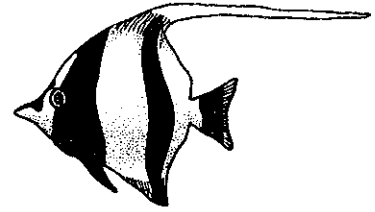


WHAT'S IN A FOOD WEB?

1. At which trophic levels of the food web would you expect to find the largest population (the total number of individuals of a particular organism)? The smallest population? Why might this be the case?



2. Which organisms might be described as “top carnivores” and why?

3. How might changes in the environment affect populations of organisms? Below are two scenarios of environmental change. Give an example of how each of these might affect the food web.

During an El Niño, there is less rainfall on land, and the water temperature around the islands will rise significantly.

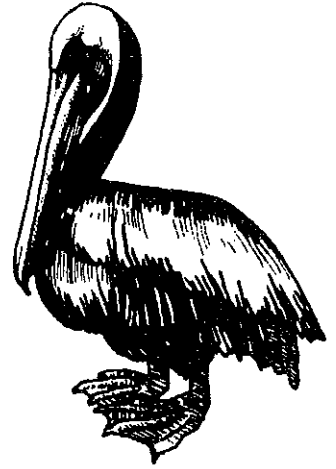
During a La Niña, there is increased rainfall on land, and the water temperature around the islands will drop.



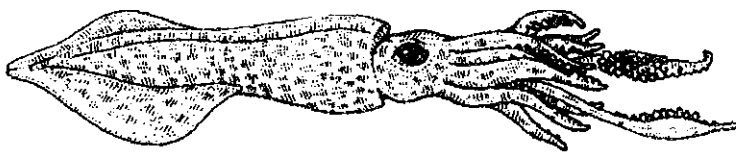
ACTIVITY 10: GALÁPAGOS MARINE FOOD WEB

WHAT'S IN A FOOD WEB?

4. Make a list of organisms in your food web that live on land, but are adapted to feed in the ocean. How has each adapted for feeding from the ocean? (Not all of these adaptations are the result of living in the Galápagos, because the forces that affect adaptation are in effect everywhere.)



5. The Galápagos sea lion and fur seal are usually found in temperate or subtropical (cooler) waters. How do you think they have adapted to the warmer Galápagos climate? Specifically, think about how the warmer climate might have affected their feeding habits.

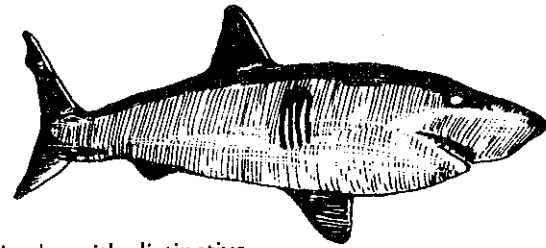
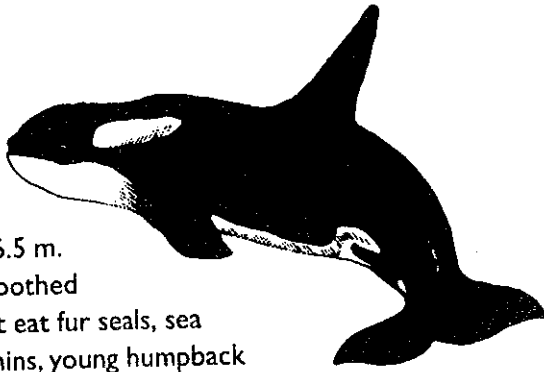


GALÁPAGOS MARINE ORGANISMS

TROPHIC LEVEL 6

Killer whales

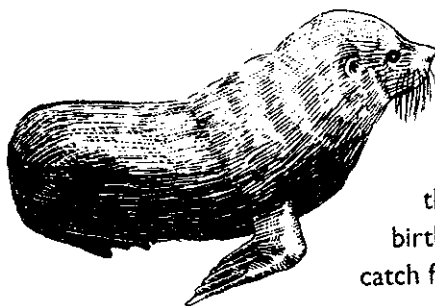
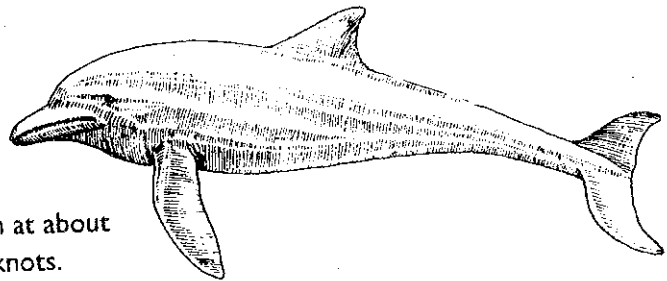
can reach lengths of 6.5 m. They are toothed whales that eat fur seals, sea lions, dolphins, young humpback whales, and large and medium-sized fish. Killer whales have no natural enemies. Their population size is limited by disease and food supply.



Galápagos sharks are large gray sharks with distinctive uniform coloration and reach 3 to 4 m in length. Their triangular upper teeth are sharp and serrated like steak knives. To satisfy their large appetites, they eat medium- to large-sized fish, and sometimes eat sea lions, fur seals, sea turtles, flightless cormorants, and occasionally marine iguanas. When human divers are in the water the sharks are very curious and approach them at close range, but usually are not aggressive. A large adult shark can be twice the size of a human diver. Only other large sharks (including cannibalistic members of their own species) prey upon them.

TROPHIC LEVEL 5

Bottlenose dolphins got their name because of their short, protruding snouts. As mammals, they must come to the surface to breathe air. Bottlenose dolphins are sociable animals, traveling in pods of about six or seven. Adults grow to approximately 2.5 m and feed on fish and squid. Their streamlined bodies allow them to swim at about 10 knots, darting in short bursts of speed to almost 20 knots. Killer whales prey upon the dolphins.



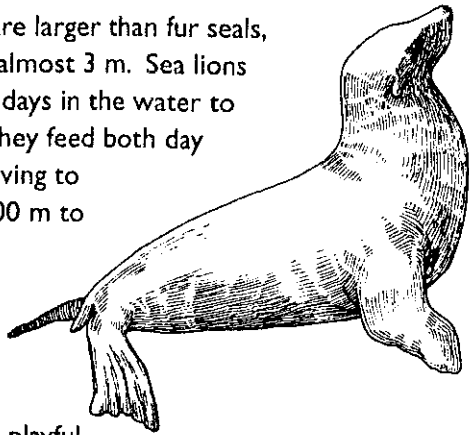
Fur seals found in the Galápagos are the smallest of all known fur seal species. Adult males grow to approximately 2.5 m and weigh about 70 kg; females are smaller, averaging about 35 kg. They live in colonies on rocks with shaded overhangs that protect them from the daytime sun, and there they breed and give birth. At night fur seals feed offshore, diving to about 30 m to catch fish and squid. Sharks and killer whales eat fur seals.

ACTIVITY 10: GALÁPAGOS MARINE FOOD WEB

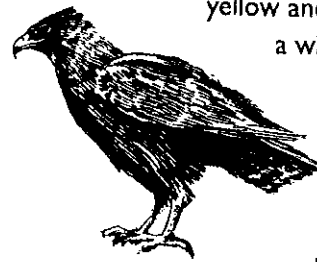
GALÁPAGOS MARINE ORGANISMS

TROPHIC LEVEL 5

Sea lions are larger than fur seals, growing to almost 3 m. Sea lions spend their days in the water to stay cool. They feed both day and night, diving to depths of 200 m to catch fish. Adults are aggressive toward humans, but juveniles are playful and curious. Sharks and killer whales prey upon them.

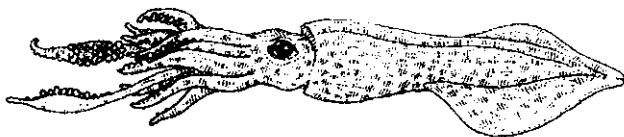


Galápagos hawks belong to the category of birds known as raptors: birds of prey. Their feathers vary in color from white and brown to a brilliant yellow and black, and they may have a wingspan of nearly 1.5 m.

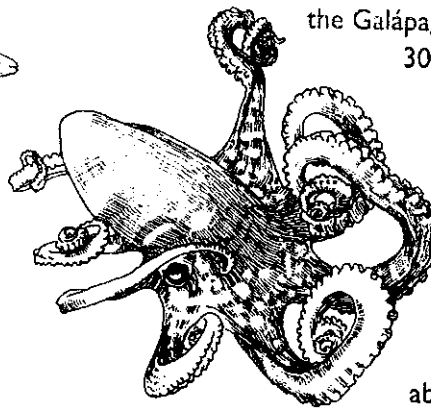


Aided by their keen eyes, they are the principal native predator in the islands. In addition to land animals such as marine iguanas, they also eat the young of other seabirds, such as boobies and flightless cormorants. Galápagos hawks are also scavengers, feeding on virtually any dead animal. These birds have no native natural enemies.

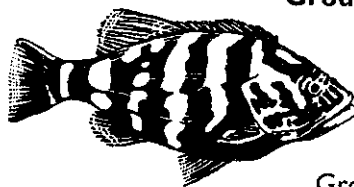
TROPHIC LEVEL 4



Squid are bottom-dwelling carnivores that, like octopi, can change the color of their skin to blend in with their surroundings. Squid are also known for their ability to squirt a potential predator with "ink" and escape backwards by forcing water from a siphon near the head. Unlike their octopus relatives, squid are not solitary creatures. They swim in schools and will frequently follow the schools of fish on which they feed. Shark, fur seals, sea lions, and sea birds such as penguins prey upon squid.



The **octopus** is a bottom dweller that, in the Galápagos, can grow to about 30 cm. They can change color quickly to blend with the background and are difficult to see. Their untidy dens are easy to locate, however, because they leave empty seashells strewn about after eating. They eat small fish, crabs, and shellfish. Octopi are eaten by cormorants and groupers.



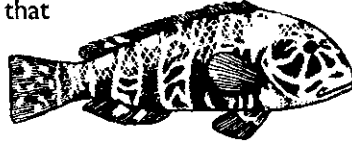
Groupers can grow to more than 1 m in length. They prey upon small and medium-sized fish, crabs, and crustaceans such as shrimp and lobsters.

Groupers are eaten by sharks.

GALÁPAGOS MARINE ORGANISMS

TROPHIC LEVEL 4

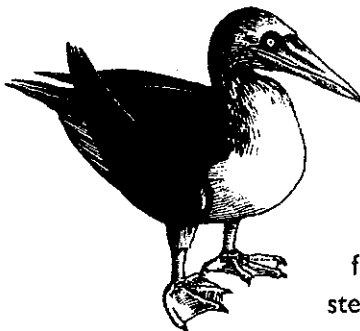
Hieroglyphic hawkfish feed on small fish and crustaceans such as Sally Lightfoot crabs. They are medium-sized, shy creatures that tend to hide in coral reefs. From the coral, they use their pectoral fins to "sit up" and watch for prey. When they spot their prey, they swoop down and devour it quickly. The name *hawkfish* comes from this swooping hunting behavior. These hawkfish are blue-black with a camouflage of bluish stripes and brownish bands that look like hieroglyphics.



Galápagos penguins, which grow to about 36 cm tall, nest in holes along the shoreline. They cannot fly in the air, but seem to "fly" in the water using their greatly modified wings like paddles. Their swift underwater swimming allows them to catch small schooling fish. Food supply regulates the population of penguins in the Galápagos; when schooling fish or crustaceans are scarce, juvenile penguins cannot survive. Occasionally penguins are eaten by sharks, fur seals, and sea lions, but most die of starvation.

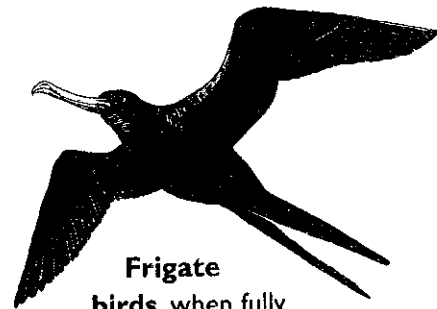
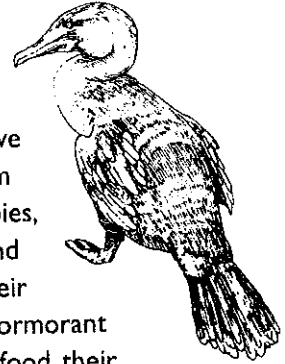


Blue-footed boobies are excellent fliers that feed on fish from the near-shore waters to a few km offshore. They frequently catch fish by folding their wings and diving down into the ocean from great



heights. Their nests are on land, and hawks prey upon the chicks. When offshore fish are scarce, many young chicks die from lack of food. The adults are harassed by the frigate bird, which tries to steal their fish.

Flightless cormorants have very small wings and cannot fly, but they have thick, muscular legs adapted for swimming. They chase and catch octopus and small schooling fish that live within 10–15 m from shore. Like the boobies, they nest on land, and hawks prey upon their chicks. If the adult cormorant cannot find enough food, their chicks die. Sharks sometimes prey upon the adults.



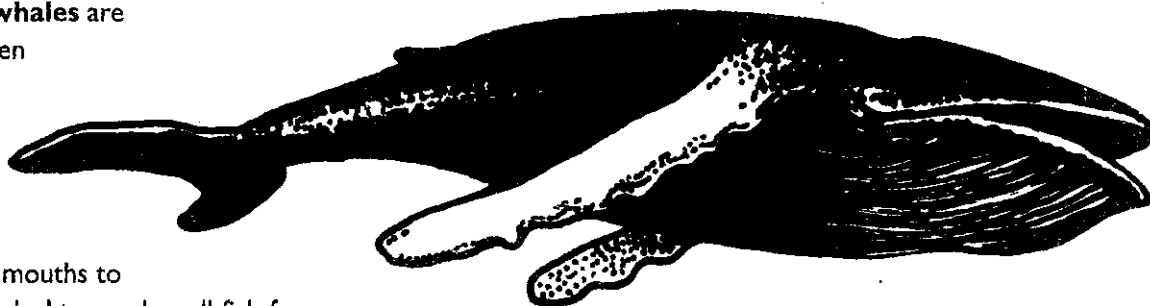
Frigate birds, when fully grown, are about 1 m long with a 2 m wingspan, but weigh only a little over 1 kg. The frigate bird can use its long, pointed wings and forked tail to make sharp spiral turns and dive at great speeds through the air. Because of their habit of stealing fish caught by boobies and other birds, these graceful birds are sometimes described as parasites. They occasionally do their own fishing, however. Their population size is regulated by food supply.

ACTIVITY 10: GALÁPAGOS MARINE FOOD WEB

GALÁPAGOS MARINE ORGANISMS

TROPHIC LEVEL 3

Humpback whales are toothless baleen whales. They gulp in huge quantities of seawater, using baleen plates in their mouths to strain out zooplankton and small fish for food. Humpbacks winter in subtropical waters, where they breed, and summer in cooler waters. They prefer coastal waters and shallow banks. When they travel from summer to winter grounds, they swim in herds led by a large male. The humpback can grow to 15 m in length and weigh more than 900 kg. The killer whale is its natural enemy, preying upon its young.



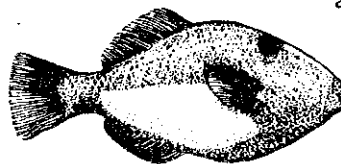
Red-lipped batfish have broad, flat heads and slim bodies and are covered with hard lumps and spines. They grow to approximately 36 cm



long and are characterized by their vivid red lips.

Batfishes are poor swimmers. Instead of swimming, they usually use their thickened, limb-like fins to walk on the sandy bottom. Batfishes have a long "snout" with whitish bumps. They use this bumpy protrusion as "bait" to catch prey such as small fish, small mollusks, clams, and worms.

Triggerfish have characteristic dorsal spines. When a triggerfish is chased into a rock or reef crevice by a larger, predatory fish, it opens its spines to wedge itself in place. The open spines not only make it difficult for the predator to dislodge the triggerfish, but also make the prey painful to swallow. Triggerfish eat sea urchins, algae, coral, crabs, and starfish.



Anchovies and sardines are small fish that normally live in the open ocean. They feed on zooplankton. When the zooplankton drift close to shore, these fish follow



their food into shallow waters. Anchovies and sardines are food for some large fish species, penguins, and boobies.

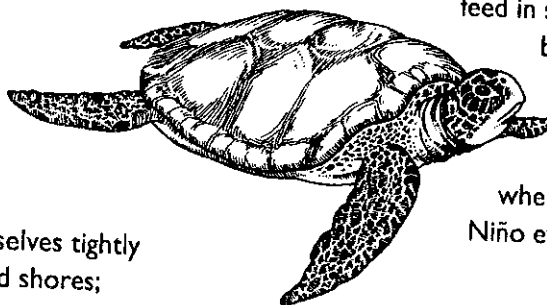
ACTIVITY 10: GALÁPAGOS MARINE FOOD WEB

GALÁPAGOS MARINE ORGANISMS

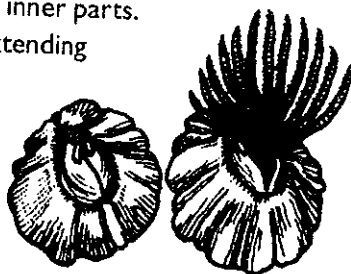
TROPHIC LEVEL 3

Sea turtles are air-breathing reptiles that come ashore to reproduce, but spend most of their lives at sea. They feed in shallow coastal waters, foraging for ulva, but also eating jellyfish and crustaceans.

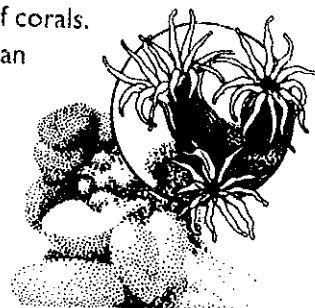
They sometimes migrate great distances in search of ulva beds. Like marine iguanas, green turtles starve when ulva becomes scarce during an El Niño event. Sharks prey upon green turtles.



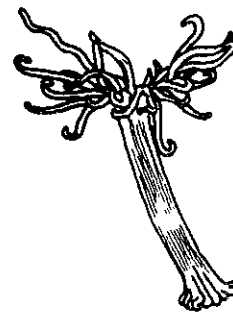
Barnacles cement themselves tightly to rocks on wave-pounded shores; sometimes they attach themselves to living whales. By attaching themselves to whales, they are easily transported to new food areas. Barnacles are small, ranging from 1 to 3 cm in diameter. The barnacle's hard outer shell is made up of overlapping calcium plates around a central opening, which can be closed tightly to protect their soft inner parts. Barnacles feed by extending appendages out of their shell and waving them about to trap small animals and fragments of food; they filter zooplankton and small food particles from the water. Birds prey on barnacles.



Coral polyps, organisms that look like tiny sea anemones, secrete a hard, calcareous skeleton. Coral reefs are made up of colonies of corals. In the Galápagos, a coral head can be as small as a golf ball or as large as a house. Coral polyps use their tentacles to reach out and capture zooplankton for food. Symbiotic algae, called *Zooxanthellae*, live in the tissue of the polyps and benefit the coral by producing additional food as well as oxygen for the polyps to use. One type of sea urchin and a number of fish feed upon the coral polyps.



Sea anemones are entirely soft-bodied animals that attach themselves to rocks. They resemble flowers or miniature palm trees because of the circle of waving tentacles that surrounds their central stalk. Anemones have a symbiotic relationship with juvenile damselfish. They live within the anemone's tentacles, which offer protection to the fish. The damselfish's bright colors attract other fish to the anemone, which it then kills. The anemone and the damselfish both eat the captured prey. Anemones are active carnivores that wave their tentacles to attract and capture zooplankton. Fully extended, anemones in the Galápagos reach 6 cm in height and 3 cm in diameter.



ACTIVITY 10: GALÁPAGOS MARINE FOOD WEB

GALÁPAGOS MARINE ORGANISMS

TROPHIC LEVEL 2

Marine iguanas live on the rocky shores, but dive in the near-shore water to depths of about 10 m to dine on the green seaweed ulva. When the ulva become scarce after an El Niño event, the marine iguanas try eating ceramium. Many iguanas starve because the ceramium does not fulfill their nutritional needs. Galápagos



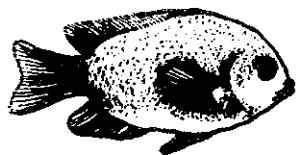
hawks prey upon marine iguanas on land, and occasionally sharks eat them in the water.

Sally Lightfoot crabs, so named because of their speed and agility, live on shoreline rocks both above water and to depths of about 1 m. Their flat bodies are well adapted to living in a high wave area.



These small crabs feed on algae and in turn are eaten by some birds and fish. Adults are bright red, but the black color of the juveniles provides them somewhat greater protection from predators.

Damselfish grow 7–25 cm long and are sometimes described as “algal gardeners” because of the way they stake out and defend their home territories. The males chase away other herbivorous fish, including other damselfish. They also pick up herbivorous sea urchins and move them away from the algal mats. They eat different types of algae including ulva and ceramium. Juvenile



damselfish have a symbiotic relationship with sea anemones, and they use the

anemones' tentacles to protect themselves from their predators: larger fish and seabirds.

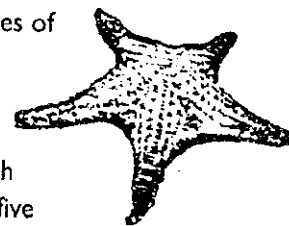
Parrotfish, so named because of its blue-green color and parrot-like beak, grows up to 1 m in length.

It uses its beak to bite off and crush chunks of coral from reefs.

Parrotfish are herbivores because although they “eat” coral, in fact they only digest the algae coating on the coral, passing the broken remains of the coral through their digestive systems. They also eat ulva and ceramium. Despite their powerful beaks, they are gentle fish and creatures of habit that swim in schools along set feeding routes. They are food for larger predatory fish and sharks.



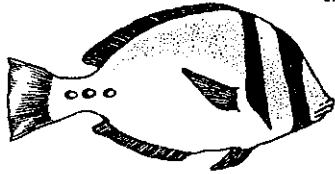
Sea stars and sea urchins, relatives of the crab, move about in large numbers over the submerged rocks and corals, searching for coral polyps and attached algae, such as ceramium, to eat. Sea stars have five rays (arms) arranged around a central mouth that is located on its underside. Tube feet help them hold onto rocks and move about in the water. Calcareous algae are their preferred food. Sea urchins have thick spines encasing and protecting their bodies. Like sea stars, they have mouths on the underside and tube feet. Predatory fish, such as triggerfish, eat both.



GALÁPAGOS MARINE ORGANISMS

TROPHIC LEVEL 2

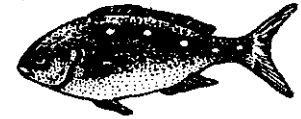
Surgeonfish, notable for their beautiful color, grow to 25 cm in length and have one or two sharp spines on



their sides. They swim together in small schools, aggressively chasing other herbivorous fish away from their territory. They feed on

algae within a set area and predatory fish eat them.

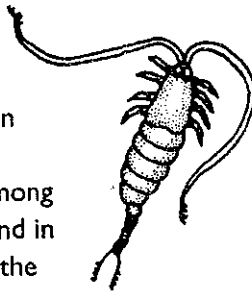
Five-spotted anthias are small gray fish with up to five white spots on the side. They travel in large schools and feed on plankton. They are eaten by other fish, squid, or birds such as the penguin or flightless cormorant.



Zooplankton are animals that float or swim very weakly. Some zooplankton, like copepods, krill, and some jellyfish, remain as floating plankton all their lives. Others, like tiny **fish larvae**, eventually outgrow their early planktonic stage. As they drift, the zooplankton feed on phytoplankton and other zooplankton. Zooplankton are eaten by many organisms from higher trophic levels.



Copepods, at approximately 0.5–2 mm in length, are a smaller relative of crabs and lobsters and the most abundant group among marine **zooplankton**. The copepods found in the Galápagos are parasites that feed on the host tissue of almost every major animal group, including sponges, corals, fish, and mammals. Copepods, in turn, are a food source for many species of fish that eat zooplankton.

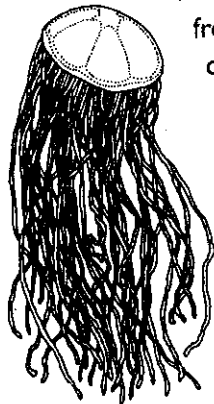


Krill are shrimp-like **zooplankton** that range in size from 8 to 60 mm. Most are bioluminescent (emit light), making them visible at night. These planktonic crustaceans feed

on phytoplankton.



They are a primary food source for penguins and are also eaten by various fish, birds, and whales.

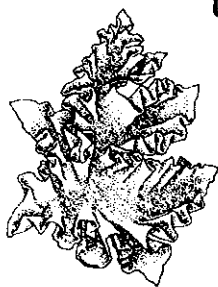


While adult **jellyfish** in the Galápagos range in diameter from about 2 to 40 cm (though some species are considerably larger, with diameters of up to 2 m), until they reach their adult size, juvenile jellyfish are microscopic and sometimes considered part of **zooplankton** because they are microscopic, free-floating animals. Some jellyfish filter-feed on phytoplankton and zooplankton, while others eat small fish that they catch in their tentacles. The tentacles have stinging cells (nematocysts) that poison and paralyze captured prey. Large fish and sea turtles feed on jellyfish.

ACTIVITY 10: GALÁPAGOS MARINE FOOD WEB

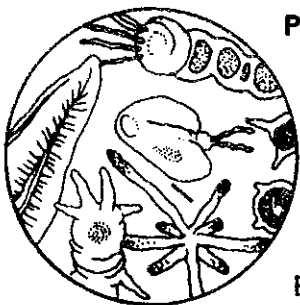
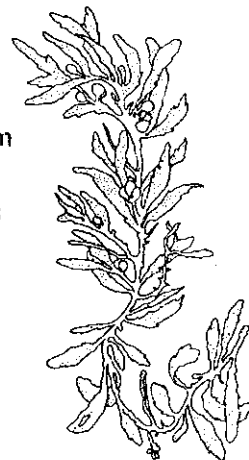
TEACHER SECTION

TROPHIC LEVEL 1



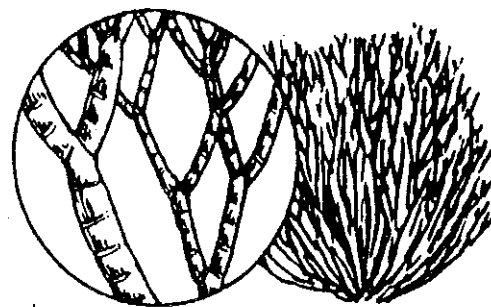
Ulva is a fast-growing green algae found from the shoreline to depths of about 8–10 m. When fully grown, ulva looks like seaweed or loosely arranged lettuce leaves; it is often called “sea lettuce.” Ulva is the favorite food of the marine iguana and an important food for turtles, as well as for damselfish and many other herbivorous fish. Thus ulva is usually found in the Galápagos looking more like mowed grass than like lettuce. The herbivores keep it cropped to about 2 cm. Warm water and a lack of nutrients during the El Niño almost wiped out the ulva population, depriving many herbivores of their primary food.

Sargassum is a brown seaweed averaging about 15 cm in length. It has characteristic air sacs that support it in the water. Although it is abundant, many organisms do not eat it because it contains toxic substances.



Phytoplankton are the very abundant but tiny (less than 1 mm) algae and plant-like organisms that drift in the ocean. Phytoplankton live near the surface, using sunlight, carbon dioxide, and water to produce food and oxygen. When they are deprived of nutrients, however, as they are in El Niño years, their numbers decrease, affecting the entire food web. Phytoplankton provide food for zooplankton and other, larger, organisms.

Ceramium is a small (5 mm) filamentous red algae that provides food for damselfish, surgeonfish, parrotfish, some sea stars, and snails. When ulva are almost wiped out by an El Niño, marine iguanas start eating ceramium, but these red algae do not provide all the nutrients the iguanas need.



Galapagos Ocean Food Web Rubric

Trophic levels numbered & labeled	5_____
Arrows point in right direction	5_____
Food web diagrammed correctly with arrows	5_____
Names of organisms on food web	5_____
Neatness	5_____
Questions	5_____
Total (30 possible):	_____

Galapagos Ocean Food Web Rubric

Trophic levels numbered & labeled	5_____
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Total (30 possible):	_____