

Kelp Forests

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KELP FORESTS

WHAT IS A KELP FOREST?

Along the west coast of North America, groves of giant kelp shelter and conceal a variety of marine life. Giant kelp is a *foundation species* or a species vital to the survival of the *flora* (plants) and *fauna* (animals) sharing its ecosystem. In other temperate and subtemperate coastal regions, aquatic forests composed of giant kelp or other large kelp species perform a similar role.

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WHAT IS KELP?

A. *Kelp* are large species of marine *algae* (seaweeds).

- Unlike land plants, marine algae lack true roots, stems, leaves, and flowers.
- Most possess a *holdfast* (a rootlike structure), *blades* (leaflike structures), and many have a *stipe* or stemlike structure that connects the holdfast to the blade.
- The weight of algae is supported by water.
- Some marine algae also have gas-filled bladders, called *pneumatocysts* that float the blades close to the water's surface to maximize access to sunlight for photosynthesis.
- Marine algae can range in size from microscopic to more than 30 m (98 ft.) tall for giant kelp (*Macrocystis pyrifera*).
- The three phyla of marine algae are primarily characterized by the dominant pigment coloring the plants.
- Kelp are large brown algae species (Phylum Phaeophyta) in the Order Laminariales.

1. Brown algae (Phylum Phaeophyta)

The color of brown algae results from the dominance of the yellowish xanthophyll pigment, fucoxanthin, over the Chlorophyll *a* and *c* and other pigments. Many large, upright kinds of brown algae are called kelp and are vital kelp forest inhabitants.

- a. giant kelp (*Macrocystis pyrifera*) – Giant kelp is golden brown with rootlike

holdfasts, long, branched stipes and hundreds of wrinkled blades supported by bulb-shaped pneumatocysts. Special reproductive blades, called *sporophylls*, near the holdfast produce and release spores to form new microscopic plants.

Giant kelp forms dense, underwater forests just offshore in water temperatures ranging from about 50° to 60° F (10°-15.5°C) and thrives at up to 30.5 m (100 ft.) depths. It grows in the cold, coastal waters of western North America, South America, South Africa, Southern Australia, and New Zealand. As the largest kelp species, giant kelp attains heights up to 45.7 m (150 ft.) In ideal conditions, giant kelp fronds can grow as much as 0.6 m (2 ft.) per day. Giant kelp frequently washes up on the beach—often still harboring many kinds of invertebrates.

In Southern California, giant kelp is harvested for the *algin* (a gelatinous substance) in its tissues and is also used as food for livestock and farmed abalone. The California Department of Fish and Game manages the commercial harvest of giant kelp.



- b. bull kelp (*Nereocystis luetkeana*)—North of Santa Cruz, California bull kelp replaces giant kelp as the dominant forest-forming species along the eastern Pacific coast. It ranges from Unimak Island in the eastern Aleutian Islands to Point Conception, California. In areas where the bull kelp's range overlaps with giant kelp, the bull kelp composes part of the understory of the kelp bed. Bull kelp has tiny holdfasts anchoring a long stipe. The stipe ends in a huge float

that resembles the heads of sea otters or seals when spotted from a distance.

- c. feather boa kelp (*Egregia menziesii*) – The dark to golden brown fronds of feather boa kelp can grow up to 10 m (33 ft.) long. The stipe branches and bears numerous small blades and floats along the edges. In the upper portion of the plant, the stipes are flattened and edged with small blades and no floats. Feather boa kelp often forms part of the kelp forest understory and thrives along the shallow-water edges of kelp forests.



- d. oar weed (*Laminaria* spp.) – Oarweed is characterized by a single, large, unribbed blade that is sometimes split into longitudinal strips. This kelp may reach 5 m (16.4 ft.) in height and often forms part of the kelp forest understory. In the past, humans burned down oar weed for soda ash used in making soap and glass. Oar weed is currently harvested, and even cultivated, in some regions for algin, fertilizer, and food.
- e. stalked kelp (*Pterygophora californica*) – This dark brown alga bears long, unbranched, woodlike stalks with straplike blades and reaches 2 m (79 in.) in length. It commonly forms dense groves in the subsurface canopy of kelp forests from British Columbia to Mexico.
- f. southern sea palm (*Eisenia arborea*) – This kelp forms part of the kelp forest understory on coastlines from Vancouver Island, British Columbia to Isla Magdalena, Baja California, Mexico. The mature plant has a substantial holdfast anchoring the single, long stipe (1–2 m or 3.3–6.6 ft.), which branches into two clumps of lengthy blades.

2. Phylum Chlorophyta (green algae)

This phylum contains more than 7,000 green algae species. The color of green algae stems from the photosynthetic pigments Chlorophyll *a* and *b*. Green algae possess these pigments in the same proportions as green land plants. Several green algae species help form turf algae or the lowest layer in the kelp forest.

3. Red algae (Phylum Rhodophyta)

The dominant pigments phycoerythrin and phycocyanin produce the red color of the more than 5,200 algae species in this group. Because red algae can photosynthesize in the dim light at the base of kelp forests, many kinds of red algae, including coralline algae, compose the turf algae at the bottom of the kelp forest.

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KELP FOREST CHARACTERISTICS

A. The physical environment

Kelp require a variety of environmental conditions to flourish into a forest.

1. Cold water.

- a. Giant kelp thrives in clear, cold coastal waters with temperatures ranging from about 50° to 60° F (10°-15.5°C).
- b. Bull kelp is the dominant canopy-forming kelp species in colder, coastal water regions. It grows best in the 39°F to 59°F (3.9-15°C) water temperature range.
- c. Both giant kelp and bull kelp beds decline when water warms due to El Niño Southern Oscillation (ENSO) events. This is probably due to the decrease in upwelling that occurs with warmer waters, which decreases nutrient availability.

2. Hard substrate.

- a. Most kelp forests grow on rocky-bottom regions of coastlines.
- b. Exceptions include kelp forests off Santa Barbara and San Clemente coasts, which anchor on old holdfasts, hardened clay, or other hard substrates within the sandy bottom.

- c. The relatively small, bull kelp holdfasts often attach to cobblestones on the seafloor.
3. Giant kelp grows best in calm waters while bull kelp thrives in more turbulent waters.
4. Kelp require access to sunlight for photosynthesis.
 - a. *Photosynthesis* is a biochemical process in living plants, algae, phytoplankton, and some bacteria, which capture sunlight as an energy source to convert carbon dioxide and water into high-energy carbohydrates (usually glucose) and oxygen.
 - b. Photosynthesis occurs in a cell's chloroplasts, which contain chlorophyll – a photosynthetic pigment that absorbs sunlight.
 - c. The floats buoy the kelp blades near the surface, allowing sunlight to reach the blades. The blades absorb water, carbon dioxide, and other chemicals. Kelp uses these chemicals and sunlight to produce food. The food is transported within the stipe from the canopy to the holdfast and to fronds growing near the bottom.
 - d. Dependence on light for photosynthesis restricts kelp to depths less than 40 m (131 ft.). Kelp forests thrive best in relatively clear waters at 6 to 37 m (20–120 ft.) depths.
5. Kelp also requires dissolved nutrients from upwelling: it needs both water (which supplies hydrogen) and carbon dioxide for photosynthesis, as well as nitrogen and phosphorus. In addition, trace elements such as zinc, copper, manganese, and iron are also essential.

B. Reproduction

- a. A *sporophyte* is the large, kelp plant. It produces sporophylls (special, reproductive blades) just above the holdfast. The sporophylls release billions of microscopic spores.
- b. Spores that settle on the seafloor develop into female or male, microscopic kelp plants called *gametophytes*. The gametophytes produce either eggs or sperm, which combine to produce new sporophytes.
- c. If a gametophyte survives, it matures into an adult plant within 7 to 14 months.

C. Layers of the kelp forest

1. canopy

- a. The intertwining kelp fronds at the surface tangle into a dense canopy.
- b. Giant kelp and bull kelp are the two main kelp types that form the canopy.
- c. In the canopy, barnacles, bryzoans, hydroids, and tubeworms encrust kelp blades while snails, sea stars, and sea slugs roam throughout the canopy's fronds.
- d. Small fishes, especially larval fish, seek shelter in the canopy. Kelp clingfish adhere tightly to kelp blades.
- e. Hungry seabirds perch on the canopy, keeping a close watch for prey among the fronds and below the surface.
- f. Other ocean animals, such as opaleye fish, graze on the kelp blades.



2. mid-kelp forest

- a. The mid-kelp habitat extends from 3.05 m (10 ft.) below the canopy to 3.05 (10 ft.) above the ocean bottom.
- b. A variety of fishes and invertebrates swim or crawl between the canopy and the mid-kelp region.

3. understory

- a. The kelp forest understory lies 1 to 2 m (3.3–6.6 ft.) above the bottom.
- b. Certain brown algae species, such as oarweed (*Laminaria* spp.) and stalked kelp (*Pterygophora californica*), fill in the understory.

4. kelp holdfasts and forest floor
 - a. Numerous tiny, ocean animals inhabit kelp holdfasts.
 - b. One holdfast can shelter more than a hundred species of marine invertebrates and fishes.
 - c. Turf algae – composed of certain low-growing, red algae species – carpets the rocks and kelp forest floor.
- C. Seasons in the kelp forest.
 1. spring
 - a. In the spring, upwelling brings cold, nutrient rich water to the coast.
 - b. Sunlight reaches the young kelp through the thin canopy layer.
 - c. Supplied with plenty of light, cool water, and nutrients, new kelp fronds rapidly grow to the surface.
 - d. Larval invertebrates drift in and settle on the fresh, new fronds.
 - e. Juvenile fishes shelter among the canopy's fronds.
 - f. Cormorants dive down to gather seaweed from the kelp bed floor to use in constructing their nests.
 2. summer
 - a. Kelp growth peaks and the kelp canopy reaches its greatest thickness in late summer.
 - b. Growth slows as the waters warm up and upwelling ends.
 3. fall
 - a. With the continuing warm waters and lack of upwelling, nutrients are used up by the kelp.
 - b. The canopy begins to thin as the blades, heavily encrusted with attached invertebrates, begin to break apart.
 4. winter
 - a. During the short, winter days, the kelp plants continue to deteriorate and weaken.
 - b. Fierce winter storms cause swells that break off kelp fronds and tear holdfasts from their anchors, setting the kelp adrift.
 - c. Once torn loose, a kelp plant can uproot other kelp plants in its path.

- d. Large quantities of kelp wash up on the beach, providing abundant food for beachhoppers, kelp flies, mites, and isopods.
- e. The kelp forest is at its thinnest until spring brings calmer waters and the ideal conditions to renovate the forest.

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KELP FOREST INVERTEBRATES

Invertebrates are animals without backbones. They are a diverse group of animals, and include many animal phyla and classes.

A. Phylum Cnidaria

The cnidarians include sea anemones, corals, jellyfishes, and their relatives. About 9,000 species are known worldwide and found throughout the oceans from the intertidal zone to the greatest depths.

Many cnidarians are large and brightly colored. Common cnidarian characteristics include:

- *Radial symmetry*: The body is symmetrical around a central axis. These animals lack a head and usually bear a crown of tentacles around the mouth.
- *Diploblastic*: Cnidarians have two main cell layers – the *ectoderm* (outer layer) and the *endoderm* (inner layer). The layers are separated and supported by the *mesoglea* (a middle layer composed of a jellylike material.)
- *Nematocysts*: These tiny stinging capsules are present in all cnidarians, and are especially abundant in the tentacles. A nematocyst consists of a bulbous double-walled structure containing a coiled-up, hollow thread with a minute barb at its tip. Projecting from the outside of the nematocyst is a tiny sensor. The entire structure is microscopic. When the sensor is stimulated physically or chemically, the cell explodes. The thread is ejected with considerable speed and force. The barb penetrates the victim's skin and injects a potent venom.
- Gas exchange takes place through the body surfaces. Cnidarians do not have gills or gill-like structures.
- Many cnidarians spend their lives in a *polyp* (a stalked and sedentary state with a ring of tentacles around the mouth) or *medusa* (jellyfish-shaped) form.

- After a cnidarian paralyzes its prey with the nematocysts, it grasps the prey with its tentacles and carries the prey to its mouth. Undigested food particles are expelled through the mouth and washed away with the tide.
1. Class Hydrozoa (hydroids)
 - a. This cnidarian class contains about 3,200 species.
 - b. The life cycle of most hydroids includes alternating polyp and medusa stages. A fertilized egg grows into a sedentary polyp. The polyp asexually buds off into one or more medusae. The medusae reproduce sexually and form polyps – continuing the cycle.
 - c. Most hydroids are colonial; many produce calcareous or chitinous exoskeletons.
 - d. Some hydroids form branched, sedentary colonies that resemble feathers or seaweeds.
 - e. Other hydroids, like the Portuguese man-o-war (*Physalia physalis*) and the by-the-wind-sailor (*Velella velella*), form *pelagic* (open ocean), floating colonies.
 - f. Some hydroids form encrusting colonies. Many hydroid species (branching and encrusting) occupy kelp blades.
 2. Class Anthozoa
 - a. This is the largest class of cnidarians and contains more than 6,000 species, including sea anemones and corals.
 - b. Anthozoans are either solitary or colonial.
 - c. Anthozoans lack a medusa stage and remain in the polyp form throughout their entire life.
 - d. Much of a sea anemone's body is a saclike *column*. At the base of the column lies a flattened *pedal disc* that attaches the anemone to a substrate.
 - e. The top of the anemone's column is flattened into an *oral disc*, ringed by twelve or more tentacles surrounding a slitlike mouth at the center of the disc. Each tentacle contains numerous nematocysts and tentacle size and shape relates to how the anemone feeds.
 - f. Sea anemones feed on various invertebrates. Large species can capture fish.
 - g. Anthozoans are mostly sedentary as adults. Although anemones usually remain attached to a substrate by a pedal disc, they can relocate by releasing the

grasp of their pedal disc and then rolling or drifting with the current to a new location.

- h. Stony corals possess similar body structure to anemones, but produce skeletons made of calcium carbonate. Most stony corals are colonial. In a colony, each polyp lies within a *theca* (skeletal cup), which it can contract into for protection. The polyps are interconnected by an outfolding of the body wall containing an extension of the stomach cavity. This sheet of tissue completely covers the colony's skeleton. Food obtained by one polyp can be passed to other polyps in the colony.
- i. Many kinds of anthozoan cnidarians inhabit the kelp forest floors and occasionally attach to kelp fronds.
 - i. frilled/plumose anemone (*Metridium senile*) – This wide-ranging anemone is found along the Pacific coast from Alaska to southern California and along both coasts of the North Atlantic. Its column and oral disc can be uniform or varied in colors of white, orange, yellow, tan, or brown. The frilled anemone can have a crown diameter of 25 cm (9.8 in.) and reach 50 cm (19.7 in.) in height.

Smaller *Metridium* often produce dense colonies of clones. Individual clones on the borders of the colonies bear long, stretchy fighting tentacles filled with nematocysts that the anemone can use to attack nonclones.
 - ii. strawberry anemone/club-tipped anemone (*Corynactis californica*) – This tiny, rose-colored anemone forms dense colonies on the pinnacles and rocky ledges of kelp forests from coastal Washington to Baja California, Mexico. Individual anemones reach only about 2.54 cm (1 in.) across. Like true anemones, strawberry anemones lack a skeleton. Yet their knobbed tentacles and colonial habits more closely resemble stony corals.
 - iii. orange-cup coral (*Balanophyllia elegans*) – This bright orange, solitary coral is common on rocky kelp forest floors of the Oregon and California coasts. Individual polyps live in a cup-shaped, stony skeleton and grow to diameters of about 1 cm (0.39 in.). Orange cup coral uses its sticky feeding tentacles to capture tiny prey.



B. Phylum Ectoprocta

This phylum is composed of *bryzoans* – tiny, colonial animals that live in rectangular or cylindrical shaped boxes.

- Each *zooid* (individual body) is about 1 mm (0.04 in.) and covered by a calcareous *exoskeleton* (outer covering).
- Zooids often connect to form a colony with a basket-weave pattern.
- Zooids use circular *lophophores* (feeding tentacles) to filter tiny particles from the water.
- Bryzoan colonies grow by asexual budding.
- Several bryzoan species colonize and encrust kelp blades.

C. Phylum Mollusca:

Mollusc is a Latin term meaning "soft-bodied." This group includes at least 50,000 species of familiar animals like clams, oysters, mussels, limpets, snails, and squid. These invertebrates are often protected by a hard shell. Molluscs are an important food source for many marine animals.

Animals in this phylum share many common characteristics including the following:

- *Mantle* – The underlying skin which secretes the shell.
- *Siphon* – A fleshy tube that draws in food and water.
- *Gills* – The organs used to respire (remove oxygen from water).
- *Shell* or a reduced shell – A hard, protective covering.
- Bilateral symmetry

1. Class Polyplacophora

- a. The Class Polyplacophora contains the chitons. There are about 1,000 polyplacophora species worldwide, with about 120 along North America's Pacific coast.
- b. Chitons are oval-shaped with a convex dorsal surface. Their shells consist of eight overlapping, calcareous plates. The plates are anchored in a thick, muscular *girdle*. A chiton's entire flattened, ventral surface is a single, large muscular foot. They are generally found clinging to a rocky substrate. When disturbed or pried loose a chiton curls up into a ball, like a pill bug.
- c. Most chitons use their radulas to scrape algae off rocks. The diets of individuals within a species vary with different habitats. Some chitons' diets consist of animal matter..
- d. The chiton's powerful, muscular foot is used for clinging and creeping.
- e. Chitons typically have external fertilization with gametes released into the water.
 - i. gumboot chiton (*Cryptochiton stelleri*) – This is the world's largest chiton – reaching a length of 33 cm (13 in.). It inhabits intertidal and subtidal zones, including kelp forests, along the coasts of northern Japan to the Aleutian Islands and to the Channel Islands off southern California.
The gumboot chiton's eight plates are completely covered by a thick, leathery, brick-red mantle. The reddish brown color of the gumboot chiton may be enhanced by the many species of red algae that grow on its mantle and by its diet, which consists mainly of red algae.

2. Gastropoda

The gastropods comprise more than 80% of all living molluscs. Many features common in this class are not found in other classes. The following characteristics are widespread among gastropods:

- a. Most species have a mouth and a radula.
- b. Eyes are on tentacles on each side of the head.

- c. The shell opening can be tightly closed with an *operculum*; a "trap-door," that seals the opening of the shell when the animal pulls in its foot.
- d. The radula is most diverse in the gastropods. Members of this class use the radula for scraping the substrate, grasping and biting, tearing flesh, rasping, boring through shells, and even harpooning prey. A gastropod uses its radula similar to the way you use your tongue to lick an ice cream cone. When the gastropod feeds, it places its radula against the substrate. The radula carries the pieces into the mouth.
- e. Gastropod means "stomach-foot" in Latin; this term describes the way a gastropod crawls by gliding along its ventral surface or foot. The foot is a broad, flat muscle. It also adheres to rocks and other surfaces. As a gastropod moves, waves of fine muscular contractions sweep along the foot. The contractions lift the animal's foot, then returns it to the surface a little farther ahead, pulling the animal forward.
- f. Gastropods produce eggs and sperm. The way fertilization takes place and how the larvae develop varies with each group of gastropods.
- g. Some common gastropods seen in kelp forests include:
 - i. giant keyhole limpet (*Megathura crenulata*) – The giant keyhole limpet is the largest of the many keyhole limpet species – each characterized by the hole at the highest point of their cap-shaped shell. The giant keyhole limpet's pink, whitish, or black shell reaches lengths of 13 cm (5 in.), while its yellowish to black body extends beneath the shell to 25 cm (9.8 in.) long. Giant keyhole limpets range in coastal areas from Monterey, California to Baja California, Mexico.
 - ii. abalone (*Haliotis* spp.) – The abalone has a caplike, oval-shaped shell characterized by a row of three to ten holes near the anterior margin that water exits from after passing over the mantle cavity and gills. The outer layer of the shell is often muted in color and often mottled with tiny encrusting marine invertebrates. The shell's nacreous (inner) layer is iridescent in a rainbow of colors. An abalone roams over rocks to graze on marine algae and can cling tightly to rocks with its muscular foot if exposed

to crashing waves or a predator.

Abalones range along all continental coastlines except for the eastern coast of North, Central, and South America. The red, pink, black, and green abalones are species common to the temperate Pacific coast of North America.

Abalone meat is a prized delicacy in many regions and the shell's iridescent inner layer is valued for use in intricate inlay for jewelry, instruments, and a wide variety of other objects.

Due to declines in abundance, several abalone species are protected. The northern or pinto abalone (*H. kamtschatkana*) is listed as "endangered" by the IUCN/World Conservation Union and the white abalone (*H. sorenseni*) is listed as "endangered" under the United States Endangered Species Act. The black abalone (*H. cracherodii*) population has plummeted since the mid 1980s because of a withering syndrome in which the abalone's foot shrinks and can no longer cling to rocks. Because of this decline, the IUCN lists the black abalone as "critically endangered."

To prevent unsustainable declines many countries and states impose regulations on commercial and recreational abalone collection for food. In California, abalone sport fishing is only allowed north of San Francisco and is strongly regulated and enforced by the California Department of Fish and Game. The Australian government regulates the Tasmanian abalone fishery, which makes up about 25% of the world's abalone harvest. In some regions of the United States and other countries, abalone is farmed, which helps meet the commercial demand for marine delicacy.



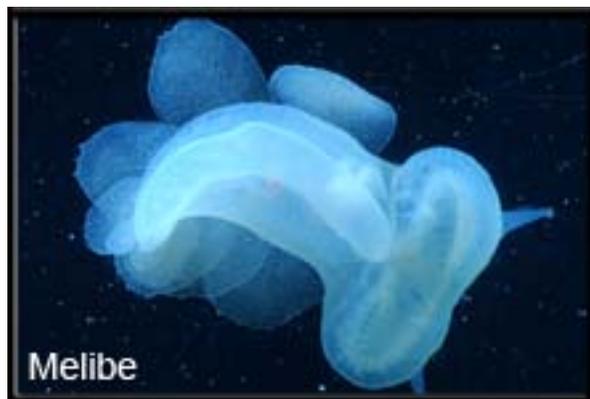
- iii. Norris's top snail (*Norrisia norrisi*) – Subtidal kelp along the Pacific coast from Central California to Baja California, Mexico provides the primary habitat for this brightly colored snail. The Norris's top snail is easily recognized by its vivid orange foot and brownish-orange shell. These snails crawl along the fronds of the kelp, vertically migrating from the kelp forest to the bottom third of the stipes, and then traveling back up at dusk. Norris's top snails eat mostly kelp – especially feather boa kelp, oarweed, and giant kelp.
- iv. brown turban snail (*Tegula* spp.) – The brown turban snail commonly inhabits the low intertidal zone and also dwells in the canopy of subtidal kelp forests. This species ranges along shorelines from Oregon to the Channel Islands off southern California. The snail's brownish to orange shell is often encrusted with coralline algae. It mainly grazes on kelp, also ingesting any encrusting diatoms and bryzoans.
- v. top snails (*Calliostoma* spp.) – Three *Calliostoma* species range in kelp forests from Alaska to Baja California, Mexico. These snails have numerous, thin, spiral ridges on their conical shells. Each species inhabits a different kelp forest level. The channeled top snail (*C. canaliculatum*) lives in the canopy and grazes on kelp and any encrusting material including hydroids, bryzoans, diatoms, and detritus. The purple-ringed top snail (*C. annulatum*) consumes the same items and roams the mid-kelp region. The blue top snail (*C. ligatum*) dwells on both the bottom portion of the stipe and the forest floor. Its diet is similar to the other two species, yet it also consumes strawberry anemones and colonial tunicates.



- vi. wavy turban snail/wavy top snail (*Megastrea undosa*) – The wavy top snail has a large, heavy shell with undulating ridges spiraling along the outside of its reddish shell. The wavy top's shell can grow to 11 cm (4.3 in.) in diameter making this one of the larger snails to inhabit kelp forests. Wavy top snails range from Point Conception, California to Baja California, Mexico.



- vii. Melibe/lion nudibranch (*Melibe leonine*) – This unusual, translucent whitish to yellowish sea slug attaches by its narrow foot to kelp or eelgrass blades. It ranges from Alaska to the Gulf of California. The huge hood on the melibe's head can reach 50 mm (2 in.) – up to half the animal's total body length. To feed, the melibe traps zooplankton (microscopic animal plankton) and other tiny animals by sweeping its caplike hood from side-to-side. If startled, the melibe flips from side-to-side to swim away.



3. Class Bivalvia

A smaller and less diverse group than the gastropods, the class Bivalvia includes animals such as mussels, clams, oysters, and scallops.

- a. In bivalves, the mantle fold encloses the visceral mass, head, and foot.
- b. The shell consists of left and right calcified valves, an uncalcified hinge, and elastic ligaments joining the two valves dorsally.
- c. Bivalves are filter feeders that siphon and filter water. Bivalves feed by passing water through a pair of gills. Gills not only extract oxygen from the water but also filter out tiny food particles. Bivalves lack a radula and most other structures of the molluscan head.
- d. Most bivalves are relatively sedentary and remain attached to wood pilings or rocks. Some bivalves can use their muscular foot to burrow into mud or sand, others can glide along the substrate in much the same manner as snails. Some bivalves, such as scallops, can swim by rapidly clapping their valves (shells).
- e. Most bivalves have separate sexes, but in many oysters and scallops individuals can produce both eggs and sperm. Fertilization is external; eggs and sperm are released into the water.
- f. Bivalves are used as food or bait by commercial and sport fishermen, and millions of pounds are harvested yearly.
 - i. kelp scallop (*Leptopecten latiauratus*)— These orange and white, thin-shelled scallops attach to kelp fronds or hard surfaces such as rocks or pier pilings in coastal waters from Point Reyes, California to the Pacific and Gulf of California coasts of Baja California, Mexico. When large numbers of these scallops attach to kelp, they may cause the stipe to sink away from the light. However, this typically only damages the frond and not the entire kelp plant.

4. Class Cephalopoda

This group of molluscs includes more than 700 species of octopuses, nautilus, cuttlefish, and squids.

- a. In cephalopods, two large eyes and other sense organs are located on the head.

Portions of the foot are modified to form eight or more sucker-bearing tentacles that radiate from the head.

- b. Camouflage is well-developed, and many cephalopods blend in by instantly changing color to the hue, intensity, and even texture of the background. They use color patterns that contrast with the background for social signaling and defense.
- c. When alarmed, an octopus may flatten its body and present an elaborate defensive color display, including color changes sweeping over its body, and large dark spots around its eyes. A large ink sac releases ink to confuse predators.
- d. Most cephalopods are active predators, well equipped for sighting prey, catching it, and grasping it with their tentacles. Glands in their beaklike jaws inject a salivary toxin to subdue prey. They can then use their jaws to tear apart their catch. Cephalopods also have a radula, which they use for delicate cleaning. The radula of the octopus can even drill into mollusc shells.
- e. All cephalopods swim by jet propulsion. They force water from the mantle cavity out through the siphon. The siphon is flexible, and a cephalopod can point it in any direction to propel itself through the water.
- f. Octopuses swim by jet propulsion, but more frequently crawl around the area in which they live.
- g. Octopuses have internal fertilization. Males have a modified arm with a spade-shaped tip. The male transports sperm to the female oviduct with this arm tip. After mating, female octopuses deposit their eggs in clusters that resemble a bunch of grapes. They remain to care for the eggs, continuously removing debris and sediment from the eggs by washing water over them.
- i. octopus (*Octopus* spp.) – Octopuses of many species inhabit kelp beds, rocky crevices, and sandy or mud-bottomed areas. Juvenile octopuses often shelter within kelp holdfasts. Octopuses mainly hunt at night – preying on a variety of fishes, crustaceans, and molluscs.



E. Phylum Echinodermata

Echinoderm is a Greek word meaning "spiny-skinned." This phylum contains many different classes including brittle stars, sea stars, sea urchins, sand dollars, and sea cucumbers. Animals in this phylum share a few characteristics:

- *Endoskeleton* (internal skeleton) – Made up of *ossicles*, a type of calcareous structure.
- *Tube feet* – Used for locomotion and also for respiration. The tube feet operate by using a hydraulic, or water-vascular, system.
- *Radial symmetry* (adults) – The adult body symmetry radiates around a central axis. The pattern of symmetry is *pentamerous* – it occurs in fives or multiples of five. In their larval stages, echinoderms have *bilateral* (two-part, mirror-image) symmetry.

1. Class Ophiuroidea

- a. The more than 1,600 species of brittle stars and basket stars make up this group of echinoderms.
- b. Like asteroid echinoderms, ophiuroids, typically have five arms; although brittle have longer, more flexible arms and move by wiggling their arms.
- c. Brittle stars are named because their arms easily break if tugged on. Fortunately, brittle stars can regrow any snapped off arms.
 - i. spiny brittle star (*Ophiothrix spiculata*) – The spiny brittle star ranges along the Pacific coast from central California to Peru and offshore to the Galápagos Islands. It shelters in under rocks and in kelp holdfasts. The brittle stars can occur in huge numbers – sometimes forming an inch thick

layer on the kelp forest floor or giving kelp holdfasts a fuzzy appearance. The spiny brittle star is named for the distinct, thornlike spines on its disc and arms. To feed, the brittle star uses the spines of at least one arm to anchor into a crevice and then extends its other arms into the water to entrap food particles on a sticky substance emitted by the spines and tube feet. The tube feet along each arm then coordinate to transfer food particles to the brittle star's mouth.



2. Class Asteroidea

- b. Scientists have identified at least 1,500 species of sea stars in the class Asteroidea. Most sea stars have five rays ranging in length from 10 to 25 cm (4–10 in.). Some species may be much larger and have more than five rays.
- c. Sea stars regenerate lost rays. Regeneration is typically slow and may take as long as one year. Some stars may have six or seven rays because two rays regenerate instead of one.
- d. Some sea stars, such as the giant-spined sea star, have *pedicellariae* – tiny pincherlike structures covering their *aboral* (top) surfaces. Pedicellariae help grind algae and other tiny pieces of debris that collect along the skin of the sea star.
- e. There are two different ways sea stars respire. Oxygen exchange takes place at the tube feet and at *papulae*, tiny bumps scattered over the aboral surface. Papulae give the animal a fuzzy appearance. Small hairlike structures create a current of water over the papulae so respiration can occur.
- f. At the tip of each arm is one tube foot that cannot be retracted. This is a tactile

organ. Just above this tactile organ is a small white eyespot that detects changes in light intensity. In searching for food the sea star relies on *chemoreception*, a combined sense of taste and smell, more than on touch or sight. If meat juices are poured into a tank containing sea stars, the sea stars become active and behave as they would in the presence of food.

- g. The mouth is located on the oral surface, or underside. A sea star feeds by a process called *evagination*: it pushes its stomach through its mouth and outside the body wall. Stomach enzymes then digest the food externally. When digestion is complete, the stomach muscles contract, retracting the stomach back into the body cavity.
- h. All sea stars use their tube feet for locomotion. The tube feet are in grooves on the undersides of each arm. The tube feet operate on a water vascular system. The tube foot is a hollow muscular structure with a balloon-like reservoir called an *ampulla* on top of the tube. The ampulla is covered with a meshwork of muscle fibers. When these muscle fibers contract, the ampulla is deflated and fluid is forced into the tube foot. This stretches the tube foot outward beyond the groove. Contraction of other muscles creates suction and forces the fluid back into the ampulla, allowing the tube foot to cling to a solid substrate.
- i. With a few exceptions, most sea stars are either male or female. They release eggs and sperm into the water where fertilization takes place. The presence of eggs or sperm in the water stimulates sea stars of the opposite sex to release their sex cells. Sea stars usually spawn once per year. Sea stars that live in temperate waters spawn in the spring. During spawning a female may release up to 2.5 million eggs.
- i. bat star (*Asterina miniata*) – Bat stars inhabit kelp forests and other coastal habitats along the Pacific coast of North America from Alaska to Baja California, Mexico. The bat star's aboral surface is brightly colored in a single color or mottled in shades of cream, red, orange, brown, or purple. Instead of having long arms like most sea stars, bat stars have webbing between their short, triangular arms. They scavenge on a variety of marine plants and

animals— especially surfgrass, algae, and colonial sea squirts. Occasionally bat stars eat other sea stars.

Individual bat stars often engage in pushing bouts where they push against other bat stars with their arms. The pushing bouts are probably related to distribution and feeding within a bat star population.



- ii. sunflower star (*Pycnopodia helianthoides*) — This unusual sea star, native to the Pacific coast of the United States, has up to 24 rays. Its aboral surface is typically pink, purple, brown, orange, or yellow. The sunflower star is the largest Pacific coast sea star— reaching more than one meter (3.3 ft.) in diameter.

The sunflower star uses its more than 15,000 tube feet to quickly pursue its preferred sea urchin or bivalve prey or to capture other marine invertebrates such as polychaete worms, snails, limpets, crabs, sea cucumbers, dead or dying market squid (*Loligo opalescens*), and even small sea urchins and sea stars.

- iii. giant-spined sea star (*Pisaster giganteus*) — This tan sea star has numerous short, white spines encircled by purplish-blue rings regularly spaced throughout its aboral surface. Each arm can reach more than 30 cm (11.8 in.) in length. It is found clinging to pier pilings, low-intertidal rocks, and off coastlines to depths of 88 m (289 ft.) and often inhabits the kelp forest floor. The giant-spined sea star preys on bivalves (especially mussels), snails, chitons, and barnacles.

- iv. ochre star (*Pisaster ochraceus*) – Found from Alaska to northern Baja California, Mexico, this colorful sea star can be yellow, orange, tan, brown or purple with an aboral surface patterned with numerous small, white spines. Ochre stars commonly hunt for mussels but will eat barnacles and gastropod molluscs if mussels are absent. Occasionally, sea otters or gulls prey on ochre stars.



3. Class Echinoidea

- a. Sea urchins are round animals. Pointed spines cover an urchin's entire body except the oral surface.
- b. The skeleton of the sea urchin is composed of closely joined calcareous plates forming a rigid case around the vital organs. People often refer to this as a "shell," but the structure is more accurately called a *test*. Tube feet emerge from the pores in the test.
- c. Sea urchins use their spines for protection, defense, movement, and burrowing. The spines rest on ball and socket joints along the test. Sea urchins can rotate their spines and burrow into solid rock or other substrate. They wear the surface down with their spines and pull away the bits of rock with their tube feet. Since the spines grow longer with age, an urchin can become imprisoned if it grows too large for the hole it burrows.
- d. There are several highly-developed types of pedicellariae among the spines and around the mouth. The pedicellariae keep algae and debris from collecting on the urchin.

- e. Most sea urchins have external gills on the oral surface. They also respire with their tube feet.
- f. Sea urchins move in much the same way as sea stars, using the same water vascular/tube foot system.
- g. Sea urchins are either male or female. An urchin releases large quantities of eggs or sperm into the water for fertilization. As with sea stars, the release of eggs or sperm stimulates the release of sex cells from the opposite sex.
- j. In many parts of the world, sea urchin gonads are considered a delicacy. Male gonads are whitish and the female gonads are a deep yellow or orange.
- k. Most sea urchins have a remarkable system of hard jaws and teeth for grinding food. The Greek philosopher and naturalist, Aristotle, described the structure now known as *Aristotle's lantern*. Aristotle's lantern is made of five long, chisel-like teeth that meet at the mouth opening. Sea urchins feed mainly on kelp but also eat other types of algae. When eating kelp, the urchin usually eats the stipe (stem). Once the sea urchin has eaten through the stipe, the rest of the plant floats away.
- l. Several kinds of sea urchins live on the kelp forest floor.
 - i. red urchin (*Strongylocentrotus franciscanus*) – The red urchin is found subtidally to 90m (295 ft.) depths on coastlines from northern Japan and Alaska to Isla Cedros, Baja California, Mexico. Adults are typically red to red-brown and can reach diameters of more than 100 mm (4 in.). Red urchins graze on a variety of red and brown algae, but prefer giant kelp. Extremely large red urchin populations can overgraze and decimate kelp beds – leaving behind a region that is known as an *urchin barren*. Sea urchin populations can be kept in check by natural predators, such as sea otters, or from commercial harvest by humans.



- ii. purple sea urchin (*Strongylocentrotus purpuratus*) – These sea urchins inhabit intertidal and subtidal ocean bottom habitats on the eastern Pacific coast from Vancouver, British Columbia to Baja California, Mexico. Adults are vivid purple while juveniles are often light green. Adults are usually 50 mm (2 in.) in diameter, but can reach diameters up to 100 mm (4 in.). Purple urchins graze on marine algae, including kelp, and detritus. Like the red urchins, if excessively abundant, purple urchins can overgraze and affect the growth of giant kelp. Sea otters and other sea urchin predators are vital in keeping these kelp grazers in check. In addition, purple urchins are another commercially important sea urchin species for human consumption.

4. Class Holothuroidea

- a. The approximately 1,150 sea cucumber species don't seem to conform to the generalized concept of echinoderms. They have cylindrical radial symmetry. (Imagine an elongated sea urchin without spines, with a softer body, and turned over on its side.) From their external appearance sea cucumbers seem to have no trace of a skeleton, but they do have tiny, nonarticulated, calcareous ossicles embedded in their skin.
- b. Sea cucumbers have various reactions to predators. Most sea cucumbers contract their body wall, pulling the ossicles closer together. This makes the sea cucumber smaller and more rigid, and perhaps less appetizing or harder for a predator to swallow. Many sea cucumbers secrete toxic substances that can be harmful to animals that ingest it.
- c. Some species defend themselves by *eviscerating* (expelling their entrails), leaving

the entrails to the predator while the sea cucumber slips away. The entrails are regenerated in a few days. Some species expel special *Cuvierian organs* that form masses of sticky tubules, which entangle predators.

- d. Inside the sea cucumber are large *respiratory trees* where oxygen exchange occurs. Water is forced into the respiratory trees through the *cloaca* (a common opening of the digestive, excretory, and reproductive systems). This process may take six to ten minutes. All the water is expelled in one contraction.
- e. The mouth of the sea cucumber is anterior and not directed downward like other echinoderms. A ring of mucus-covered tentacles circles the mouth. Food particles are trapped in the mucus and are then wiped off as the sea cucumber pulls its tentacles out of its mouth.
- f. Sea cucumbers move using tube feet. The tube feet of some sea cucumbers are distributed over the entire body, some are concentrated on a "ventral" surface, and some are restricted to rows along each radius. As in sea stars, the tube feet operate using a water-vascular system. The body cavity is filled with fluid. The sea cucumber uses its tube feet for moving along the rocky substrate and for burrowing into sand and mud.
- g. Sea cucumbers are either male or female, and both eggs and sperm are released into the water.
- h. In some parts of the world, sea cucumbers are harvested by humans for food and traditional Chinese medicine.
- i. Some sea cucumbers inhabit the bottom layer of kelp beds, although many other species inhabit soft-bottomed habitats.
 - i. warty sea cucumber (*Parastichopus parvimensis*) – The warty sea cucumber is found in the intertidal and to depths of 27 m (89 ft.) on the Pacific coast of North America from Monterey, California to Baja California, Mexico. This species is brown or orange with numerous, conical black-tipped projections all over its body. The warty sea cucumber's tube feet lie on its ventral side. Tentacles around the sea cucumber's mouth produce sticky mucus and are used to dab up detritus and other particles from the sea bottom.



F. Phylum Arthropoda

Arthropod is a Greek word meaning "jointed appendage." With more than six to nine million known species, this is the largest and most diverse invertebrate phylum. This large group includes crustaceans, insects, and spiders. Arthropods make up more than 80% of all animal species.

Animals in this phylum share these characteristics:

- Segmented bodies
- Jointed appendages
- An *exoskeleton* made of *chitin* – As it grows, an arthropod must *molt*; shedding its old exoskeleton and producing a larger, new exoskeleton.
- Bilateral symmetry

2. Class Crustacea

- a. Crustaceans are the dominant arthropods in the sea, with more than 38,000 described species.
- b. This arthropod class includes crabs, shrimps, lobsters, barnacles, krill, and amphipods.
- c. The exoskeleton of crustaceans contains calcium carbonate in addition to the chitin, giving these animals their crusty texture. Many different crustaceans creep along the kelp forest floor or cling to kelp blades.
 - i. northern kelp crab/shield crab (*Pugettia producta*) – Kelp crabs tightly grip onto kelp fronds in the canopy or roam among kelp holdfasts. This species ranges along the Pacific coast from Alaska to Baja California, Mexico. Kelp crabs reach 9.3 cm (3.7 in.) carapace lengths and are reddish to golden to

olive brown, which helps camouflage them with the kelp and to hide from predators. These crabs mainly graze on kelp, which gives them their coloration. When kelp is not available the crabs can switch to a more carnivorous diet, preying on barnacles, bryzoans, and hydroids in the low intertidal zone or on pier pilings.

Another kelp crab species, *Taliepus nuttallii*, clings to kelp on shorelines from Santa Barbara to Bahia Magdalena, Baja California, Mexico.

ii. decorator crab (*Loxorhynchus* spp.) – To blend in with their surroundings, crabs in this genus attach algae, hydroids, anemones, barnacles, bryzoans, and sponges to bristlelike hooks on their carapace. The crabs' decorations hide them from predators such as cabezons and croakers. When decorator crabs molt, they recycle their old decorations to attach to their new shells. *L. crispatus* is a common inhabitant of kelp holdfasts, pier pilings, and rocks from northern California to Baja California, Mexico. Decorator crabs eat a variety of algae and small invertebrates.

iii. brown rock crab/Pacific rock crab (*Cancer antennarius*) – This rock crab species is characterized by the red speckling on its white underside. It is commonly found on rocky shorelines or around kelp holdfasts and ranges from Coos Bay, Oregon to northern Baja California, Mexico including Islas de Todos Santos.

C. antennarius scavenges and also dines on a variety of live prey such as marine snails, echinoderms, clams, hermit crabs, and barnacles.

Several species of fishes, including cabezon, rockfishes and benthic-feeding sharks eat rock crabs. Sea otters off the central California coast often dive down to catch and consume rock crabs.

C. antennarius is one of several rock crab species that are fished for and consumed by humans. The State Departments of Fish & Game regulate the size, season, and catch limits for the commercial and sport rock crab fisheries.

iv. red rock shrimp (*Lysmata californica*) – The red rock shrimp is a distinctly patterned shrimp that is red with broken lines of white along its body. It reaches 70 mm (2.8 in.) lengths. Red rock shrimps cluster in groups of

hundreds on rocky-bottomed habitats from the intertidal to more than 60 m (197 ft.) depths. They range along the eastern Pacific coast from Santa Barbara to central Baja California, Mexico. Red rock shrimp are cleaners – plucking parasites and dead tissue off moray eels, garibaldi, spiny lobsters, and other coastal inhabitants. They will even clean beneath the fingernails of scuba divers who extend their hands to groups of these shrimp.

- v. spiny lobster/rock lobster (*Palinurus* spp.) – The California spiny lobster (*P. interruptus*) ranges from central California to Baja California, Mexico and inhabits rocky areas, surfgrass beds, and kelp beds. California spiny lobsters are commercially fished. The California Department of Fish and Game sets the season, minimum size, fishing methods, and daily bag and possession limits for the California spiny lobster recreational fishery.

Unlike true lobsters, spiny lobsters lack enlarged front claws. Instead, spiny lobsters have numerous sharp spines on their tail, carapace, and antennae that can cause painful cuts and scrapes if handled by humans or other potential predators.



- vi. kelp isopod (*Idotea resicata*) – This elongate, flattened crustacean uses its seven pairs of curved in walking legs to cling to kelp stems in the canopy or to eelgrass blades. It inhabits bays and coasts from Alaska to Mazatlán, Mexico. The kelp isopod is brown when on kelp and bright green when on eelgrass. It always orients itself along the long axis of the stem or blade. Kelp isopods primarily consume kelp. When feeding on giant kelp, it often eats the part of the blade near the float, causing the blade to break off and float away. Numerous fishes prey on kelp isopods, especially juvenile kelp

bass.

- vii. mysids/opossum shrimp (Order Mysidacea) – Mysids are tiny, shrimplike crustaceans that usually grow to about 5 mm to 25 mm (0.2-1.0 in.) lengths. They are called opossum shrimp because the females have a brood pouch in which they carry the larvae until they reach the free-swimming stage. Many mysid species, particularly *Holmsimysis sculpta*, swarm just above the kelp forest floor. A variety of fishes, seabirds, and even gray whales eat mysids.

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KELP FOREST VERTEBRATES

Many classes of vertebrates (Phylum Chordata, Subphylum Vertebrata) live in or visit kelp forests. Vertebrates all have a backbone/spinal column.

A. Class Osteichthyes (bony fishes)

Fishes in this Class share the following characteristics:

- scales
- paired fins
- gills with a single pair of gill openings – to extract dissolved oxygen from water.
- jaws
- paired nostrils
- endoskeleton made of bone

You can learn more about fishes in the SeaWorld/Busch Gardens [Bony Fish InfoBook](#) at [SeaWorld.org](#).

Hundreds of fish species visit or even rely on the kelp forest environment.

1. California moray eel (*Gymnothorax mordax*) – Although moray eels look like snakes, they are really a kind of fish. The California moray has a long, mottled greenish to brownish body, a small, round gill opening, and lacks pectoral or pelvic fins. Its tapered body shape allows the moray eel to swim through a forest of kelp stipes and to back in and out of the rocky crevices in which it prefers to shelter. California morays are large fish, reaching 1.5 m (5 ft.) lengths. Although morays look menacing as they open and close their mouths revealing numerous needle-sharp

teeth— this behavior helps the morays respire by washing water over their gills. California morays inhabit rocky areas from Pt. Conception, California to southern Baja California, Mexico. These nocturnal hunters slither through the water in search of octopuses, crustaceans, fishes, and sea urchins. Moray eels have two sets of jaws— both with needlelike teeth. These jaws, located in the mouth and in the back of the throat, help a moray catch its meals. A moray grabs prey with the first set of jaws. Next, the second set swiftly shoots forward, seizes the food, and drags it through the throat to be swallowed.

California morays have a mutually *symbiotic* relationship with the red rock shrimp (*Lysmata californica*). The shrimp cleans parasites and dead skin off the moray, while the moray shares its home with the shrimp and provides protection. While not aggressive, morays occasionally bite unwary divers who plunge their hands into rocky crevices when searching for lobsters.



2. Pacific sardine (*Sardinops sagax*)— The sardine is a cigar-shaped, schooling fish with a metallic blue or green dorsal, a silvery belly, and a line of dark spots extending back from its *operculum* (gill cover). The Pacific sardine reaches 41.3 cm (16.25 in.) lengths. Sardines form an integral part of the ocean food web. Sardines feed low on the food chain, straining plankton through specialized gill rakers, and a multitude of marine animals prey on sardines. Schools of sardines swim in synchrony— presenting predators with a substantial silhouette rather than small individuals that predators can easily pick out.

The Pacific sardine has a widespread distribution and is found off coasts from Kamchatka (U.S.S.R.) to southeast Alaska to Guaymas, Mexico and is possibly the same species found off Peru and Chile.

From the 1920s through the 1940s sardines were the most important commercial fish in California – used for canned fish, fish meal, and oil. However, the fishery soon collapsed due to overfishing and unfavorable conditions for reproduction. In the early 1980s, sardine populations started to increase in southern California waters, supporting a small commercial bait and seafood fishery.

3. topsmelt (*Atherinops* spp.) – Topsmelt are nearshore, schooling fish that grow to 37 cm (14.5 in.) lengths and have greenish backs and a silver stripe on each side. They are named for their behavior of schooling near the surface where they feed on plankton and algae. Topsmelt live in estuaries, along sandy beaches and in kelp beds off the coastlines from Vancouver, British Columbia to the Gulf of California. Topsmelt often school in kelp forests.
4. kelp clingfish (*Rimicola muscarum*) – The kelp clingfish fish have pelvic fins modified into a suction disc that enable it to adhere tightly to eelgrass and kelp – particularly kelp blades high in the canopy. This species is colored greenish to brown to blend in with the kelp. Adults grow to 7 cm (2.75 in.) lengths. Kelp clingfish range from the Queen Charlotte Islands, British Columbia to northern Baja California, Mexico. Kelp, especially bull kelp, also provides a haven for larval northern clingfish (*Gobisox maeandricus*) as they mature into juveniles.
5. blue rockfish (*Sebastes mystinus*) – The blue rockfish is a perch-shaped fish with a mottled gray to bluish-black body, darker fins, and a dorsal fin with 13 spines. They range from Vancouver Island, British Columbia to northern Baja California, Mexico where they swim in mid to surface waters over rocky reefs and near kelp beds. Juveniles often shelter in the kelp canopy. Blue rockfish eat zooplankton, fishes, hydroids, and kelp. Due to its popularity in sport fisheries, the blue rockfish has been overfished in many parts of its range.
6. kelp rockfish (*Sebastes atrovirens*) – These perch-shaped fish are mottled cream to dark brown and have 13-spined dorsal fins. Kelp rockfish preferentially dwell in the mid-water to bottom regions of kelp forests and range from northern California to central Baja California, Mexico. They often hang motionless and up-side-down while among rocks or kelp fronds. These fish mainly consume small crustaceans, but occasionally eat small fishes and squids.
7. treefish (*Sebastes serriceps*) – This distinctly colored rockfish has reddish lips and

dark brown to black vertical bars that alternate with olive or yellow ones. Treefish range from San Francisco to central Baja California, Mexico. Adults inhabit rocky caves or crevices while mats of drift kelp provide a refuge for young treefish. Treefish roam along the seafloor, preying on a variety of small fishes and invertebrates.



8. cabezon (*Scorpaenichthys marmoratus*) – Cabezon are unscaled fish and are mottled brown, red, or green. Individuals have a long, branched protuberance over each eye and a skin flap on their snout. Cabezon are large sculpins – attaining 76 cm (30 in.) lengths. They inhabit tide pools to 110 m (362 ft.) depths and range from Sitka, Alaska to central Baja California, Mexico. Young cabezon are silvery and commonly seek refuge under mats of drift kelp. Adult cabezon dwell on rocky reefs, oil platforms, and wrecks, often sheltering in crevices on the bottom. They occasionally wander up into the kelp canopy. Cabezon eat crabs, fishes, chitons, octopuses, and even abalone – somehow knocking abalone off rocks, eating them whole, and then spitting out the shell. Sea otters, Brant's cormorants, and several other kinds of seabirds prey on cabezon. Cabezon are caught by recreational fishermen. Even though their flesh is blue, cabezon are safe for humans to eat. However, cabezon eggs are highly poisonous.
9. kelp bass/calico bass (*Paralabrax clathratus*) – Kelp bass have brown gray or olive backs and sides with squarish white patches and lines. Younger fish typically display brighter coloration than adults. Larval kelp bass often settle out on kelp blades or in thick patches of algae. Small kelp bass commonly shelter among kelp fronds. Adults inhabit kelp beds, oil platforms, rocky areas, wrecks and around any other area with solid structures in bays and coasts from Washington to southern

Baja California, Mexico.

Young kelp bass mainly eat plankton and tiny, algal-dwelling invertebrates. Adults eat fishes, squids, octopuses, shrimps, crabs, and algae. Kelp bass are a popular sport fish in southern California waters.

10. giant sea bass/ black sea bass (*Stereolepis gigas*) – These massive fish reach lengths of more than 2 m (7 ft.) long and can weigh hundreds of pounds. Young giant sea bass are perch-shaped with red and black spots. Adults have a more basslike shape, are mottled gray to dark brown, and often have black spots. Juvenile giant sea bass dwell in kelp forests or over sandy areas. Adult giant sea bass hover over rocky reefs at kelp forest edges, often in groups of up to 10 individuals. From July through September, giant sea bass gather in even larger spawning aggregations.

The diet of these giants includes fishes, spiny lobsters, crabs, and squids. Giant sea bass range from northern California to the Gulf of California. They can live a long life – the oldest recorded giant sea bass survived to 75 years.

Giant sea bass are listed as "critically endangered" by the IUCN/World Conservation Union. Giant sea bass populations plummeted due to overfishing throughout the 1900s. With the onset of stricter commercial and sport fishing laws in 1982 for California and in 1992 for Mexico, giant sea bass populations seem to be recovering in some areas.



11. Pacific jack mackerel (*Trachurus symmetricus*) – Jack mackerel are elongate fish with metallic blue or greenish backs, silvery bellies and a dark spot on their gill cover. Adults reach 0.8 m (2.7 ft.) lengths. Pacific jack mackerel range from the Gulf of Alaska to southern Baja California, Mexico and into the Gulf of California. Young jack mackerel often school over rocky areas near kelp or piers. Adults are usually

more solitary and dwell offshore. The jack mackerel's diet includes plankton and small fishes and squids. Dolphins, Dall's porpoises, sea lions, large fishes, and sea birds prey on jack mackerel. Young jack mackerel are common catches in both commercial and recreational fisheries.

12. sargo (*Anisotremus davidsoni*) – The sargo is a silvery, perch-shaped fish with a dark bar on each side that extends down from the dorsal fin to about mid-body. Instead of a bar, juveniles have two dark stripes on each side. Adults grow to a maximum of about 51 cm (20 in.)

Sargos range from central California to southern Baja California, Mexico with an isolated population in the northern Gulf of California and an introduced population in the Salton Sea in southeastern California. They commonly school around structures including kelp, rocks, piers, and oil platforms. Sargos prey on small invertebrates including amphipods, shrimps, and kelp scallops. Sport fishermen in southern California and the Salton Sea occasionally catch sargo.



13. salema (*Xenistius californiensis*) – The salema is a big-eyed fish with six to eight horizontal, orange stripes along each side. They reach 30 cm (11.8 in.) lengths. Salema school in fairly shallow water around kelp and rocks off coasts from central California to Peru. At night, they feed on amphipods, mysid shrimps, and worms.



14. white seabass (*Atractoscion nobilis*) – White seabass are silvery to bronze elongate fish that grow to 1.5 m (5 ft.) lengths. Juveniles have a set of dark bars on their sides. White seabass range from Juneau, Alaska to southern Baja California, Mexico, although they are more common south of Point Conception. Very young seabass live just beyond the surfline under drift algae mats. Larger juveniles dwell in schools in shallow water regions of bays and coasts near kelp or rocks. Adult white seabass inhabit reefs or kelp beds, often moving into deeper water in winter. Adults eat mainly sardines, anchovies, mackerels, and squids.

The white seabass is a very popular fish in both the commercial and sport fisheries. Due to overfishing, by the 1970s, white seabass populations became severely depleted. In 1982, the Hubbs-SeaWorld Research Institute (HSWRI) established the Ocean Resources Enhancement and Hatchery Program – a stock replenishment program that has released more than a million, hatchery-reared white seabass into southern California bays and coastal areas.



15. opaleye (*Girella nigricans*) – The opaleye is an oval-shaped, olive-colored fish with iridescent blue eyes and one to three light dots on each side, just beneath the base of the dorsal fin. They grow to 66 cm (26 in.). Opaleyes range from Oregon to southern California. During their first couple years, opaleyes inhabit tide pools. As they

mature, opaleyes occupy kelp beds and shallow-water reefs. In kelp forests, adults are usually found near the bottom, although they occasionally swim up into the mid-water and canopy. Opaleye feed during the day – mainly consuming algae, along with an occasional tiny invertebrate. They are commonly caught by recreational fishermen.



16. halfmoon/ Catalina perch (*Medialuna californiensis*) – This fish has a bluish back, a silvery bellies, and a halfmoon-shaped *caudal* (tail) fin. They can grow to 48 cm (19 in.) lengths. Halfmoons typically school in kelp forests, over rocky reefs, near oil platforms, or under drift kelp mats. They range from Vancouver Island, British Columbia to the Gulf of California. The halfmoon's diet includes algae (including giant kelp), sponges, small strawberry anemones, and other tiny invertebrates. Sea lions, fur seals, bald eagles, and a variety of seabirds often eat halfmoons. Halfmoons are also popular game fish and are commercially fished on a small scale.



17. kelp surfperch (*Brachyistius frenatus*) – The kelp surfperch is an oval -shaped, golden-brown perch with an upturned snout and up-slanted mouth. Kelp surfperch usually grow to about 20 cm (8 in.), although some grow larger. These fish are named for their preferred habitat within the kelp canopy, although some live near

other kinds of algae or seagrass. Kelp surfperch often school in groups of hundreds and range from northern British Columbia to central Baja California, Mexico. Young surfperch eat zooplankton, while adults eat tiny marine invertebrates that live on kelp blades. Some adults also act as cleaners – picking-off external parasites from other fishes – especially blacksmith.

18. blacksmith (*Chromis punctipinnis*) – The blacksmith is a bluish gray to dark gray, perch-shaped fish with small black spots scattered over the back part of its body and its dorsal and caudal fins. Blacksmith are large members of the damsel fish family – growing to 30.5 cm (12 in.) lengths. Juveniles less than 5.1 cm (2 in.) have purplish fronts, yellow-orange rears, and blue-edged fins. Breeding males have a dark bar through their eyes and take on a lighter color when guarding nests.

Blacksmith range from Monterey, California to central Baja California, Mexico – often hovering over rocks and in kelp forests. Blacksmith eat zooplankton and are eaten by larger fishes, seals, sea lions, and sea birds. Smaller adult blacksmith occasionally clean parasites off other fishes. There are small scale commercial and sport fisheries for blacksmith.



19. *garibaldi* (*Hypsypops rubicunda*) – The garibaldi is a bright orange damsel fish and reach 36 cm (14 in.) lengths. Juvenile garibaldi have brilliant blue spots scattered over their bodies and blue-edged fins. Garibaldi range from Monterey, California to southern Baja California and Isla Guadalupe, Mexico, although they are just common south of Santa Barbara. They usually inhabit shallow, rocky reefs with abundant algae and occasionally wander up kelp searching for food. Adult garibaldi actively defend territories against intruders – even human swimmers and divers. They often make a thumping sound when disturbed. During the breeding season, males prepare nests by removing everything on a rocky patch except red algae. Female garibaldi lay their eggs on these nest patches, and the males diligently guard their nests until the eggs hatch. Each male may nest several times during the spawning season from March through October. Garibaldi consume a variety of invertebrates. Harbor seals prey on garibaldi. Since the garibaldi is the California state marine fish, fishing for garibaldi is prohibited within California.



20. rock wrasse (*Halichoeres semicinctus*) – The rock wrasse is an elongated fish that has different color patterns at different life stages. Very young rock wrasse are greenish. Juveniles are orange to yellow and have two white stripes along their body and two dark spots on their dorsal fin. Mature females have green to orange backs and sides, yellowish bellies, and may have lighter bars on their bodies. Males have greenish-brown backs and a dark bar behind their pectoral fin. Like other wrasse, rock wrasse function first as females and then a small number change into males in a later life stage. Male rock wrasses can reach 38 cm (15 in.) lengths.

Rock wrasse range from Point Conception into the Gulf of California. They live in shallow, rocky reefs near patches of sand and occasionally along the kelp forest bottom. Rock wrasse rest at night partly buried in sand with their heads uncovered. If threatened, they will also dart under the sand.



21. *senorita (Oxyjulis californica)* – The *senorita* is a long, slender wrasse with an orange to yellow body and a distinctive dark spot at the base of its caudal fin. These fish can grow to 30 cm (11.7 in.) lengths and range from northern California to central Baja California, Mexico. *Senoritas* reside in rocky reefs or kelp beds. *Senoritas* forage during the day with small individuals mainly eating plankton and larger fish consuming an assortment of small invertebrates and algae. They are also occasional cleaner fish – picking external parasites off bat rays, giant seabass, garibaldi, blacksmith, opaleyes, and other fishes. Other fish species usually do not eat *senoritas*. Seabirds, such as cormorants, prey on *senoritas*. If alarmed, a *senorita* can dive into a clump of kelp – becoming well camouflaged. At night, *senoritas* burrow into the sandy bottom to sleep with only their heads sticking out. Some also surround themselves in protective mucus nets.
22. California sheephead (*Semicossyphus pulcher*) – These large wrasses can grow to 0.9 m (3 ft.) lengths. They are distinctively colored at different life stages. Young sheephead are yellow to red-orange with at least one white stripe running along each side, two dark spots on their dorsal fin, and a dark spot at the base of their caudal fin. The adult female is pink with a white chin. As with many other wrasses, all male sheephead were once females. Females change into males at about 8 years old, when they are 30.5 to 35.6 cm (12–14 in.). It takes approximately a year for the female to completely change into a male. The male sheephead has a large bump on

its forehead, a black head and tail region, a white chin, and a large reddish-orange band on its midriff.



Sheephead use their large, protruding teeth to pry hard-shelled prey like crabs, lobsters, barnacles, mussels, clams, sea urchins, snails, and worms off rocks. Juveniles sometimes clean parasites off other fishes. They hunt during the day and rest in caves and crevices at night – producing a mucus covering to mask their scent from various marine mammal and fish predators.

California sheephead roam in rocky reefs, often within kelp forests. They range from Monterey, California to Isla Guadalupe, Baja California and in the northern Gulf of California. Sheephead are caught in both recreational and commercial fisheries, including live fish supplied to Asian markets. Since 2001, California fish and Game regulations restrict the size and location of sheephead catches.

23. giant kelpfish (*Heterostichus rostratus*) – These elongated fish are red, golden brown, or green and usually mottled with a lighter color. Giant kelpfish reach maximum lengths of about 38 cm (15 in.). They often hang out among kelp blades, which they resemble. They further camouflage themselves by angling their bodies and swaying with the kelp fronds and by changing color to match their surroundings. Giant kelpfish live along the Pacific Coast from British Columbia to Baja California, Mexico.

Kelpfish eggs have threads that tangle in kelp and males guard the eggs until they hatch. Larval kelpfish are planktonic for the first couple weeks then settle in schools along with mysid shrimp near the bottom of kelp beds. Adults are solitary. Giant kelpfish hunt during the day for small crustaceans and fishes. Brandt's cormorants and terns prey on kelpfish.

24. blue-banded/ Catalina goby (*Lythrypnus dalli*) – These little gobies only grow to about 6.35 cm (2.5 in.) and are crimson with 4 to 9 iridescent blue bands. Individuals can be male or female or both male and female, although most hermaphroditic bluebanded gobies are female-biased. They are found on rocky outcrops in rocky reefs and kelp forest floors, from Morro Bay, California to central Baja California, Mexico and also the Gulf of California.

Blue-banded gobies actively defend their territories – typically perching near a crevice that they can dart into if threatened by a predator. They also often shelter beneath red sea urchins. Blue-banded gobies mainly eat zooplankton and occasionally consume sponges, bryzoans, and other tiny invertebrates.



25. Pacific barracuda (*Sphyraena argentea*) – The Pacific barracuda is a very long, skinny fish with a pointed snout and a mouthful of needlelike teeth. These barracuda have a metallic blue or brown back and silver on their sides and belly. They usually grow to about 89 cm (35 in.).

Pacific barracuda school over rocky reefs – commonly near kelp forest edges. They range along the Pacific coast from Kodiak Island, Alaska to southern Baja California, Mexico.

Pacific barracuda prey mainly on small, schooling fishes and squids. They are popular game fish with most caught by recreational fishermen in the nearshore waters off southern California and Baja California during spring and summer.

Barracuda are also caught in a small-scale commercial fishery.

B. Class Chondrichthyes (cartilaginous fishes)

This Class includes fishes with skeletons made of cartilage instead of bone. You can learn more about cartilaginous fishes in the SeaWorld/Busch Gardens [**Sharks and Rays InfoBook**](#)

at SeaWorld.org. Many sharks and rays dwell in kelp forests including the following species.

1. horn shark (*Heterodontus francisci*) – The horn shark is a small shark – reaching average lengths of about 0.6 m (2 ft.). It is grayish brown with dark spots, a spine in front of each dorsal fin, and prominent eye ridges. It is a nocturnal, bottom-dwelling shark sheltering in caves, crevices, and kelp beds during the day. Horn sharks with longer spines prefer kelp forest habitat, while those with shorter spines live in rocky regions. Individual horn sharks return to the same place to rest each day. At night, they leave their shelter to hunt for small fishes, squids, crabs and sea urchins. The California horn shark ranges from central California to the Gulf of California. There are also possible populations in the waters of Ecuador and Peru. Horn sharks spawn from February through April. Mature females lay spiral-shaped egg cases which lodge in rocks and crevices to provide protection as the larval shark develops.



2. swell shark (*Cephaloscyllium ventriosum*) – Swell sharks are red to yellowish-brown with dark saddles and blotches and small white spots. These small sharks only grow to about 1 m (3.25 ft.) long. When threatened by potential predators, swell sharks suction in air or water to fill their bellies up like a balloon. Strangely, small swell sharks that may be able to benefit most from this behavior are unable to swell up. Swell sharks often live among the rocks and kelp in shallow waters but occasionally stray into 4,572 m (1,500 ft.) depths. They range from Monterey Bay, California to Acapulco, Mexico and also inhabit the coasts of Chile. Swell sharks feed at night on numerous small fishes, often suctioning in the fish. They also hold their mouths open in a long yawn, quickly closing their mouths

when unsuspecting prey swims in.

Swell sharks lay dark brown, rectangular egg cases that often have long tendrils that catch in the rocks. These egg cases often wash up on beaches, still with a tiny shark wiggling around and attached to a large yolk inside.

3. tope/southern shark (*Galeorhinus galeus*) – The tope is a long, bluish-gray shark with a white ventral region and a pointy snout. The upper lobe of this shark's caudal (tail) fin is deeply indented. Male tope reach 1.8 m (6 ft.) lengths while females can grow to 2 m (6.5 ft.).

The tope has an almost worldwide distribution in shallow waters to waters 411 m (1,350 ft.) deep. They prey on fishes – especially sardines, mackerel, midshipmen, and rockfishes. Humans commercially fished for tope in the late 1930s through the 1940s. The tope fins were dried and sent to Asia to use in shark fin soup. These sharks were also prized for their livers, which contain an unusually high vitamin A content. Tope populations declined until the end of World War II when synthetic vitamin A began to be manufactured.

4. leopard shark (*Triakis semifasciata*) – This beautiful shark has an elongated, light tan body with dark brown bars, saddles, and spots scattered on its back and sides.

Occasionally, a leopard shark lacks the bars and saddles and has only spots.

Leopard sharks average 1.8 m (6 ft.) lengths.

Leopard sharks often swim in very shallow water, but can be found in depths up to 90 m (300 ft.) on coastlines from Oregon to Baja California, Mexico and in the northern Gulf of California. Leopard sharks often inhabit bays and kelp beds where they search along the bottom for crabs, clams, shrimps, fishes, and fish eggs for food.



5. round stingray (*Urolophus halleri*) – This is a small tan to dark brown ray with a total length of about 25 cm (22 in.). It has a stinging spine located about midway down its tail. A round ray swims by rippling the edges of its nearly circular-shaped disc. Round rays are very common in sandy or muddy bottomed habitats from very shallow waters to 21 m (70 ft.) depths from northern California to Panama. Smaller round rays eat worms, shrimps, crabs, and amphipods while larger rays eat mainly clams.

Throughout its range, the round ray causes more stinging injuries to human swimmers than other kinds of sting rays. It is important to remember that these rays only use their stinging spine in defense. To avoid being stung when you're at the beach, shuffle your feet when moving through the water and the rays will just swim away.

6. bat ray (*Myliobatis californica*) – The bat ray is a brownish diamond-shaped ray with rounded edges to its "wingtips". Its head is elevated above the disc and at least one spine lies at the base of its whiplike tail. Bat rays can grow large—reaching disc lengths of (6 ft.) from tip-to-tip. Bat rays "fly" through the water by moving the tips of their discs up-and-down.

Bat rays are benthic dwellers in mudflats, estuaries, surfgrass zones, and kelp beds along coastlines from Oregon to the Gulf of California. In soft-bottomed habitats bat rays mostly eat clams, crabs, shrimps, and fishes. Yet, those that live in kelp forests mainly eat snails, abalones, and worms.

Like round rays, bat rays are a type of sting ray and are responsible for a number of painful injuries to swimmers. Bat rays will swim away without stinging if you shuffle your feet as you move through the water when at the beach.



B. Class Reptilia

The reptile class includes snakes, lizards, alligators and crocodiles, and turtles. Reptiles have scaly skin, breathe air with lungs, and have a three-chambered heart. Most reptiles also lay eggs. Sea turtles sometimes swim into kelp forests. Discover more about sea turtles in the SeaWorld/Busch Gardens [Sea Turtle InfoBook](#) at [SeaWorld.org](#).

1. black sea turtle/ east Pacific green turtle (*Chelonia mydas agassizii*) – The black sea turtle is a green sea turtle (*Chelonia mydas*) subspecies that inhabits the western coasts of North and South America, from San Diego, California south to Peru and west to the Galapagos Islands. It is typically found in bays and coastal areas and occasionally wanders through kelp beds. Juveniles usually live in the open ocean. Sea turtles have a streamlined shell, two paddlelike front flippers, and two rudderlike hind flippers. The black sea turtle's *carapace* (dorsal shell) is dark and mottled with brown and yellow. This species reaches shell lengths of about 78 to 112 cm (31–44 in.) and can weigh 68 to 186 kg (150–410 lb.).

Adult black sea turtles graze on seagrasses and marine algae. Black sea turtles are hunted, along with other sea turtles, by humans for their meat and eggs. Sea turtles are also accidentally caught on hooks and in nets by fishermen targeting fishes and shrimps. The species is listed as "endangered" by the IUCN/World Conservation Union, and the black sea turtle subspecies is listed as "endangered" by the U.S. Fish & Wildlife Service.



C. Class Aves

Class Aves includes all birds. All birds have an outer covering of feathers, are *endothermic* (warm-blooded), breathe air, have front limbs modified into wings, and lay eggs. Some bird species rest on the tangle of kelp fronds at the surface or feed on certain kelp forest inhabitants.

1. gulls (*Larus* spp.) – Gulls are medium to large, stout, long-winged sea birds in the scientific Family Laridae. Like other members of this bird family, gulls have three webbed toes on each foot. Most adult gulls are gray and white and some have black markings on the head or wing regions. Gulls of the *Larus* genus are widespread and abundant at many coastal and even inland areas. Gulls are omnivores and will hunt and scavenge for food.
2. brown pelican (*Pelecanus occidentalis*) – Pelicans are stout-bodied, long-necked, seabirds with webbed feet. They are characterized by a large bill with a thin, membranous pouch. The brown pelican is grayish-brown with a blackish belly. Adults have a whitish head and neck. An adult in breeding *plumage* (feather coloration) is more vividly colored with a yellow crown, a reddish-brown hind-neck region, dark gray body feathers, and bright red at the bill's base. Brown pelicans can reach 1.27 m (4.2 ft.) lengths and have a 1.98 m (6.5 ft.) wingspan. Brown pelicans inhabit coasts, bays, and estuaries along the Pacific coast from western Canada to northern Peru and on the Atlantic coast from northern United States to northern Brazil. To feed, brown pelicans dive from as high as 15 m (60 ft.) above the water. They plunge into the water head-first and use their bill to scoop up schooling fishes and a mouthful of seawater. They then tip their bill downward to drain the water before swallowing the fish.



Brown pelicans are listed by the U.S. Fish & Wildlife Service as "endangered" throughout their range except for Florida, Alabama, and the U.S. Atlantic coast.

3. cormorants (*Phalacrocorax* spp.) – Cormorants are mostly black seabirds with long, s-shaped necks. They have webbed feet and a slender, hooked-tip bill. Many cormorant species have brilliant eyes and are brightly colored on their face and throat pouch regions. Some also grow small, whitish feather tufts on the sides of their head in the breeding season. Cormorants rest in an upright stance out of the water. In the water, they float and paddle around, often diving down beneath the surface to hunt for fishes. After fishing, cormorants climb out onto rocks, pier pilings, or other dry perches and sun themselves with their wings spread out to dry.

D. Class Mammalia

Mammals are endothermic, breathe air, have hair or fur, bear live young, and females nurse their young with milk. Marine mammals live in or rely upon the marine environment and often prey on kelp forest animals.

1. harbor seal (*Phoca vitulina*) – This common seal of the subarctic to temperate coastal regions of the northern hemisphere often swims and hunts for fishes, crustaceans, and molluscs in kelp forests. It has a rounded head, a *fusiform* (tapered at both ends) body, and four, short, webbed flippers. Harbor seals range in color from light gray to silver with dark spots. Some are black or dark gray to brown with white rings. Most have darker dorsal and lighter ventral coloration. Male harbor seals grow slightly larger than females, reaching 1.4 to 2.0 m (4.6-6.6 ft.) lengths and weighing 70 to 170 kg (154-375 lb.).

For more information on harbor seals visit the SeaWorld/Busch Gardens [Harbor Seal InfoBook](#) or [Animal Byte](#) at [SeaWorld.org](#).



2. California sea lion (*Zalophus californianus*) – Like other sea lions and fur seals, California sea lions have prominent external ear flaps and are able to tuck their hind flippers beneath their body and use all four flippers to move around on land. Mature female and immature male California sea lions are light yellowish to tan in color. Adult males are usually darker brown and are easily distinguished by their prominent *sagittal* (cranial) crest. Unlike many other species of sea lion, California sea lion males lack a well-defined mane. Male California sea lions reach about 2 to 2.5 m (6.5–8 ft.) lengths and 200 to 400 kg (440–880 lb.) in weight. Female California sea lions are smaller, reaching about 1.5 to 2 m (5–6.5 ft.) and 50 to 110 kg (110–240 lb.). California sea lions inhabit coasts and shorelines from southern British Columbia to northern Mexico including Baja California. Another subspecies, the Galápagos sea lion (*Z.c. wolfebaeki*), is found mainly on the Galápagos Islands, with some occasionally spotted off the coasts of Ecuador and Columbia. Sea lions often swim acrobatically through kelp forests. They prey on many kinds of fishes, squids, and octopuses within the forest. Visit the SeaWorld/Busch Gardens [California Sea Lion InfoBook](#) or [Animal Byte](#) at [SeaWorld.org](#) to discover more.



3. gray whale (*Eschrichtius robustus*) – Gray whales are a kind of baleen whale that are named for their mottled gray appearance. Instead of a dorsal fin, gray whales have 9 to 13 bumps or "knuckles" from the midpoint of the back to the tail flukes. Female gray whales grow larger than males and average 14.1 m (46 ft.) in length and can

weigh about 32,000 kg (70,000 lb.).

California gray whales range along the coastal regions of the northeastern Pacific Ocean. They spend summers in the icy waters of the Bering and Chukchi seas, off Alaska. As the ice pack advances in the fall, gray whales embark on one of the longest known migrations of any mammal. Hugging the North American coastline, the whales swim south more than 10,000 km (6,000 mi.) to Baja California, Mexico. During migration, gray whales occasionally swim through the canopy of kelp forests to conceal themselves from potential detection and predation by killer whales. Although gray whales mainly scoop up huge mouthfuls of amphipods from the seafloor, in some regions they prey on swarms of mysid shrimp found within kelp beds.



Find out more about gray whales in the SeaWorld/Busch Gardens [California Baleen Whale InfoBook](#) or [Gray Whale Animal Byte](#) at [SeaWorld.org](#).

4. sea otter (*Enhydra lutris*) – Sea otters are large members of the weasel (Mustelidae) family, which have rounded heads, short tails, and thick, cinnamon-brown fur. Adults develop lighter gray or buff coloration on their heads. Sea otters have small, dexterous forefeet and flipperlike hind feet. They are the second smallest marine mammal – only marine otters are smaller. Adult sea otters reach lengths up to 148 cm (58 in.) and weigh 20 to 39 kg (44–85 lb.) on average, with males growing larger than females.

Sea otters live in or near kelp beds. They typically rest on their backs at the surface and wrap kelp strands around their body to keep from drifting away. Each sea otter needs to eat 25 percent of its body weight each day. They dive down to prey on more than 50 kinds of animals including sea urchins, crabs, shrimps, abalone, sea stars, clams, mussels, octopuses, and slow-moving fishes. Sea otters surface with

their catch and are among the few types of animals to use a tool. Holding a flat rock on its chest, an otter pounds hard-shelled prey on the rock to break it open. They also use a rock to knock an abalone off its substrate.

The sea otter is a *keystone species*; playing a vital role in the kelp forest ecosystem. They prey on sea urchins which, in turn, feed on kelp. In some areas where sea otter populations are depleted, unchecked sea urchin populations can overgraze the kelp, especially near the holdfast. The weakened kelp then breaks loose and washes away destroying a key habitat for many different fishes and invertebrates.

Sea otters once were abundant along most of the coastal northern Pacific Ocean – from northern Japan, along the Alaskan coast and down into Baja California, Mexico. In the 18th and 19th centuries, fur traders hunted sea otters for their thick, luxurious pelts. By the year 1900, sea otters were nearly extinct – only about 1,000 to 2,000 remained in scattered populations.

In 1911, sea otters were protected from hunting through the International Fur Seal Treaty. With this treaty and further protection through the Marine Mammal Protection Act of 1972 and the U.S. Endangered Species Act in 1977, sea otters have made a comeback in Alaska and, to a lesser extent, in California waters. Sea otters are listed as "endangered" by the IUCN/World Conservation Union, as "threatened" by the U.S. Fish & Wildlife Service, and in CITES Appendix I. Oil spills, toxins from motor oil and pesticide runoff, entanglement in fishing nets, and infectious diseases and parasites still pose a threat to sea otters.

Visit the SeaWorld/Busch Gardens [Sea Otter Animal Byte](#) or [Otter Infobook](#) at [SeaWorld.org](#) to learn more about sea otters.



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HUMAN IMPACT & CONSERVATION

As human populations continue to increase along coastlines, more people have access to the nearshore ecosystems such as kelp forests, impacting many of the plants and animals that rely upon this habitat. In addition, these underwater forests are popular destinations for recreational scuba divers.

A. Hunting of sea otters

As sea urchin predators, sea otters are a keystone species within the kelp forest ecosystem. Removal of the otters from the ecosystem has a disproportionate effect on the entire kelp forest food web.

1. Due to hunting by fur traders, by the end of the 19th century sea otters became locally extinct in many areas of their former range, removing them from the kelp forest ecosystems in these areas.
2. Among other prey, sea otters consume large numbers of sea urchins, which mainly feed on kelp. Lobsters and predatory fishes, such as sheephead, also prey on sea urchins.
3. Without a key predator to keep their numbers in check, sea urchin populations exploded. The sea urchins overgrazed the kelp, destroying kelp beds and leading to urchin barrens – former kelp forests absent of any algae except for encrusting coralline algae.
4. The loss of kelp beds leads to declines in populations of animals and plants that rely on these undersea forests for food and shelter.
5. With international and national protection, sea otter populations have recovered in some areas returning the balance to kelp forest ecosystems.
6. In some areas where sea otters are still absent, humans have removed sea urchins for food (red sea urchins) and to help keep their populations under control so kelp could thrive.

B. Kelp harvesting

Humans harvest kelp for a multitude of uses.

1. giant kelp – In addition to being a food source for humans and livestock, giant kelp is widely harvested for a variety of other uses. Historically, acetone and potash were extracted from giant kelp for use when manufacturing explosives during World

War I. Currently, algin extracted from the cell walls of kelp has a wide range of food and industrial applications. It is used to thicken ice cream, gelatins, and canned foods. Algin is also used to stabilize salad dressings and beer foams. It can help bakery products stay moist and ensure that frozen foods thaw uniformly. Algin is also used for paper and welding rod coatings and for textiles. It is used by the pharmaceutical industry to make tablets, dental impressions, face creams, and antacids. Giant kelp is also harvested, along with bull kelp, for use as feed in abalone culture and in some other fisheries. The California Department of Fish and Game has managed the commercial harvest of giant kelp since the early 1900s. Licenses and leases are required for commercial harvesters of giant kelp, and strict regulations must be followed. In addition, certain kelp beds can be closed to harvesters. The regulations implemented by the Department of Fish and Game allow kelp beds to regenerate and ensures that kelp is harvested in an environmentally sustainable manner.

2. bull kelp— Bull kelp is harvested commercially for use as food for abalone culture and, to a lesser extent, both commercially and recreationally for use as an edible seaweed. As with giant kelp, the California Department of Fish and Game monitors the commercial harvest of bull kelp and restricts or prohibits the harvest from specific kelp beds, especially some located off Northern California.

C. Sport and commercial fishing

1. Kelp forests provide habitat for hundreds of commercially and recreationally harvested fishes and invertebrates.
2. Overharvesting of certain kinds of large, predatory fishes and invertebrates can increase the abundance of algal herbivores such as sea urchins, limpets, marine snails, which can deplete kelp when their populations are unchecked.
3. Throughout the United States, fishing or collection of coastal animals and plants, for any kind of use, is regulated. Collection of any animals or plants is prohibited in state or national parks or in regional reserves. In addition, animals and plants are protected in NOAA's (National Ocean & Atmospheric Administration) national marine sanctuaries and monuments.
4. Many states also have regulations. Species regulated by the California Department

of Fish & Game include ocean fishes, abalone, spiny lobsters, octopuses, scallops, sea cucumbers, sea urchins, shrimps, and sculpins. In California and many other states, a valid fishing license is necessary to fish or collect live molluscs.

5. Many other countries also have regulations and restrictions on collection or harvesting of ocean animals.
6. If you eat seafood, including commercially-harvested marine invertebrates like lobster, sea urchins, and shrimp, be sure to support sustainable fisheries by eating only seafood certified by the Marine Stewardship Council. Sustainable fisheries are healthier for both humans and the environment.

C. Pollution and coastal runoff

Coastal pollution also poses a threat to kelp forest ecosystems.

1. Types of coastal pollution include discarded trash, oil spills, sewage spills, warm water discharge, and toxic chemical runoff – all of which can negatively impact marine life along coastlines.
2. Kelp requires clean, clear water so that sunlight can reach the blades for photosynthesis. Sewage outflow decreases water clarity and can degrade kelp beds.
3. Remember not to trash where you splash! Improperly disposed of trash – even in areas away from oceans – is often washed down creeks and rivers during rainstorms and eventually ends up in the ocean.
4. SeaWorld regularly participates in local beach clean-ups to prevent trash from polluting the coastal and ocean environments. One great way for you to help, is by participating in local beach and waterway clean-ups. You can look for beach cleanups in your area on the Web site for the Ocean Conservancy's International Coastal Cleanup at oceanconservancy.org.
5. To help reduce trash build-ups at landfills, SeaWorld and Busch Gardens use biodegradable plates and utensils at many restaurants and employee lounges within the parks. In addition, each year SeaWorld and Busch Gardens recycle millions of pounds of a variety of items including plastic bottles, paper, manure, cooking oil, metals, batteries, and wooden pallets. Furthermore, SeaWorld offers several e-recycling events a year in which people from the community can recycle TVs, computers, and other electronic devices for free. As an added benefit, money raised from these e-recycling events goes to the SeaWorld & Busch Gardens

Conservation Fund.

E. Climate change

1. In the oceans, human-induced climate change – linked to excess emission of carbon dioxide and other greenhouse gases – has led to a significant rise in global ocean temperatures and related changes in ocean currents, ice coverage, and sea level. Extreme weather events may also become more frequent as a result of climate change. These climatic changes will impact a variety of marine animals and plants and even entire ocean ecosystems including kelp forests.
2. Giant kelp thrives in temperate coastal waters with temperatures between 50° to 60° F (10°–15.5°C). Warmer water decreases kelp's ability to reproduce. Furthermore, extreme storms during El Niño/Southern Oscillation (ENSO) events can rip kelp from the seafloor and destroy these ocean forests within days. The entire kelp forest ecosystem is threatened by the climate change effects of warmer coastal waters and by increases in intensity of ENSO events.
3. Like forests on land, kelp forests can also act as an important carbon sink, helping to remove carbon dioxide from the atmosphere. During photosynthesis, plants such as kelp, utilize carbon from carbon dioxide and release oxygen. Large areas, such as kelp beds may uptake significant amounts of carbon dioxide from the Earth's atmosphere.
4. Climate change: What can you do?
 - a. *Share a ride with a friend or walk or ride your bike.* Carpooling saves energy and money. Walking and biking use no fuel at all and both are healthy activities.
 - b. *Increase home energy efficiency.* Turn off lights when not in use. Switch the incandescent light bulbs in your home with energy saving compact fluorescent bulbs (CFLs). Replace old appliances with fuel and water-efficient models. Plugged in appliances use energy even when turned off. Plugging your computer, TV, and other appliances into a power strip and switching this off when the appliances are not in use conserves energy.
 - c. *Help create a carbon sink.* During photosynthesis, plants use carbon dioxide and produce oxygen. Planting a garden, even a patio garden, of flowers, trees, and other plants that attract a variety of local birds and beneficial insects can also help soak up excess carbon dioxide.

- d. *Recycle and reuse.* Recycling, especially recycling of heavy garbage such as glass, cans, paper, and green matter from the garden, not only prevents these items from polluting the ocean, but also recycled materials can be processed more efficiently than raw materials, reducing power use. SeaWorld and Busch Gardens recycle everything from cardboard to plant cuttings to food scraps. If you bring a reusable coffee mug, water bottle, or lunch bag to school or work every day you can save even more energy.
- e. *Eat locally.* Food at your grocery store often comes from hundreds or thousands of miles away. Fruits, vegetables, and other locally grown food at Farmer's Markets or Farm Co-ops are less likely to contain pesticides and use much less energy to transport.
- f. *Explore nature.* Enjoy natural areas such as parks, wildlife reserves, and beaches near your neighborhood. Discover all you can about the plants and animals that live there. Share what you learn with family and friends. If you educate yourself, you can more effectively support conservation measures.

F. Marinelife parks.

1. SeaWorld Parks offer a safe and stimulating environment in which individuals and even kids can closely observe a variety of kelp forest fishes, invertebrates, and other animals.
2. At marinelife parks, guests learn about marine animals, their ecosystems, and important conservation issues. Guests leave with a heightened appreciation of the importance of conserving marine animals and preserving their habitats. A 2005 public opinion poll conducted by Harris Interactive® found the following:
 - a. 96% agree that marine life parks, aquariums and zoos provide people with valuable information about the importance of oceans, waters, and the animals that live there.
 - b. 93% agree that people are more likely to be concerned about animals they learn about at marine life parks, aquariums, and zoos.

G. The SeaWorld & Busch Gardens Conservation Fund.

1. The non-profit SeaWorld & Busch Gardens Conservation Fund is committed to species research, habitat protection, animal rescue, and conservation education. The Fund was created to strengthen and expand the parks' existing conservation efforts while also providing guests an easy, direct way to make a difference for wildlife. To learn more about the Fund visit *SWBG-ConservationFund.org*.
2. The Fund has granted millions of dollars to hundreds of conservation projects around the world, including those involving conservation of coastal marine habitats and animals where kelp forests thrive.
 - a. The SeaWorld & Busch Gardens Conservation Fund presented a grant to the Orange County Kelp Restoration Project. In California, the Orange County coastline has experienced a loss of nearly 90% of its kelp beds. The project aims to educate students and residents of southern California about the importance of the local kelp forests, and also to help restore and monitor kelp forests in Orange County.
 - b. The SeaWorld & Busch Gardens Conservation Fund provided a grant to the Ocean Conservancy for its International Coastal Cleanup – a program that encourages people from around the world to remove trash and debris from beaches and inland waterways, to identify the sources of debris, and to change behaviors that negatively impact the marine environment. Each year on the third Saturday in September, hundreds of thousands of volunteers converge on every major body of water throughout the world. In 2005 alone, The Ocean Conservancy engaged more than 448,000 volunteers through this event. More than just a one-day event, the Fund-supported International Coastal Cleanup is a year-round program focused on marine debris prevention and education.
 - c. The Fund has also given grants to Defenders of Wildlife to help support the Sea Otter and Coastal Water Quality Protection Program. Sea otters continue to struggle due to many factors, including poor water quality along California coasts. With support from the SeaWorld & Busch Gardens Conservation Fund, Defenders of Wildlife launched a water quality protection program to help

protect the declining sea otter population inhabiting California's central coast. Through building broad-based and diverse partnerships, investing in targeted public education efforts such as its annual "Sea Otter Awareness Week," and reaching out to people who utilize the central coast for recreation and fishing, Defenders of Wildlife aims to directly impact the coastal ecosystem on which sea otters and other wildlife species rely for food and habitat.

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VOCABULARY

ABORAL – on a two-sided invertebrate, the surface opposite the mouth.

ALGAE (AL jē) – (s. alga) simple, aquatic plants. Unlike other plants, algae have no roots, leaves, or stems.

AMPHIPOD (am FI pod) – a shrimplike crustacean with a vertically compressed body.

BENTHIC – living or growing on the ocean bottom.

BIVALVE – two-shelled molluscs, such as clams, mussels, scallops, and oysters.

BLADE – the leaflike portion of kelp.

BRYZOAN (BRĪ zo en) – tiny, mosslike animals of the Phylum Ectoprocta, which live in calcareous rectangular or cylindrical shaped boxes, often connected into colonies with a basket-weave pattern.

CALCAREOUS (kal KAR ē es) – containing calcium carbonate (a compound of calcium).

CANOPY – the upper kelp forest layer where the kelp fronds intertwine.

CARAPACE – in crustaceans, the part of the exoskeleton that covers the head and thorax. In turtles, the dorsal (top) part of the shell.

CAUDAL – relating to the tail region.

CHELIPED (CHĒL i ped) – a clawed thoracic appendage found in decapod crustaceans.

CHITIN (KĪ-tn) – a hard substance in the external skeleton of arthropods.

CHLOROPHYLL (KLOR ō fil) – a photosynthetic pigment that absorbs sunlight.

CLASS – a division of animal or plant classification. A *class* is a subdivision of a *phylum*.

CNIDARIA (nī DAR ē a) – a phylum of radially symmetrical, soft-bodied marine invertebrates that includes jellies, hydroids, sea anemones, and corals.

CRUSTACEAN (krus TĀ shen) – an arthropod of the class Crustacea, including mostly aquatic forms such as lobsters, crabs, shrimps, and barnacles.

DETRITUS (de-TRĪ-tus) – tiny pieces of dead and decomposing plants and animals.

DIATOM (DĪ e TAM) – single-celled, microscopic algae with exoskeletons containing silica.

DORSAL – pertaining to the back or top surface of the body.

ECHINODERMATA (ē KĪN ō durm a ta) – the invertebrate phylum of spiny-skinned animals with fivefold radial symmetry in adults. Sea stars, brittle stars, sea cucumbers, sand dollars, and sea urchins are some types of echinoderms.

ECOSYSTEM – a unit of plants, animals, and non-living components of an environment that interact.

ECTOTHERMIC – cold-blooded. Body temperature varies with the temperature of the surrounding environment.

ENDANGERED – a population of organisms that is at risk of becoming extinct.

ENDOTHERMIC – warm-blooded. Able to maintain a constant, internal body temperature.

ENVIRONMENT – one's surroundings.

EVAGINATION – the act of pushing out, as when sea stars evert their stomachs during feeding.

EXOSKELETON – the outer covering or external skeleton of some invertebrates, especially arthropods.

FOOD CHAIN – a diagram showing "who eats what" in an ecosystem.

FOOD WEB – a complex diagram showing all the interconnecting predator-prey relationships in an ecosystem.

FROND – the kelp portion that includes a stipe and any attached blades and pneumatocysts.

FUSIFORM (FŪS i form) – tapered at both ends.

HOLDFAST – the rootlike structure that anchors kelp and some other algae species to the bottom. Unlike true plant roots, the holdfast does not absorb any nutrients.

HYDROID (HĪ droyd) – a member of the Hydrozoan class of Cnidarians. Hydroids are soft-bodied and have a stalked or colonial medusae form.

INTERTIDAL ZONE – the shoreline area within the tidal range.

INVERTEBRATE – any animal that lacks a spinal column.

GAMETE (ga MĒT) – a male or female reproductive cell.

GAMETOPHYTE (ga MĒT ō fit) – microscopic male or female kelp plants. In plants, the life stage in which eggs and sperm are produced.

KELP – large, brown marine algae; including giant kelp.

KELP BED/KELP FOREST – oceanic communities of large brown algae forming important ecosystems in cool, nutrient-rich waters.

KEYSTONE SPECIES – a species whose impact on its ecosystem are much greater than would be expected from its relative abundance or total biomass.

KRILL – a planktonic, shrimplike crustacean.

MAMMAL – a vertebrate class of animals. Mammals give live birth, maintain a constant body temperature, have hair or fur on their body, and females produce milk and nurse their young.

MARINE – related to the seas or oceans.

MOLLUSCA (mō LUS ka) – the phylum of soft-bodied invertebrates – many with calcium carbonate shells. This phylum includes chitons, limpets, snails, slugs, clams, mussels, oysters, scallops, octopuses, squids, and nautilus.

NEMATOCYTES (ne MAT ō sist) – cnidarian stinging cells.

NUDIBRANCH (NŪD i brank) – sea slugs.

OPERCULUM – the gill covering in most bony fishes. In invertebrates, the doorlike covering to a molluscan gastropod shell.

ORAL – of or pertaining to the mouth.

ORDER – a division of animal or plant classification. An *order* is a subdivision of a *class*.

PAPULAE (PAP ū lā) – the tiny, external respiratory organs of sea stars.

PARASITE (PAR e sīt) – an organism that lives in or on, and feeds on, a host organism, harming the host.

PEDICELLARIAE (PED e sel ĀR ē a) – tiny, pincherlike projections found on the dorsal surfaces of some sea stars.

PHOTOSYNTHESIS – a biochemical process in living plants, algae, phytoplankton, and some bacteria, which utilizes sunlight as energy to convert carbon dioxide and water into carbohydrates and oxygen.

PHYLUM (FĪ lem) – (pl. Phyla) a division of animal or plant classification. A *phylum* is a subdivision of a *kingdom*.

PHYTOPLANKTON (FĪ tō PLANGK ten) – plant plankton.

PILING – a column made of wood, steel, or concrete that holds up a dock, wharf, or pier.

PLANKTON (PLANGK ten) – free-floating, microscopic plants and animals.

PNEUMATOCYST (nū MA tō sist) – the gas-filled, floatation bladders found on some types of brown algae.

PREDATOR (PRED e ter) – an animal that eats another animal.

PREY (PRĀ) – an animal eaten by another animal.

RADULA (RAD ū la) – a ribbonlike structure bearing rows of teeth found in the "mouths" of many molluscs. The molluscs use their radula for rasping and scraping.

SCHOOL – a behavior in which same species fish cluster together in large groups.

SUBSTRATE – the surface to which an organism attaches.

SUBTIDAL – the shoreline region that is always covered by seawater just beyond the lowest low tide level.

SESSILE (SES il) – attached to the bottom or another hard substrate.

SPOROPHYLL (SPŌR ō fil) – in kelp, one of the reproductive, leaflike blades located just above the holdfast.

SPOROPHYTE (SPŌR ō FĪT) – in kelp, the generation characterized by a large plant which produces sporophylls.

STIPE – a stemlike structure that connects the kelp holdfast to the blade.

SYMBIOSIS (SIM bē Ō sis) – two organisms that live together in close association. The symbiosis can be commensal (one benefits, the other is unaffected), mutualistic (both benefit) or parasitic (one benefits, the other is harmed.)

TELSON – the last segment of the thorax of an arthropod or an extension of the last segment such as a scorpion's stinger or a lobster's tail fan.

TEMPERATE – the regions in the middle latitudes of the northern and southern hemispheres with moderate year-round temperatures.

TERRITORIAL – establishing and defending a particular territory.

THREATENED – populations of organisms that are vulnerable to extinction in the near future.

TUNICATE – animals in the Subphylum Urochordata that are also called sea squirts. Adult tunicates have saclike bodies, with a *tunic* or thick outer covering made of cellulose and an incurrent and an excurrent siphon through which water flows.

UNDERSTORY – the layer 1 to 2 m (3.3 to 6.6 ft.) above the kelp forest floor.

UROPODS – in some crustaceans, a flattened pair of appendages at the posterior end of the abdominal section.

VENTRAL – pertaining to the underside or bottom surface.

ZOOPLANKTON (zō PLANGK ten) – animal plankton.

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