase flow across the animal.

	**Chiton, *Stenoplax conspicua.*** Many species of chiton occupy the intertidal, with its rich algal floras that provide food for these rasping herbivores. The low profile and 8 bony plates are adaptive.
	**Acorn barnacle, *Balanus glandula.*** Hard calcified plates and a shallow cone profile are adaptat-ive for both wave shock and desiccating conditions. The barnacle secretes a strong cement to attach itself to the rock.
	**Sea palm, *Postelsia palmaeformis.*** Sea palms survive only on the most wave-battered rocky shores. The rubbery stalk is generally 10-40 cm tall.
	**Gooseneck barnacle, *Pollicipes polymerus.*** These barnacles have a leathery stalk with some flexibility. They also grow in thick clumps that reduce surface area exposed to wave force.
	**Holdfast, sea palm, *Postelsia.*** A glue secreted by the holdfast cements the haptera of the holdfast to the rock.
	**Holdfast, *Egregia.*** Holdfasts serve only to hold the organism to the rock, and do not function in the transport of materials to the rest of the alga.

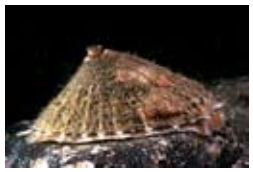
	**Foot of brown turban snail, *Tegula brunnea .*** Sensing increasing currents around it, the snail will increase the strength of its hold on the rock by raising the central portion of the foot to create added suction force.
	**Foot of limpet, *Tectura.*** Limpets generate strong suction forces. When a limpet is washed off the rock its chances of righting itself before being attacked by a predator or scavenger are low.
	**Tube feet of common ochre sea star, *Pisaster ochraceus.*** Each tube foot is tipped with a disk. A muscle in the center of the disk can contract to cause suction.
	**Clingfish, *Gobiesox .*** Inset: pectoral and pelvic fins modified for suction
	**Foot of the California mussel, *Mytilus californianus.*** The foot extends out from the shell (as much as 2-3 shell lengths) where it senses an attachment site. A groove in the foot carries a sticky fluid secreted by a byssus gland at the base of the foot. The fluid congeals in a short time to create a strong attachment thread (byssal thread). Many threads are secreted by each mussel.
	**Byssal threads of California mussel, *Mytilus californianus*.** Mussels tend to stay attached in one location but they can move by dissolving away selected byssal threads, moving slightly, and attaching new threads.

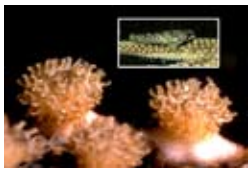
	**Purple sea urchin *Strogylocentrotus purpuratus.*** Sandstone pockets excavated by generations of sea urchins, are found in some coastal areas. The pockets are created by abrasion of the tips of the spines. No chemical action is known to be involved.
Defense	
	**Anemone, *Urticina coriacea.*** A 'typical' sea anemone with rings of tentacles around the margin of its disc. This species is usually partially buried in sand.
	**Hydrozoan.** A small hydrozoan feeding polyp (less than 1 cm). Inset shows a cnidoblast in a tentacle.
	**Orange cup coral, *Balanophyllia elegans.*** This solitary cup coral species shows batteries of stinging cells, cnidoblasts, in each tentacle.
	**Strawberry anemone , *Corynactis californica.*** Stinging cells line the surfaces of tentacles and are concentrated in the bulb at the tip of each tentacle.
	**Aggregating anemone, *Anthopleura elegantissima.*** The anemone is being eaten by a predator nudibranch, *Aeolidia papillosa*.

	**Sea mouse nudibranch, *Aeolidia papillosa.*** An aeolid nudibranch showing the dorsal tentacles or cerata, each with a white sac containing cnidoblasts captured from its anemone prey.
	**Tip of tentacle of *Aeolidia*, nematocysts discharged.** Two views of the tip of a nudibranch cerata. The insert shows a sac containing cnidoblasts before discharge. In the wide vie, the cnidoblasts have been released and they have discharged.
	**Spanish shawl nudibranch, *Flabelinopsis iodinea.*** This remarkable species feeds on hydrozoans, and is presumably defended by the cnidoblasts it retains in the tips of its own cerata.
	**Red encrusting sponge.** Encrusting species such as sponges often rely on toxic or noxious chemicals for defense. Many of these compounds have been found to be active as anti-viral or anti-fungal agents.
	**Sea lemon nudibranch, *Archidoris montereyensis* .** In certain conditions, such as here, this nudibranch stands out dramatically (to color-perceiving predators)
	**Sea lemon nudibranch, *Archidoris montereyensis* eating sponge, *Halichondria.*** Noxious or toxic chemicals from the sponge are incorporated into the tissues of the nudibranch predator, acting as a deterrent to predation.

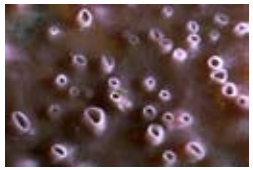
	**Clown nudibranch, *Triopha catalinae.*** This nudibranch eats sponges and bryozoans, and some defensive compounds from the prey species are utilized. Presumably, the color pattern acts as a warning to predators, although this has not been confirmed.
	**Hopkin's rose nudibranch, *Hopkinsia rosacea.*** This nudibranch feeds primarily on a pink-red bryozoan (*Eurystomella*) from which it probably extracts and stores defensive toxins.
	**Tidepool sculpin, *Oligocottus.*** The animal had just moved from among green algae where it was perfectly camouflaged.
	**Bryozoan, *Membranipora membranacea* on brown algae.** Note cryptic nudibranch, *Doridella steinbergae,* a predator on the zooids (tiny worms) of the bryozoan colony.
	**Red nudibranch, *Rostanga pulchra*; sponge, *Ophlitaspongia.*** Both the nudibranch and its eggs are cryptic on red sponges which provide most or all of the food for this species.
	**Cryptic broken back shrimp, *Heptacarpus.*** Cryptic coloration produced by hormonally controlled chromatophores. The hormone-secreting organs are in the eye-stalks.

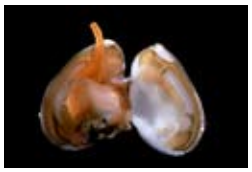
	**Intertidal sculpin.** The banded pattern acts to break up the visual field of a potential predator, while the pink coloration (produced by chromophores under hormonal control) matches the pink encrusting coralline algae characteristic of this habitat.
	**Sand bottom shrimp, *Crangon.*** Chromophores in the skin of the shrimp can be adjusted to create patterns cryptic against the background. This process is under hormonal control.
	**Chick of the oyster catcher, *Haemotopus bachmani.*** Oystercatcher nests are small depressions near the high tide line. When the chicks hatch they are cryptic against lichen-covered rocks of the splash zone.
	**Red sea urchin, *Strongylocentrotus franciscanus.*** The spines of tropical urchins may reach two or more times as long as the diameter of the test. Each spine is a single crystal of calcium carbonate and is actually covered by a thin layer of epidermis.
	**Sharp nose crab, *Scyra acutifrons.*** This species has long claws and a defensive posture that threatens predators. It also develops camouflage by promoting colonizing animals such as hydrozoans on its carapace.
	**Helmet crab, *Cryptolithodes sitchensis* bottom view.** This crab is a relative of the hermit crabs. The umbrella-like carapace protects the animal.

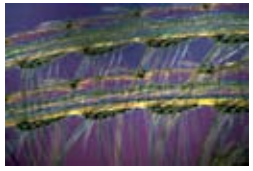
	**Helmet crab, *Cryptolithoides sitchensis* side view.** Swimming predators cannot see or easily reach the crab.
	**Hermit crab withdrawn into shell, *Pagurus* .** The body of the hermit crab is adapted to the coiled shells of snails. The larger claw can either cap the opening or act as a pinching extension.
	**Hermit crab, *Pagurus,* body extended out of shell.** Appendages at the posterior end can hold the animal in the shell by exerting pressure on the walls of the snail shell.
	**Masking crab, *Oregonia gracilis.*** This crab has collected pieces of sponge and bryozoans and attached them to its legs and carapace with hooks present on the exoskeleton.
	**Purple sea urchin, *Strongylocentrotus purpuratus* .** Sea urchins hold rocks and pieces of shell, as well as algae with their tube feet. This material may act as camouflage or as physical protection. The algae can be moved to the mouth for consumption.
	**Keyhole limpet, *Diadora aspera.*** Mantle in normal position, hidden beneath the shell

	**Keyhole limpet, *Diadora aspera.*** Mantle in extended position in response to being touched by a predatory sea star. The extended mantle acts to prevent the predator from getting a grip on the shell.
	**Sunflower or 21-rayed sea star, *Pycnopodia helianthoides.*** Insets show views of pedicellaria and the skin gills, papulae. Two types of pedicellaria are present, the smaller variety in clumps of 20-60 surrounding the spines.
	**Sea star, *Evasterias troschelii.*** Inset shows how pedicellaria can grab object such as an arm hair.
	**Pedicellaria of the fish eating sea star , *Stylasterias forreri.*** Detail of large pedicellaria that cluster around spines. Inset shows a fish grabbed by pedicellaria on an arm of this species.
	**Green sea urchin, *Strongylocentrotus droebachiensis.*** The spines of this species are smaller in relation to the body, than for the purple or red sea urchins of the west coast. This species is found on quiet rocky shores.
	**Green sea urchin, *Strongylocentrotus droebachiensis.*** Closeup of pedicellaria, tube feet and spines. Two sizes of pedicellaria are present. The larger, purple type are closed, while the transparent type are open.

Feeding

	**Volcano sponge, *Haliclona permollis.*** Sponges feed mainly on bacteria and other extremely small plankton and detritus.
	**Red sponge, unidentified.** Sponges live in the lowest intertidal areas and below, with some species (detritus/ suspension feeders) living in deep ocean basins.
	**Light bulb tunicate, *Clavelina huntsmani.*** The feeding basket of these sea squirts can be clearly seen through the transparent body wall. The curved pink structure marks the location of the endostyle, the organ that secrets mucus to entrap the food.
	**Solitary tunicate, *Cnemidocarpa finmarkiensis.*** Two other suspension feeders are also present in the photograph, a small scallop sits at the base of the tunicate, and the crevice is occupied by a clam with siphons extended.
	**Bed of the California mussel, *Mytilus californianus*. Ochre star, *Pisaster ochraceus* seen feeding on a mussel in the bed.** This mussel species is a dominant feature of most Pacific coast exposed rocky shores. The mussels range in size from microscopic, recently-settled juveniles to adults that may reach up to 40 centimeters.
	**Dissected California mussel, *Mytilus californianus*.** The two sets of paired gills secret mucus that will travel along the gill edge, carrying food particles. The particles are sorted by the labial palps at the bottom of the picture.

	**Mussel quarantine warning sign.** Mussels, like most other suspension-feeding shellfish may concentrate pathogenic bacteria or water-borne toxins in their tissues. One group of toxins that includes paralytic shellfish poisoning (PSP) is derived from consuming quantities of certain dinoflagellate species.
	**A type of soft shell clam, *Macoma inquinata.*** In this species the incurrent and excurrent siphons are separate for most of their lengths. This species may be largely a detritivore, its incurrent siphon extends out and sweeps across the sand like the hose of a vacuum cleaner.
	**Dissection of clam, *Macoma secta.*** The longer, incurrent siphon is seen at the left. Only the mantle and portions of the adductor muscles remain in the shell on the right.
	**Siphons of the horse clam , *Tresus capax.*** The incurrent opening of this large clam (shell length to 25 cm) is equipped with tentacle-like protrusions that serve to block large or unwanted items from being sucked into the animal's body cavity.
	**Japanese oyster, *Crassostrea gigas.*** This species was introduced onto the west coast of North America from Japan. It is now common in many bays and quiet waters. It feeds mainly on smaller suspended material such as bacteria.
	**Swimming scallop, *Chlamys hastate.*** The scallop has no siphons but it creates incurrent and excurrent openings by pursing the margins of its mantle. Numerous eyes and tentacles also adorn the mantle margins.

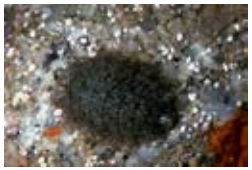
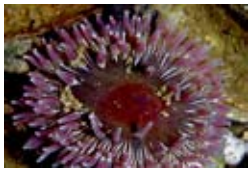
	**Brachiopod or lamp shell, *Terebratalia.*** Another ciliary suspension feeder, these clam-like animals once dominated the suspension feeding niches of most of the world's oceans.
	**Bryozoan, *Eurystomella bilabiata.*** Bryozoan zooids (the tiny worms in a colony) feed by generating currents that bring food inside the tentacles and then into the mouth.
	**Pelagic gooseneck barnacle, *Lepas anatifera.*** This barnacle is generally a pelagic species found attached to floating logs and other objects. The legs are extended as the animal sweeps through the water in an attempt to grab passing food.
	**Giant acorn barnacle, *Balanus nubilus.*** The legs are extended in feeding position. Careful analysis reveals that the entire 'basket' formed by the legs is an extremely fine-mesh net formed by setae extending laterally.
	**Microscope view of setae on barnacle legs, *Lepas anatifera.*** The fine setae extending laterally from the legs serve to strain the water as the legs are moved.
	**Feeding basket of blue mud shrimp, *Upogebia pugetensis.*** Fine, hair-like setae on the first and second legs of this species make a basket as water is pumped through its tubular burrows.

	**Mole crab or sand crab, *Emerita analoga.*** Front view. Feeding antennae retracted.
	**Mole crab or sand crab, *Emerita analoga.*** Side view. Feeding antennae extended.
	**Detail of feeding antennae, mole crab or sand crab, *Emerita analoga.*** The feather-like structure of the antennae enable the mole crab to sift organic material from the receding wave.
	**The orange sea cucumber, *Cucumaria miniata.*** This species is one of the most common sea cucumber species of Pacific coast quiet waters. The tube feet are clearly seen. Feeding tentacles are modified tube feet.
	**Orange sea cucumber, *Cucumaria miniata*, view of oral tentacles underwater in quiet bay.** The oral tentacles of this species often look like bright orange flowers. The animal hides under rocks and in crevices, extending only the tentacles.
	**Bottom detritus feeding cucumber, *Stichopus californicus.*** This cucumber has oral tentacles tipped with relatively small sticky pads. The pads are placed on the bottom, twisted as they are picked up, and then shoved into the mouth with any detritus food that has become attached.

	**The white cucumber, *Eupentacta quinquesemita*, and red-tentacled *Psolus chitinoides.*** Suspension detritus feeders. The tentacle from the lower left of the red cucumber has been inserted into the mouth for removal of attached detritus.
	**Hairy gilled worm, *Thelepus crispus.*** This species is a bottom-feeding ciliary-mucus detritivore. Small particles of organic material settle on the tentacles which extend out over the substrate. Ciliated grooves on the tentacles deliver the food to the mouth.
	**A type of hairy-gilled worm, *Cirratulus spectabilis.*** This species is another detritivore using tentacles to bring small particles of food to the mouth.
	**Calcareous tube worm, or serpulid, *Serpula vermicularis.*** This species is a relatively passive suspension feeder, collecting mainly bacteria and small detritus.
	**Calcareous tube worm, or serpulid, *Serpula vermicularis*, detail of tentacles.** Cilia on the tentacles create localized currents. Food is trapped by mucus on the tentacles and transported to the mouth by conveyor-belt action. The trumpet-shaped portion is a modified tentacle that caps the tube when the animal draws in.
	**The 'feather-duster' worm, *Eudistylia vancouveri.*** The tentacles act to strain food particles from water passing through. These tube worms can often be found in large masses attached to floating docks.

	**Purple sea urchin, *Strongylocentrotus purpuratus*** . The tube feet and spines of urchins function to hold drifting algae. The tube feet can coordinate to move pieces of algae around to the undersurface.
	**Purple sea urchin, *Strongylocentrotus purpuratus*, undersurface showing mouth.** The mouth on the undersurface is used to consume algae. Urchins eat attached, growing algae but probably most of their nutrition is from drift algae.
	**Top shell, *Calliostoma ligatum*, feeding on algae.** This species feeds largely on kelp, but it will also eat detritus and some encrusting animals.
	**Undersurface of black turban, *Tegula funebralis.*** This species uses its rasping radula to scrape diatoms and other algae from the rocks. It also eats drift algae that settles in tide pools.
	**Higher magnification, black turban, *Tegula funebralis.*** Over 12 rows of tooth like files adorn the flexible radular tongue.
	**Ringed top shell, *Calliostoma annulatum.*** In addition to eating kelp, this colorful species feeds on encrusting animals such as bryozoans and hydrozoans.

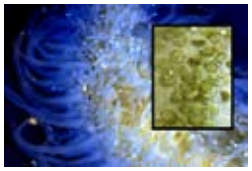
	**Northern abalone, *Haliotis kamtschatkana.*** Abalone are efficient consumers of algae.
	**Periwinkle, *Littorina.*** These small upper zone snails feed mainly on the surface coating of diatoms and fine strands of green algae covering rocks.
	**Limpets, *Tectura.*** These limpets have cleaned off the area adjacent to the depressions where they spend time during low tide. Note the algae growing on the shell top.
	**Giant gumboot chiton *Cryptochiton stelleri*, in its habitat.** This species is the largest chiton species in the world, up to 34 cm or more. It feeds on red algae and may live up to 20 years or more.
	**Giant gumboot chiton, *Cryptochiton stelleri.*** A gumboot chiton adjacent to a size 12 rubber boot. The foot of the chiton is revealed. Gills are in the space between foot and mantle.
	**Radula of giant gumboot chiton, *Cryptochiton stelleri.*** The radular teeth of this chiton are hardened with iron salts - up to 65 percent magnetite (Fe_3O_4).

	**Hairy chiton, *Mopalia lignose.*** The radula of species of *Mopalia* have a hardness of 6 on the Mohs scale.
	**Chiton, *Lepidozona.*** A chiton that feeds on a variety of encrusting animals as well as algae.
	**Black or leather chiton, *Katharina tunicata.*** A common chiton of the mid and low intertidal zone, this species feeds on brown algae, with *Hedophyllum* as the preferred species.
	**Lined chiton, *Tonicella lineata.*** This species feeds primarily on encrusting coralline red algae. Its radular teeth must be harder than the calcified tissues of the algae.
	**Anemone, *Urticina coriacea.*** Anemones are passive predators, waiting for animals to swim or be washed onto their stinging cell-laden tentacles.
	**Nudibranch, *Hermissenda crassicornis* .** The nudibranch is feeding on a hydrozoan, *Tubularia*. This species is a predator on a variety of hydrozoans and small anemones.

	**Nudibranch, *Tritonia festiva,* feeding on sea pen, *Ptilosarcus gurneyi.*** The nudibranch will likely only crop some of the feeding polyps from the colony before moving on to another sea pen.
	**Nudibranch, *Archidoris montereyensis*, feeding on sponge, *Halichondria panicea.*** Most of the dome-shaped dorid nudibranchs are sponge predators. Individuals of this nudibranch species may live their entire lives on one sponge colony.
	**Nudibranch, *Rostanga pulchra*, near its food the red sponge, *Ophlitaspongia pennata*.** This cryptic dorid nudibranch seems to feed primarily on red sponges. Eggs are laid directly on the sponge surface where they are cryptic.
	**The unusual predatory chiton, *Placiphorella velata*, dorsal view.** The only North American predatory chiton, this species captures amphipods and other crawling animals by trapping them under a flap.
	**The unusual predatory chiton, *Placiphorella*, ventral view.** Showing coloration on the veil extension of the mantle which is raised when in the feeding position. The coloration serves as camouflage.
	**The red rock crab, *Cancer productus*, feeding on a clam.** Crabs use their great claw strength to chip away the shell edges. Eventually they sever the adductor muscles to get at the clam's body.

	**The two-spot ribbon worm, *Amphiporus bimaculatus.*** This predatory worm feeds on small animals by extending a long eversible proboscis that entangles the prey.
	**A nereid worm, probably *Nereis.*** Members of this family (Nereidae) are opportunistic carnivores, occasionally taking a prey animal with an everting proboscis equipped with sharp jaws.
	**Common ochre sea star, *Pisaster ochraceus*, feeding on California mussel, *Mytilus californianus.*** Most sea stars are predators. Prey for this species includes barnacles, snails, and mussels.
	**Common ochre sea star, *Pisaster ochraceus*, feeding on California mussel, *Mytilus californianus*, detail of oral surface.** The sea star pulls with its tube feet until a small gap is created between the mussel valves. The stomach is inserted through this gap into the mussel shell. Digestive enzymes digest the mussel in its own shell, and the products of digestion are absorbed into the sea star.
	**Dawson's sun star, *Solaster dawsoni*, feeding on an ochre star.** This sea star is a predator on other sea stars and sea cucumbers.
	**Dawson's sun star, *Solaster dawsoni*, feeding on an ochre star.** While feeding on an ochre star, *Solaster* seems to dissolve away the endoskeleton as well as the tissue.

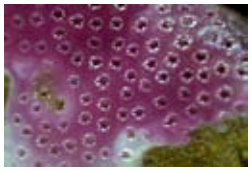
	**The giant sunflower or 21-rayed sea star, *Pycnopodia helianthoides.*** A predator with a diverse range of tastes, this sea star is one of the largest (up to 1 meter across) and fastest-moving (several meters per minute) sea stars in the world. It feeds on molluscs, other echinoderms, and a variety of other sea life.
	**Octopus, *Octopus rubescens.*** Octopus may move into the intertidal zone at high tide, and they are sometimes trapped in tidepools by the receding tide.
	**Black bear , Ursus americanus.** In many coastal regions, black bears feed heavily on crabs found by turning rocks in the intertidal zone.
	**Oyster catcher, *Haemotopus bachmani.*** An important predator on chitons and other molluscs, this bird uses its strong bill to quickly open or pry off the prey shell.
Symbiosis	
	**Giant green anemone, *Anthopleura xanthogrammica.*** This large species (up to 30 cm diameter) harbors mutualistic symbionts (zooxanthellae)
	**Aggregating anemone, *Anthopleura elegantissima*, and one giant green anemone.** In contrast with the giant green anemone, aggregating anemones harbor either zoochlorellae or zooxanthellae symbionts or a mixture of the two.

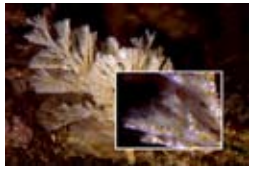
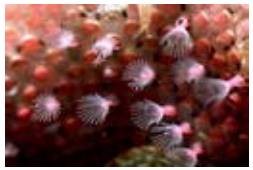
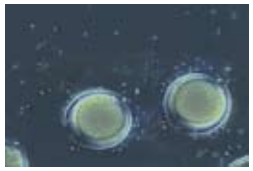
	***Velella vellata*, a hydromedusa jellyfish.** Inset shows a photomicrograph of the dinoflagellate endosymbionts.
	**Rainbow star, *Orthasterias koehleri* and its commensal scaleworm, *Arctonoe.*** Details of the relationship are not completely known, but the worm appears to feed extensively on other polychaetes it encounters as the host moves along.
	**Rainbow star, *Orthasterias koehleri*, ventral view, with commensal scaleworm, *Arctonoe.*** Only one scale worm is likely to be found on a host.
	**Cryptic scaleworm on the surface of the sea cucumber, *Stichopus californicus.*** Another example of the diversity of forms taken by the scale worm, *Arctonoe* .
	**The fat innkeeper, *Urechis caupo*, and two of the symbionts that share its burrow.** The scaleworm (*Hesperonoe*) and the pea crab (*Pinnixa*) probably eat detritus and small invertebrates that get into the innkeeper's burrow, and they may take food from the host's mucus net.
	**A horse clam, *Tresus capax*. Shell cut away to reveal gills and the commensal pea crab, *Pinnixa faba.*** There will usually be one female and one male in a clam. Females are known to feed on strings of mucus as well as some of the food brought in by feeding currents

	**Keyhole limpet, *Diadora aspera* and its commensal scaleworm, *Arctonoe vittata.*** The scaleworm will return to its host if removed, and it shows a preference for its original host when presented with alternative hosts.
	**Keyhole limpet, *Diadora aspera* and its commensal scaleworm, *Arctonoe vittata.*** It is likely that the worm stays with its host for its entire life. The scaleworm will attack and bite the tube feet of a predator sunflower star, thus helping to defend the host limpet.
	**A commensal clam that lives attached to the pleopods of the blue mud shrimp, *Upogebia pugettensis.*** The clam anchors itself to the host with byssal threads. It benefits by obtaining food from the water passing through the burrow and by gaining protection from predators.
	**Parasitic isopods, *Phyllodurus abdominalis*, on the blue mud shrimp, *Upogebia pugettensis*.** A male and female pair of isopods live attached to the abdomen, feeding on body fluids. Inset shows the adult shrimp.
	**Parasitic isopod, (Suborder Epicaridea) living under the carapace of a broken back shrimp, *Heptacarpus.*** Parasitic isopods of this type are found living under the carapace of many different shrimp species. The cavity beneath the bulge is occupied by a large female and diminutive male attached to her.
	**Parasitic barnacle, *Sylon sp.*, living under the abdomen of the pandalid shrimp.** The 'root-headed' parasitic barnacles (Order Rhizocephala) are among the more bizarre animals of the shore. The parasite is largely internal. The white bulb is the gonad and cavity where fertilized eggs are brooded to the nauplius stage.

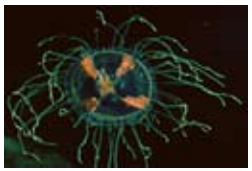
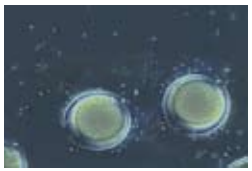
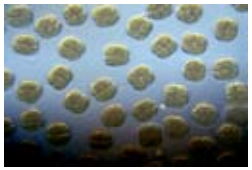
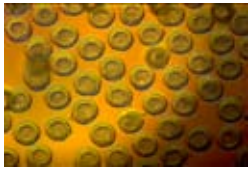
	**Parasitic barnacles on the body of a tube-dwelling hermit crab, *Orthopagurus smittii.*** Many barnacles have parasitized this small (2cm long) hermit crab.

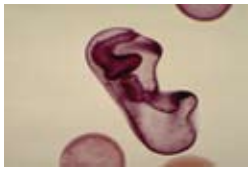
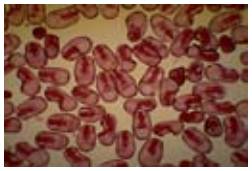
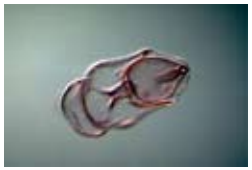
Reproduction

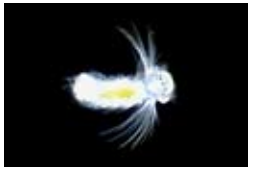
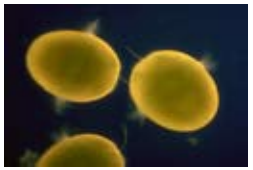
	**Red sponge (unidentified).** Sponge colonies grow by asexual reproduction of cells. Some sponges have been dated at over 2000 years old. New colonies of some sponge species are propagated by release of small clumps of cells which settle and begin a new colony.
	**Colony of aggregating anemones, *Anthopleura elegantissima.*** Large clones of aggregating anemones form on rocks as individuals divide asexually over the years. When one clone encounters another, individuals on the contact margin will battle for space.
	**An aggregating anemone, *Anthopleura elegantissima.*** The process of splitting asexually may take several days.
	**A colony of the strawberry anemone, *Corynactis californica.*** Many species of cnidarians divide asexually to form colonies. The colony members are not directly attached in this anemone.
	**The hydrocoral, *Stylantheca porphyra.*** Hydrozoan colonies grow by the budding of individuals.

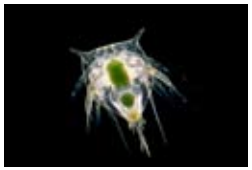
	**Light bulb tunicate, *Clavelina huntsmani.*** Stolons form at the base of the individual and grow outward along the substrate. New individuals form from budding along these stolons.
	**Bryozoan, *Tricellaria occidentalis.*** Inset shows details of colony branch and arrangement of individual zooid worms and their calcified houses (zooecia).
	**Bryozoan, *Eurystomella bilabiata.*** New feeding zooids are formed by budding at the growing margins of the colony.
	**A six-rayed star, *Leptasterias hexactis*, has lost three rays and is regenerating them.** Most temperate sea stars can only regenerate arms from a nearly intact central disc. Several tropical species can regenerate entire new individuals from broken off pieces of an arm.
	**Spawning in *Pisaster ochraceus*. Oregon coast, March.** Most sea stars have separate sexes. Spawning occurs in the spring with eggs and sperm released directly into the ocean. Females are often triggered to spawn by sperm in the water.
	**Eggs and sperm of the purple sea urchin, *Strongylocentrotus purpuratus.*** Fertilization of broadcast spawners takes place in the open sea. This strategy usually involves producing as many gametes as possible within the constraints of parent survival and survival of the fertilized zygote.

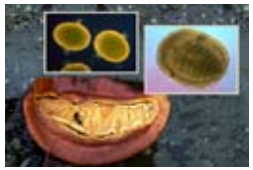
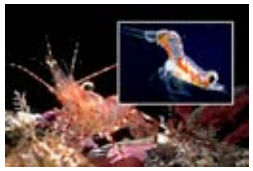
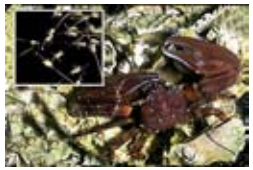
	**Hermaphroditic mating in the sea mouse nudibranch, *Aeolidia papillosa*.** During mating, packets of white sperm can be seed moving through the transparent penis of each individual in opposite directions.
	**The sea mouse nudibranch, *Aeolidia papillosa*, with recently-laid eggs.** The eggs develop through embryonic stages for 20 or more days before they escape as veliger larvae.
	**Egg-laying in the nudibranch, *Antiopella (Janolus) fuscus*.** Larger nudibranchs may produce up to a million larvae from one mating.
	**Hermaphroditic mating in the nudibranch, *Triopha catalinae*.** Both animals are fertilized during mating.
	**Egg cases of two dorid nudibranchs.** Egg cases of many dorid nudibranchs are laid as spiraling curtains.
	**Clasping in red rock crabs, *Cancer productus* prior to female molt and mating.** When the female's shell begins to soften for molting, her position changes so that fertilization of the eggs takes place as they are deposited on the swimmerets.

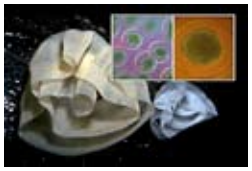
	**Cancer crab, *Cancer oregonensis* with 'berry' (eggs held by abdominal flap).** The eggs are fertilized as they are deposited on swimmerets under the abdomen of the female. The zygotes develop here to the zoea stage.
	**Hydrozoan medusa, *Gonionemis* showing gonads.** Sexes are separate. Gametes are released simultaneously from both sexes in the early summer, normally at dusk. A planula larva develops and swims for several days before settling.
	**Spawning in *Pisaster ochraceus*. Oregon coast, March.** Many seashore organisms are broadcast spawners. Eggs and sperm are released directly into the sea. Fertilization and development in these species takes place entirely in the sea. In species that brood their young, development time within the parent varies.
	**Eggs and sperm of the ochre star, *Pisaster ochraceus*.** Fertilization takes place in the open sea.
	**Developing sea star embryos, 8 and 16 celled stages.** In a matter of hours, the zygote divides into 2 cells which divide synchronously into 4, 8, 16 cells and so on. The cells divide in such a way that rows of cells are stacked one upon another, a pattern called radial cleavage.
	**Developing sea star blastulae.** At about the 64-cell stage the larva is a hollow sphere with a prominent central cavity.

	**Early gastrula larva, stained slide.** The primitive gut (embryonic gut or archenteron) forms from an invagination in the sphere. The opening to the outside is the blastopore.
	**Early gastrula larva (several hours later), stained slide.** The primitive gut is about to pinch off two pocketings which will form the coelomic cavity.
	**Late dipleurula larva or early auricularia larva, side view.** The stage on the following slide, the early dipleurula, will lead to this stage. The ciliary bands elongate and function to propel the larva and bring food to the mouth.
	**Mass of early dipleurulae larvae, stained slide.** This stage develops from the gastrula larva. It is typical of all echinoderms.
	**Auricularia larva, stained slide.** Lobes of the larva will extend and it will become a bipinnaria, the final swimming stage of the sea star larva.
	**Brachiolaria larva, stained slide.** As the lobes extend into finger-like structures, the larva settles to the bottom and rapidly metamorphoses into the adult form in a matter of hours.

	**Juvenile 6-rayed sea star, recently settled, stained slide.** The larval tissue has been resorbed entirely into the body of the juvenile. The water vascular system is being formed (shown in red).
	**Juvenile 5-rayed sea star, recently settled, stained slide.** This view emphasizes the formation of the skeletal system and ambulacral groove.
	**Adult ochre stars, *Pisaster ochraceus.*** Little is known about the biology of juvenile and young sea stars. The life span of the common ochre star is at least 8 years, and may be as much as 20 years.
	**Planktonic larva of spionid polychaetes.** The variety and numbers of polychaete worm larvae in the plankton are, at times, astounding.
	**Early trochophore of gum boot chiton, *Cryptochiton stelleri.*** Like other trochophore larvae, the gumboot trochophore swims with cilia. Development is fueled by yolk from the original egg
	**Late trochophore of gum boot chiton, *Cryptochiton stelleri.*** The 8 segments leading to the 8 plates have become visible. The larva will elongate further and then settle.

	**Nauplius larva of barnacle.** All crustacean classes exhibit a nauplius larva. Barnacle nauplii have characteristic 'horns' at the corners of the carapace. Nauplii swim, feed and grow in the plankton, molting several times.
	**Cyprus larva of barnacle, *Balanus glandula.*** After several naupliar molts, the barnacle larva molts and changes to a cyprid. The cyprid does not feed. The antennae have an adhesive gland used to cement the animal to the substrate.
	**Crab zoea larvae.** Crab larvae exhibit from 1 to 8 zoea stages, depending on the species.
	**Crab megalops larva.** Almost all crab species have one megalops stage. The abdomen can be turned beneath the larva or held out during swimming.
	**Shrimp larva.** Shrimp larvae undergo a number of molts, looking more and more like the adult shrimp.
	**Sea star brachiolaria larva.** As the lobes extend into finger-like structures, the larva settles to the bottom and rapidly metamorphoses into the adult form in a matter of hours.

	**Gumboot chiton, *Cryptochiton stelleri.*** Insets show early and late trochophore larval stages.
	**Acorn barnacle, *Balanus glandula.*** Inset shows cyprid and nauplius larvae. Fertilized eggs develop for several weeks in the barnacle before their release as nauplius larvae.
	***Cancer antennarius* with typical crab larvae: zoea and megalops.** The stages shown were collected from plankton and may be from different crabs.
	**The shrimp, *Pandalus danae.*** Inset shows a planktonic larval shrimp, not necessarily from the same species.
	**Porcelain crab, *Petrolisthes.*** Inset shows typical porcelanid zoea, showing long spines.
	**Rainbow sea star, *Orthasterias kohleri.*** Inset shows typical sea star larval stages (dipleurula, brachiolaria) from plankton.

	**Tunicate, *Styela montereyensis.*** Inset shows larva that is about to settle and metamorphose into the adult form.
	**Brittle star, *Ophiopholis.*** Inset shows ophiopluteus larva from plankton.
	**Hydrozoan colony, *Obelia.*** Inset shows feeding polyps and medusa.
	**Hydrozoan, *Tubularia marina.*** Detail shows feeding polyp with reproductive gonophores. The eggs are fertilized and develop to an advanced larval stage inside the gonophores.
	**Barnacle-eating whelk, *Nucella lamellosa*, with egg capsules.** Group of snails laying yolky eggs in cluster of egg cases. Both nurse eggs and fertilized eggs are present in the capsule. As the larvae develop inside the capsule they eventually grow mouths and feed on the nurse eggs. Growing rapidly, they emerge from the egg case as tiny crawling snails.
	**Dorid nudibranch egg cases.** Four cell stages and trochophores that develop within egg case.

	**The red nudibranch, *Rostanga pulchra*, with its egg case laid on the sponge, *Ophlitaspongia.*** Several hundred eggs are laid in the spiraling egg case. The parent does not 'guard' the eggs but it does deposit the egg case on a red sponge, providing camouflage. The developing offspring may benefit from the chemical environment created by the sponge, which discourages predators. Larvae develop to the late trochophore stage, at which time the egg case breaks down and the larvae swim off.
	**Cancer crab, *Cancer oregenensis* with 'berry' (eggs held by abdominal flap).** Eggs are held by the abdomen flap of the female for periods up to a few weeks. The brooding larvae develop through several stages until they are released as swimming zoea. (Inset: detail of developing zoea within eggs).
	**Skeleton shrimp, *Caprella.*** Female showing abdominal egg flaps (brood pouch or marsupium) with developing young . Young develop through all larval stages until they are released as juveniles.
	**Skeleton shrimp, *Caprella.*** Close up of brood pouch with developing larvae. Caprellids avoid the necessity for a planktonic larva by developing to juveniles in the brood pouch.
	**The brooding anemone, *Epiactis prolifera.*** Fertilized eggs develop inside the gut of the female until they are swimming planula larvae. Larvae exit from the mouth and glide to the base of the disk, where they attach and develop to about 5mm. They then move off to a new location.
	**Octopus, *Octopus rubescens.*** Octopus females lay their eggs in a mass, often attached to the ceiling of a small cave. She guards the eggs while they brood to small juveniles that will swim in the plankton for a short while before settling.

Oyster catcher with eggs. Oystercatchers nest in depressions on rocky shores, just above the highest tide line. The spotted eggs are cryptic on shell-strewn pebbled beaches.

Rocky Shores/Intertidal Zonation

Rocky shore as viewed from water, medium wave impact site, even slope of shore about 40°. Zonation patterns clearly visible. This unusually clear banding is a result of the relatively constant gradation of conditions on this section of shore.

Closer view of previous location. The five distinct bands on this shore from the water up are: 1) a reddish zone with coralline red algae, ochre sea stars, and brown algae (including the feather boa kelp); 2) A mix of whitish barnacles (goose barnacles and thatched barnacles) along with small tufts of red, brown and green algae; 3) a blue band of mussels in dense beds; 4) a brown band of mixed rockweed *Fucus* and barnacles; and 5) a white band of barnacles and limpets.

More gently sloping rocky shore showing zonation patterns. The bands of organisms starting from the water's edge and moving up the shore are: 1) dark green - surf grass (*Phyllospadix*); 2) light green - green algae including *Ulva*; 3) dark blue-black - California mussels; 4) brown - the rockweed, *Fucus*; and 5) dark green - *Porphyra*.

Rocky shore at Pacific Grove, California. The tide level in this photograph has exposed the high tide zone along with a small portion of the mid tide zone.

Rocky shore on beach with granite boulders. Water level is near the lower area of the high tide zone. The boulders show barnacles, limpets and tufts of algae.

Rock with encrusting algae, limpets and barnacles. A 'typical' rocky area in the high intertidal zone shows a species of red algae encrusting on rock, another red alga that forms tufts (*Endocladia*), along with limpets and barnacles.

High tide zone tide pool. Large upper zone tidepools can harbor species from lower down the shore. Smaller tidepools tend to be influenced more by temperature and salinity fluctuations.

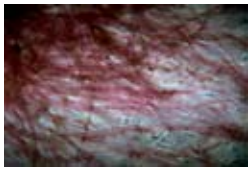
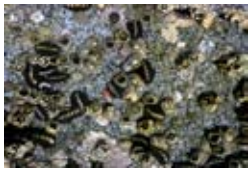
The rock louse isopod, *Ligia pallasii* - underside showing legs. The sea slater, or rock louse is a scavenger, feeding mainly on decaying algae.

Acorn barnacles, *Balanus glandula.* Densities of over 100,000 barnacles per square meter have been recorded on some coasts.

The purple dog whelk, *Nucella canaliculata* feeding on barnacles. *Nucella* drills a small hole at the edge of the opening plates of a barnacle, injecting a muscle relaxant which allows the snail to pry its large feeding proboscis into the barnacle.

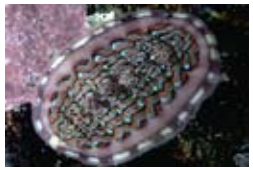
	**Checkered periwinkle, *Littorina scutulata.*** The scraping of littorine snails is thought to wear down the surface of sandstone as much as 5cm in a century.
	**Limpet, *Lottia digitalis.*** A limpet often found among the highest rocks that will support a growth of diatoms or surface algae.
	**Limpet, *Lottia paradigitalis.*** Common from Alaska to Baja California, this species lacks the conspicuous brown spot found inside the *C. digitalis* shell.
	**Limpet, *Lottia pelta.*** These limpets cluster as the tide goes out, and when the tide returns they disperse outward to forage by rasping algae.
	**Rockweed, *Fucus.*** Rockweed grows in luxurious abundance on most coastal rocky shores. Swollen bladders on the tips of some blades are reproductive regions of the alga.
	**Isopod, *Idotea wosnesenskii* on rock weed.** A large isopod (up to 40mm) this species is common at the lower edge of the high tide zone and lower. It is often found on *Fucus*.

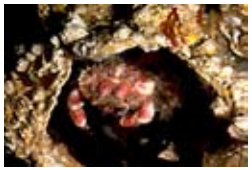
	**Purple shore crab, *Hemigrapsus nudus,* with the characteristic purple dots on its claws.** This species is more likely to be found on exposed rocky shores and it is largely replaced on quiet rocky shores by *Hemigrapsus oregonensis*.
	**Mid-tide region with mussel beds and goose barnacle clumps.** Mussels and gooseneck barnacles compete for space on open coast rocky shores. Mussels feed mainly when submerged, while the barnacles are also active as waves break over them.
	**Bed of mussels, *Mytilus californianus.*** The California mussel ranges from Alaska to Southern Baja California.
	**Close view of tightly packed *Mytilus californianus.*** Small mussels are susceptible to a number of predators, but only the ochre sea star is a significant predator on large mussels. Clumps of very large mussels (>15cm) will sometimes be found in the zone of ochre star survival, having avoided contact until they have outgrown even the sea star's predation abilities.
	**Gooseneck barnacle, *Pollicipes polymerus.*** Unlike the acorn barnacles which feed by repeatedly grabbing at the water with their feeding legs, gooseneck barnacles capture food by holding their appendages out in a basket while the receding wave rushes through.
	**Black turban, *Tegula funebralis.*** The black turban snail is found only on wave-swept coasts.

	**A thin branching red alga –photomicrograph.** Several red algal species form mats on the surfaces of rocks, varying in form from thin red coatings to thick black blobs that may resemble oil pollution.
	**Black leather chiton, *Katharina tunicata* and thatched barnacle *Semibalanus cariosus.*** The black, or 'Katy' chiton, may be very common in some areas. The eight bony plates that constitute its shell, are largely hidden under the overgrown black mantle.
	**Hairy chiton, *Mopalia ciliata.*** The mantle of this chiton is covered with thick hairs, in this case holding attached algae that give it a green appearance.
	**Thatched barnacle, *Semibalanus cariosus.*** This large barnacle, up to 6cm across, is found lower down the rocky shore than other acorn barnacles. Larger and heavier, it is less susceptible to predation by barnacle-eating whelks.
	**Aggregating anemone, *Anthopleura elegantissima.*** This anemone lives in the mid intertidal zone on down to shallow subtidal areas. It has two feeding methods - a passive collection of nutrients donated by endosymbiotic algae, and it captures drifting/crawling prey with its tentacles.
	**Lined shore crab, *Pachygrapsus crassipes.*** This species ranges from Southern Oregon south to Baja California. It feeds on algae, particularly *Ulva*.

	**Group of tide pool sculpins, *Oligocottus.*** Efficient scavenger/predators, these fish occupy most tidepools in the mid tide zone. They are territorial, returning to their home pool if experimentally displaced (up to 1 km or more).
	**Hermit crab, *Pagurus samuelis.*** Hermit crabs are efficient scavengers of under-rock areas and especially tidepools.
	**Porcelain crab, *Petrolisthes cinctipes.*** Extremely common under rocks, this flattened crab species with large claws is a actually a filter feeder - straining diatoms and detritus with its mouth parts.
	**Sculpin, *Oligocottus.*** As the wave shock on a shore increases, tidepool sculpins tend to be restricted more toward tidepools higher in the shore.
	**West Coast of Vancouver Island, British Columbia.** Rock shelf exposure at exceptionally low tide.
	**Encrusting hydrocorals, *Stylantheca,* found at the lowest tide levels.** Also note hanging growth of feathery hydrozoans.

	**Encrusting organisms with chiton.** Red sponge, *Ophlitaspongia*, white encrusting tunicate, red bryozoan colonies, and coralline red algae in upper left.
	**Sponge (unidentified).** Requiring virtually constant immersion, sponges are only rarely found above the lowest low-tide line. Under-rocks, in crevices, and under overhangs are the best places to find them.
	**Competition for space in low zone tide pool.** Giant green anemones, *Anthopleura xanthogrammica,* and purple sea urchin, *Strongylocentrotus purpuratus*
	**Bat ray star *Asterina miniata* (formerly *Pateria miniata*).** A sea star with a high degree of genetic diversity expressed in color forms.
	**Giant sunflower star or 21-rayed star, *Pycnopodia helianthoides.*** A common predatory sea star from the lowest intertidal down to more than 400 meters deep. It is also found in bays and protected waters.
	**Brittle star, *Ophiopholis aculeate.*** Many brittle stars occupy crevices and under-rock spaces.

	**Blood star, *Henricia leviuscula.*** Common in the lowest intertidal areas of rocky shores, this species feeds on bryozoans and sponges.
	**Tide pool invertebrate diversity.** Brittle star, bat ray star, keyhole limpet, chiton
	**Lined chiton, *Tonicella lineata.*** The lined chiton has an extremely hard radula capable of scraping the calcified tissues of encrusting red algae.
	**Dunce-cap limpet, *Acmaea mitra.*** Characteristic of low open-coast rocky shores with encrusting coralline red algae, its main source of food.
	**Opalescent nudibranch, *Hermissenda crassicornis.*** A common nudibranch on rocky shores and on docks and pilings.
	**Spanish shawl nudibranch, *Flabellinopsis iodinea.*** One of the most striking of all the nudibranchs, this species' flamboyant colors probably serve to warn potential predators of its distasteful and stinging-cell equipped condition.

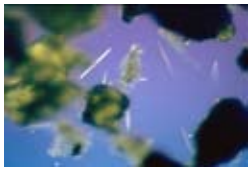
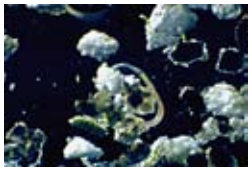
	**Ribbon worm, *Amphiporus bimaculatus.*** This ribbon worm may range upward into the mid intertidal. It feeds on segmented worms, capturing them with an eversible proboscis armed with a poisonous stylet.
	**Crab (A young *Cancer oregonensis*).** This crab likes to live in small holes or pockets not much larger than its own carapace.
	**Crab, *Cancer antennarius*.** This rock crab species has tremendous claw strength, utilized to break open prey animals and defend itself against most predators.
	**Harbor seal, *Phoca vitulina.*** Found in all temperate northern hemisphere oceans, this seal hauls out on rocky islands and exposed shores, resting at low tide and taking to the water to feed as the tide comes in.

Sandy Beaches

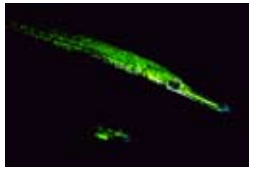
	**Sandy beach near Florence, Oregon.** Long stretches of sandy beach dominate the wave-exposed shores of many North American coast areas.
	**Sandy beach from above showing dunes held in place by vegetation.** Vegetation stabilizes the back-beach areas of sandy beach shores.
	**Beach near San Francisco with by-the-wind-sailor jellyfish, *Velella vellata* washed ashore.** Beach strandings of this species are common during periods of prolonged strong onshore winds.
	**By-the-wind-sailor jellyfish, *Velella vellata* on beach.** This animal is a large polyp hanging mouth-side down from the surface. The sail is a chitinous triangle arranged diagonally across the base of the polyp, enabling the animal to 'tack' against the wind.
	**Beach hopper in hand, *Traskorchestia.*** Lifting up a pile of drift algae on the beach will often reveal a mob of beach hoppers feeding on algae or animals washed up on the beach.
	**Beach hopper, *Megalorchestia californiana.*** Largest of the west coast beach amphipods, this species hides in the sand during the day, coming out at night to scavenge.
	**Mass of beach hoppers, *Traskorchestia traskiana*.** This species is more characteristic of beaches with some protection from waves.
	**Shovel that has removed several mole crabs from sand.** Effectively hidden from most beach walkers by its habitat and habits, the mole crab may live in densities of hundreds per m^2.

	**Mole crab (sand crab) *Emerita analoga,* ventral view.** The egg-shaped body aids in burrowing and resisting movements of sand and water in its tumultuous environment.
	**Mole crab (sand crab) *Emerita analoga,* dorsal view.** *Emerita* moves up and down the beach with the tide so that it can get more time feeding in receding waves.
	**Razor clam, *Siliqua patula.*** If washed out of the sand by a wave, the razor clam burrows so rapidly it can dig itself completely under before a second wave hits.
	**Razor clam foot, *Siliqua patula.*** The razor clam ranges from central California to the Queen Charlotte Islands.
	**Olive snail, *Olivella biplicata.*** The smooth dynamic shape and elongated opening are characteristic of this predatory snail.
	**Olive snail foot extended.** Using the muscular foot as a plow this smooth snail travels just below the sand surface in search of food.

	**Channeled basket snail, *Nassarius fossatus.*** Found subtidally on sandy beach coasts and intertidally in sandy/muddy bays, this species is an efficient scavenger. It has a dramatic escape response from a predator such as the short-spined sea star.
	**Test of the sand dollar, *Dendraster excentricus.*** Relatives of the sea urchin, sand dollars are flattened and have small tube feet and spines. The floral like pattern on the sand dollar 'test' or skeleton is an arrangement of holes where the tube feet stick out.
	**Sand dollar, *Dendraster excentricu.*** Sand dollars feed on detritus trapped against the body as it lies angled out of the sand. These animals concentrate particles of heavy iron oxide from the sand, which are stored inside to act as a weight belt.
	**Netting surf smelt.** Several species of fish lay their eggs at the highest tide lines of the beach where they are incubated in the moist warm sand.
	**Fisherman with catch of surf smelt.** Unlike grunion, which spawn at night on the beaches of Southern California and below, surf smelt spawn during the day on spring high tides.
	**Surf smelt, *Hypomesus pretiosus.*** A small (about 12 cm) slender fish the surf smelt burrows into the wet sand too quickly during spawning to be caught by hand.

	**Pennate diatoms among sand grains.** Pennate diatoms can move among the sand grains and they are not as easily crushed as centric diatoms.
	**Harpacticoid copepod among sand grains.** These small copepods (<0.2mm) crawl across the surface of sand grains removing bacteria and detritus.
	**Nematode worm among sand grains.** As a group, the nematodes are probably the most common meiofauna animals.
	**Gnathostomulid from one meter deep sand sample.** Discovered only in the 20th century, this phylum of animals is somewhat like flatworms, but has several distinguishing characteristics. They feed on bacteria, fungi, diatoms and organic material by scraping the surfaces of sand grains.
	**Cumaceans, sand dwelling crustaceans.** These crustaceans (about 6mm) have a distinctive hood-like carapace and a long abdomen. They are common in many sandy substrates where they clean the microorganisms off sand grains.

Muddy Bays and Estuaries

	**Muddy bay at low tide, Bodega Bay California.** Large bays are usually influenced by freshwater streams or rivers bringing silt. The salinity of the water may fluctuate widely as the tide comes in and out.
	**Muddy bay at low tide.** The intense productivity of eelgrass beds in muddy bays is critical to the rearing of many important commercial fish stocks.
	**Eel grass, *Zostera marina.*** This flowering plant thrives in many quiet bays and estuaries. Eelgrass beds support and harbor a rich community of organisms.
	**Hydrozoan jellyfish, *Polyorchis penicillatus* in an eel grass bed.** This hydrozoan jellyfish generally rests on the bottom with outstretched tentacles during the day.
	**The bay pipe fish, *Sygnathus griseolineatus.*** The pipe fish is often green and is well-disguised among leaves of eel grass.
	**The sea slug, *Phyllaplysia taylori,* on a blade of eel grass.** This shell-less opistobranch mollusc is cryptic on eel grass leaves, the habitat where it lives exclusively. It feeds on diatoms at the surface of the blade.
	**The "lion" nudibranch, *Melibe leonine.*** The flattened cerata of this large (to 10 cm) nudibranch are used as paddles in a curious swimming behavior. The animal attaches with its foot to eel grass blades and uses its large bulbous hood ringed with tentacles to capture swimming crustaceans.

	**Shrimp (unidentified).** Shrimp are abundant scavengers in eelgrass beds.
	**Red rock crab, *Cancer productus.*** Although it is called the 'rock' crab, this species is common in muddy bays where there is plenty of algae or eelgrass.
	**Amphipod (unidentified).** In the same group as the beach hoppers, muddy bay amphipods are an extremely important group of grazer/scavengers that serves to feed many fish species.
	**Isopod (unidentified).** Small isopods abound in eelgrass beds and in surface sediments of muddy and sandy bays. They generally act as scavengers.
	**Moon snail, *Polinices lewisii*, with egg case.** Moon snails feed on clams by boring a hole in a selected site on the shell with their rasping organ, the radula. The proboscis is inserted through the hole to collect the food.
	**Moon snail, *Polinices lewisii.*** When expanded, the body of the moon snail is much larger than its shell. It can, however, retract entirely into the shell by excluding water from the tissues. The shell opening is then capped by a horny operculum.

	**Moon snail, *Polinices lewisii* - egg case.** The collar-shaped egg case holds thousands of eggs imbedded in a matrix of sand. The larvae develop for a time until they are released to swim in the plankton as the case breaks up.
	**Clam diggers in a sand/mud bay.** Clam digging is a popular activity in many coastal areas. Studies show that holes should be refilled and discarded clams buried just below the mud surface to ensure best survival.
	**Digging in a mud bay reveals worms and worm tubes.** In most low tide areas of muddy bays, a shovel full of mud yields a variety of polychaete worms (or worms from other phyla), along with clams. These are the two main groups of macro-invertebrates in the mud.
	**Worm, *Notomastus tenuis.*** This worm may be common in muddy bays. It feeds by ingesting sediment and extracting the organic material.
	**Phoronid worms in mud, *Phoronis viridis*.** This worm is abundant in Bodega Bay and other bays with sandy mud substrates.
	**Glycerid worm, *Hemipodus sp.*** A carnivorous worm, this species everts its proboscis tipped with four black jaws to grab its prey - other annelids.

Large nereid worm, *Nereis (Neanthes) brandti.* This very large nereid worm (up to 90cm long) lives in sandy quiet water sediments where it probably feeds on detritus algae and live algae. Occasionally, during the summer, these worms swarm in the water in a mating orgy where eggs and sperm are spewed out into the water.

Tentacle whorls of the green phoronid worm, *Phoronis viridis* extended into water from sand/mud environment. Phoronids are members of the phylum Phoronida and are not closely related to the segmented polychaete worms that also tend to be abundant in mud. Phoronids filter feed with their lophophore tentacles which stick up out of the substrate.

Green phoronid worm, *Phoronis viridis.* The hemoglobin pigments found in red blood cells can be seen through the body wall. Hemoglobin is an efficient chemical bonding agent that functions well in low oxygen conditions.

Fat innkeeper, *Urechus caupo.* This echiuran worm lives in U-shaped burrows through which it pumps food-containing water.

Fecal casting of the lugworm, *Abarenicola pacifica.* Materials deposited on the mud may indicate the identity of a nearby burrower. This fecal casting is a characteristic deposit of the lugworm.

Lugworm, *Abarenicola pacifica.* The lugworm ingests mud from one end of its J-shaped burrow, gaining nutrients from the organic material as it passes through the gut.

Blue mud shrimp, *Upogebia pugettensis.* Mud shrimp live in multi-channel burrows where they feed on detritus, nutrients extracted from ingested mud, and plankton brought in by currents created by movement of the pleopods.

Ghost shrimp, *Callianassa californiensis.* This burrowing crustacean is found in more sandy substrates than the blue mud shrimp, although they may occur together. It builds an elaborate set of tunnels and is thought to be a significant 'bioturbator' of the sediment, possibly turning over sediment in local areas to a depth of 50 cm in 6 months.

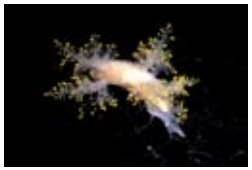
Clams on shovel, probably *Saxidomus nuttalli.* This species is common in muddy bays of California and to the south.

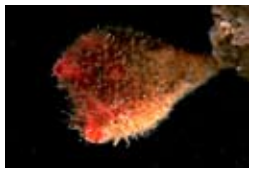
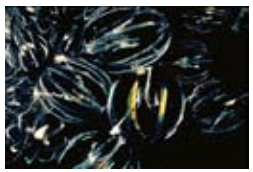
Butter clam, *Saxidomus giganteus.* Up to 10 cm across or larger, this common clam of the Pacific northwest shores lives up to 30 cm deep on muddy shores and mixed shores with mud, rocks and shells.

Horse clam or gaper clam, *Tresus capax.* A deep-burrowing clam with long siphons, this clam has the largest shell of Pacific coastal clams. The anterior end of the shell has a wide gap where the siphons stick out.

Docks and Pilings

Plumose anemones, *Metridium senile.* The fine tentacles of this anemone indicate a plankton-feeding species.

	**Branching hydroid colonies, *Obelia.*** These thin, wire-like branching hydrozoan colonies support communities of small organisms less than 1cm long.
	**Skeleton shrimp, *Caprella* sp. on *Obelia.*** One of the animals commonly found among *Obelia* colonies, this scavenger/suspension feeder grabs food crawling on the *Obelia* or swimming nearby.
	**Skeleton shrimp, *Caprella.*** These amphipods are extremely abundant in a variety of settings, especially on the living organisms attached to docks.
	**Nudibranch, *Dendronotus.*** This small (1.5 cm) nudibranch may be camouflaged from predators by its color and branching form.
	**Nudibranch, *Polycera atra.*** A variety of small nudibranchs are common on docks and pilings, supported by hydrozoan and bryozoan food.
	**Sponge, *Leucilla nuttingi.*** Suspension-feeders dominate the fauna of floating docks, with sponges as a key component of the community.
	**Tube worms, *Eudistylia polymorphis.*** Feather-duster worms are common attached to docks. Large masses weighing hundreds of kilograms will occasionally sink a dock or portion of one.

	**Flat-top tunicate, *Chelyosoma productum* with white sea cucumber *Eupentacta quinquesemita.*** This common tunicate of docks has a flattened front surface covered with easily-visible plates. While the body is translucent white in color, the surface is usually covered with diatoms, giving the animal a brownish appearance.
	**Colonial tunicate *Botryllus.*** This species is a compound tunicate. All members of the colony live under one common tunic. They are arranged in oval clusters of about 8-15 individuals each with its own incurrent opening and sharing a common excurrent opening at the center.
	**Hairy tunicate, *Boltenia villosa.*** The outside covering, or tunic, of the hairy tunicate is covered with stiff, hairlike outgrowths. Their function is not known.
	**Sea spider, *Achelia.*** Not a true spider but rather a relative belonging to the Class Pycnogonida, sea spiders are generally small (<1cm) inhabitants of *Obelia* colonies and similar environments.
	**Moon jelly, *Aequorea Victoria.*** A hydromedusa up to about 8cm across the bell. This is a bioluminescent species, emitting a beautiful blue glow visible if the viewer is adapted to a very dark night or room.
	**Sea gooseberry or comb jelly, *Pleurobrachia.*** Commonly seen drifting by docks, this small species (the spherical body is 2cm diameter or smaller) feeds by dangling long sticky tentacles that trap plankton.