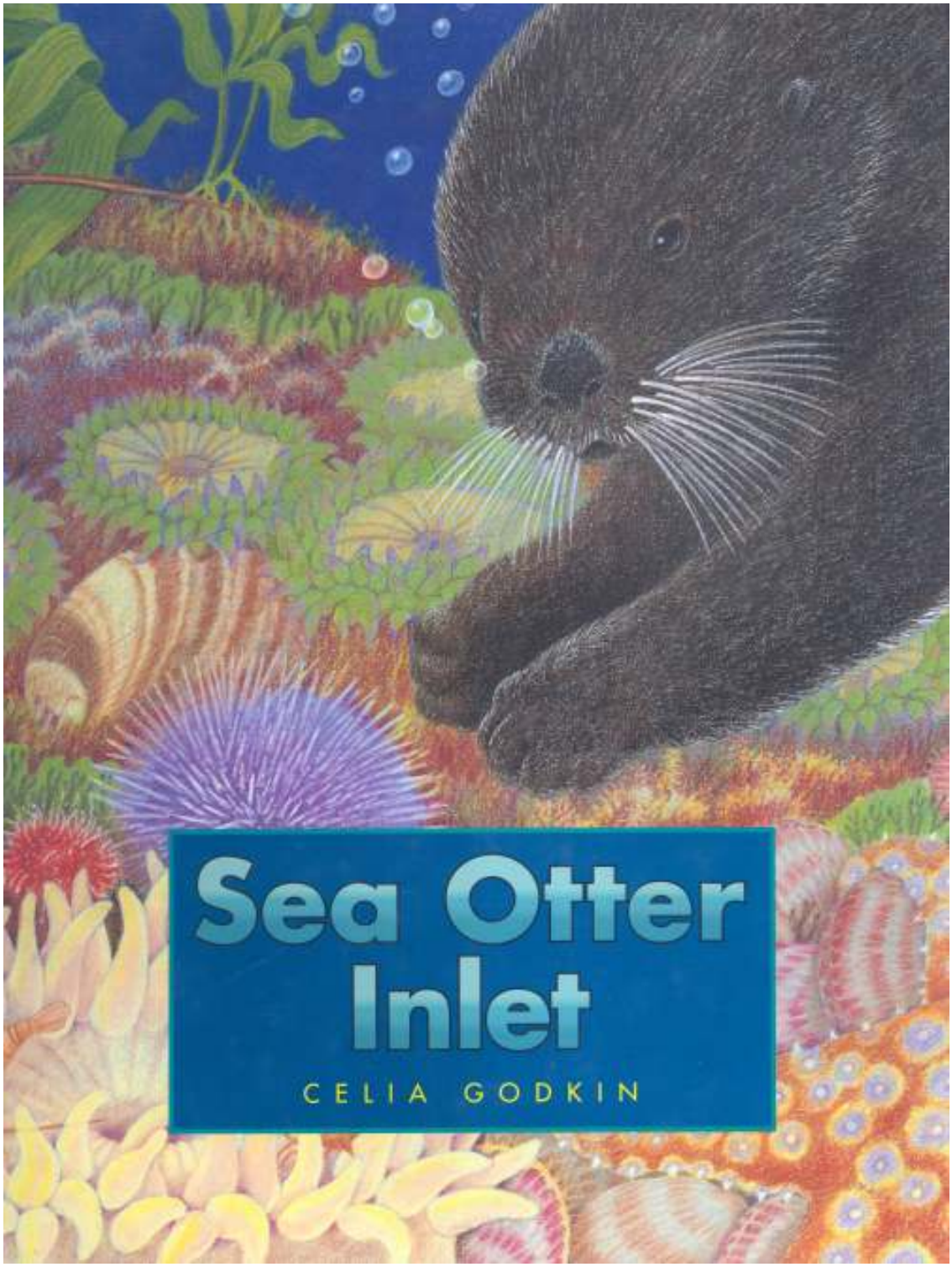


INFORMATION GUIDE

PAGE BY PAGE NOTES:

p. 1/2 *In a long arm of the sea,*
hemmed in by land on either side...

This is a description of an inlet. In Norway they are called fjords (fee-ords), but this story takes place on the West Coast, where they are known as inlets. Sea otters (seen lower left in the picture) may be found alone or in rafts of up to 300 animals. A raft is the correct term for a grouping of otters, but is not used in the story due to the unfamiliarity of the term. The bald eagle flying above is a danger only to young otters - less than a couple of weeks old - which are light enough for eagles to carry off as prey.

p. 3/4 *The sea otters lived their whole lives*
in the waters of this inlet ...

Sea otters eat a variety of shellfish, including abalone, clams, snails and mussels, as well as crabs, squid and octopi (plural for octopus), sea stars, sea urchins and small fish. Their taste for shellfish sometimes brings them into conflict with fishermen who harvest the same food items.

The otters dive down to the sea floor to collect their food. They usually live in areas where the sea floor is 20 m. (60 feet) deep or less, but they can dive as deep as 40 m. (120 feet). They may pick up a rock off the bottom and use it like a hammer to dislodge a shellfish. Food and rock will be carried up to the surface, where the otter floats on its back, placing the rock on its belly and using it as an anvil on which to smash open the shellfish. Sea otters are one of the very few tool-using animals; others include chimpanzees, dolphins, some birds and, of course, ourselves.

The birds perched on the rocks in this picture are cormorants. They are fish-eating birds and, like the otters, they dive for their suppers. The presence of many cormorants indicates that fish are plentiful.

p. 5/6 *After a meal of these delicacies,*
the otters groomed themselves with great care.

Unlike other marine mammals (whales, dolphins, seals and sea lions) sea otters lack a thick layer of blubber in the skin, as insulation against the cold ocean water. Instead, they have the thickest fur of any mammal; as many as one million hairs per square inch - ten times in one square inch what the average person has on their entire head. The otter's thick fur traps a layer of air bubbles, which not only acts as insulation but also provides buoyancy, helping to keep the otters afloat. In order to maintain this vital layer of air bubbles, the fur must be kept very clean, and otters spend a great deal of time grooming themselves, especially after eating. Their bodies are very flexible, and they can reach every part of themselves.

p. 7/8 *One day the otters awoke from their nap*
to find hunters all around.

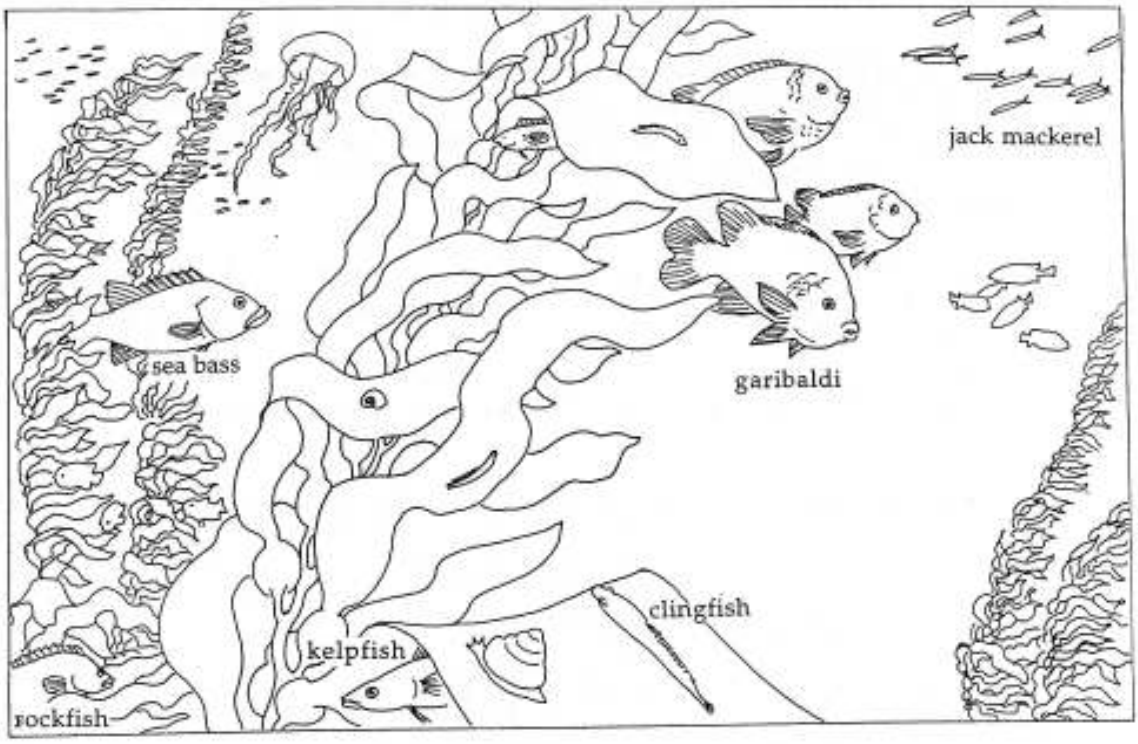
Native peoples of the Pacific rim hunted sea otters for many thousands of years without seriously depleting their populations. Then, in the 18th century, Russians discovered that thick, luxurious, sea otter fur could fetch high prices, and widespread commercial hunting began. The Russians claimed Alaska, enslaving the native Aleuts and forcing them to use their expert skills to hunt otter. Within fifty years Alaskan sea otters were nearly exterminated, and the hunters moved south, where they were joined by the Americans and English.

p. 9/10 *The otters dived to escape the hunters.*

Like us, otters are air breathing mammals, and they exhale bubbles of air when swimming underwater. They can stay below the water for no more than four or five minutes before they must come up for air.

p. 11/12 *One by one,*
the otters were hunted and killed ...

It is estimated that, from 1786 -1868, during the peak years of the sea otter hunt in California, more than 200,000 otters were killed. Once abundant, and with a range which originally extended all the way around the north Pacific rim, from Mexico to Japan, sea otters were hunted almost to extinction. The hunt only stopped when there were so few of them left that it was no longer profitable.



p. 13/14 *There were clingfish ...*

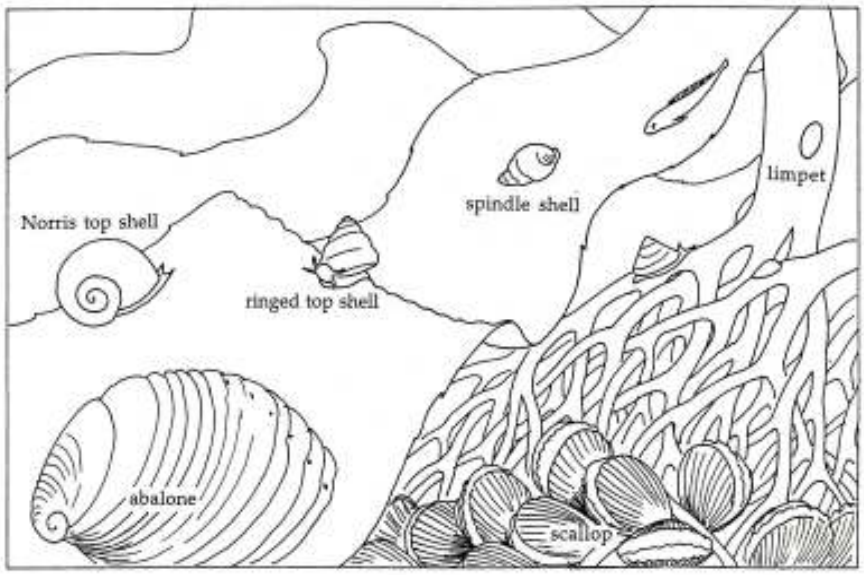
Clingfish have an adhesive suction disc on their undersides, with which they cling to the kelp, hiding from the larger fishes which eat them. Kelpfish use the kelp both for concealment and ambush. They are shaped and coloured to resemble kelp blades, and sway with the kelp fronds, making them nearly invisible to predator and prey alike. In addition to eating smaller fishes such as clingfish, kelpfish also eat small crustaceans (shrimps) and shellfish. Sea bass and rockfish swim through the kelp, looking for smaller fishes to pass within striking range. The giant sea bass grows to a length of 2.25 m. (7 feet) and passes through three quite distinctive colour phases as it matures; the young are red with dark spots, junior adults (illustrated here) are brown with dark spots, adults uniformly dark.

In addition to the fishes described here, there are over a hundred more fish species living in the kelp forest, of which the bright red garibaldis are perhaps the most conspicuous. They can afford to be, for they are not good to eat and have little to fear from predators. Garibaldis eat a variety of invertebrates. (An invertebrate is any animal, which lacks a backbone: for more information, see the follow-up section on zoology.)

p. 15/16 *The kelp forest was made of giant seaweeds ...*

There are many species of giant seaweed or kelp. The two depicted here are giant kelp and bull kelp. Giant kelp is the largest aquatic plant in the world, and one of the fastest growing, reaching lengths of 60 m. (200 feet) or more, and growing at a rate of 45 cm. (18 inches) per day. Bull kelp grows to about half this size.

Picture yourself swimming around in a kelp forest; the kelp is as tall as any tree, but the plants move and sway continuously in the currents. It is a forest of dancing trees.

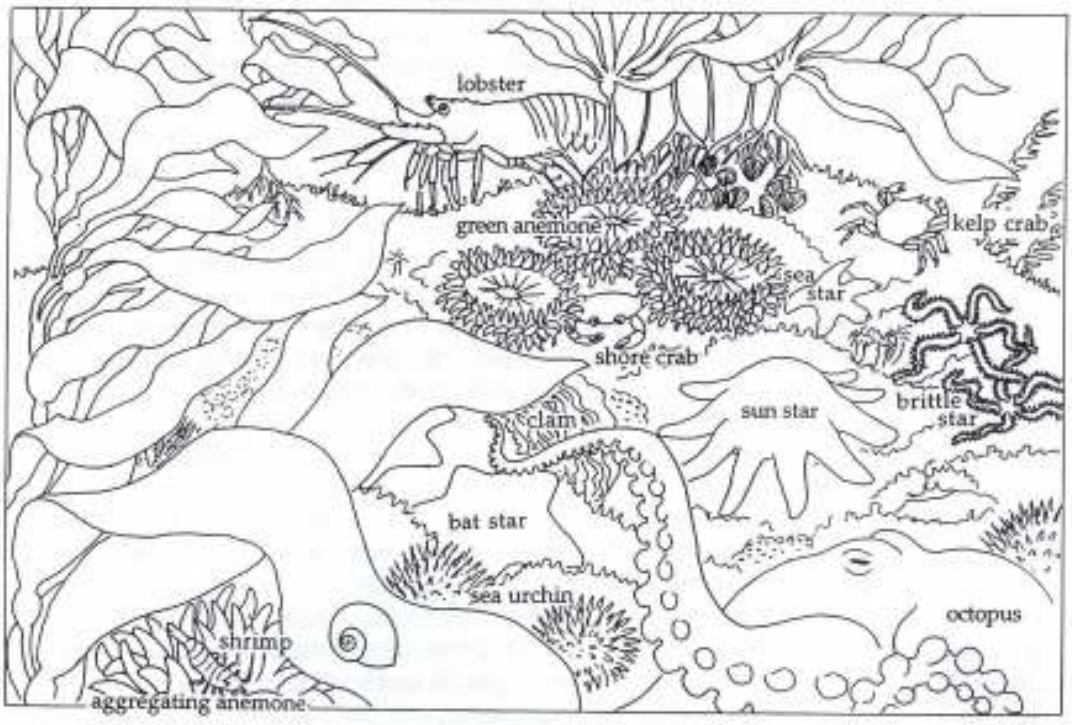


p. 17/18 *Living on the bottom ...*

This page shows a detail from the lower left of the previous page. The large shellfish bottom left is the red abalone, which grows up to 30 cm, (one foot) in length and is highly prized both for its pretty shell and as food, both for humans and sea otters. All the shellfish depicted here are mollusks (phylum mollusca: a phylum, pronounced fy-lum, is the largest animal grouping). The mollusks are divided into a number of sub-groups, or classes, three of which are illustrated in *Sea Otter Inlet.*

Mollusks with a single shell belong to the class gastropoda (gastropods). These include limpets and abalones which live under cup-shaped shells and top-shells and spindle-shells which live in coiled shells, like snails. The bivalve mollusks (class bivalva), live between two shells, held together by a hinge on one side, which allows them to open and close the shell at will; open for feeding or closed for protection. These animals are filter feeders, filtering out microscopic plants and animals from the surrounding sea water. They are here represented by the scallops, and in the following pages by clams and mussels.

You may be surprised to learn that the octopus which appears on the next page is also a mollusk, belonging to the class cephalopoda (cephalopods). This is the giant Pacific octopus, which reaches 5 m. (16 feet) in length when full grown, clearly too big for an otter to eat. However, their young and other, smaller species of octopi are eaten by otters.



p. 19/20 *There were flower-like sea anemones ...*

Sea anemones may look like flowers, but they are in fact animals, relatives of the jellyfish (see page 13) and corals. Their bodies are sac-like, with a single opening at the top, surrounded by a ring of tentacles. The tentacles are used to draw food into the mouth opening, and they bear stinging cells which paralyze prey animals coming within their reach.

The little clown shrimp (bottom left) is not, however, in danger of being eaten by the aggregating anemone in which it is nestled, for these two animals live together amicably in a symbiotic relationship. The shrimp lures prey in range of the anemones stinging cells, but is not itself stung. Instead it receives shelter and protection from the anemone.

Relatives of the shrimp pictured on this page are the lobster and crabs. All are crustaceans, the marine representatives of the joint-legged animals or arthropods (phylum arthropoda) of which the insects and spiders are the dominant terrestrial forms.

Sun stars, sea stars, brittle stars and sea urchins are all echinoderms (eh-kine-o-derms: phylum echinodermata), the only animal group which has five-part (pentamerous) symmetry. This may not be obvious in the case of sea urchins, but if you examine a sea urchin skeleton, you will find five lines which mark the position of pores, through which tiny sucker-like tube feet are extended. These are what moves the sea urchin along, not the spines. In living sea urchins these features are obscured by the spines, which drop off after death, leaving a rigid spherical skeleton.

In addition to the anemones, there are many other animals which resemble plants, including porous sponges and dense mats of moss animals. In between these, the sea floor is covered with a dense carpet of plant life; dull brown or olive green branching sea weeds; green and leafy sea lettuce; brightly coloured corraline (coral-like) algae.

p. 21/22 *For a long long time life in the kelp forest went on ...*

The fish with blue spots is the kelp greenling. A little above the kelp greenling is an interesting animal; the hermit crab. Interesting because, unlike other crabs, it has a soft body that it protects by inserting it into a convenient sized empty mollusk shell. As the crab grows larger, it replaces its shell with progressively larger ones. Some, like this one, acquire an anemone on top. The anemone benefits from bits of food discarded by the hermit crab living beneath, and the hermit crab in turn is protected from predators by the stinging cells of the anemone. One of the chief predators of the hermit crab is the Pacific rock crab - also illustrated this page, just above the hermit crab.

hermit crab

p. 23/24 *The spiny purple sea urchins multiplied and multiplied.*

Besides sea otters, only one kind of fish, the sheepshead, is equipped to eat sea urchins. But, like sea otters, these fish are rare. In the absence of predators, sea urchin populations grow steadily over time (50 years) and may reach a density of 300 animals per square meter (yard). The mass of urchins then move over the sea bed, grinding everything in their path, severing kelp at its base and setting the whole kelp forest adrift. The devastation they wreak is akin to clear-cutting a forest.

p. 25/26 *The kelp washed ashore and rotted on the beaches.*

Kelp which is not anchored will sooner or later end up on the shore, and with it the animals which live attached to it. This provides a great feast for shore birds like the herring gull, as well as many small beach animals (mostly crustaceans) who make a living by scavenging among the seaweed and debris washed up on the beach.

The large iridescent shell, lower right, is the inside of an abalone. Other shells shown here, from left to right, are the Pacific pink scallop, Lewis' moon shell, blue mussel, Norris top shell, another pink scallop and, next to the crab claw, a limpet.

p. 27/28 *Those animals that lived on the bottom,*
under the kelp, had no place to hide.

The schooling fish in the foreground are jack mackerel. They are being chased by sea lions. Sea lions, like sea otters, are air breathing mammals which must go to the surface for air. Like otters, they leave a trail of bubbles when they dive. Can you see how sea lions are different from otters?

A shark lurks in the background. The great white shark of "Jaws" fame, which grows to 6.4 meters (21 feet) in length was, until recently, the chief predator of sea lions, and also of sea otters. Below the shark are bat rays. Bat rays have venomous tail spines, which can inflict a painful sting. Both sharks and rays are fishes, and can breathe in water, so there are no tell tale bubbles. But they differ from all the other fishes in our story in having skeletons made of cartilage, not bone, and they have a series of external slits, or gill openings, instead of just one.

p. 29/30 *Then one day a wonderful thing happened...*

In 1911, by which time sea otter populations were thought to be nearly extinct, an international treaty was signed to protect them from further hunting. Since then, their numbers have slowly increased from a world population of one to two thousand, to a present estimated total of 150,000. As otter populations increased, some have re-colonized their former range.

We should not, however, become too complacent about sea otter recovery. Their numbers are still seriously depleted compared with original populations, and because they live on the surface of the water and must keep their fur clean at all times, they are more vulnerable to the effects of an oil spill than other animals. Otters whose fur is contaminated with oil, soon loose the insulating layer of air bubbles and die of cold (hypothermia).

Recently, a new threat to sea otters has appeared in the form of killer whales, which have been observed feeding on them. Killer whales normally feed on seals and sea lions, but the populations of these animals have suffered a serious decline in recent years, possibly due to collapsing fish stocks. Ecologists estimate that, in 500 miles of Alaskan coast these whales may eat around 8,000 otters a year. In the last twenty years of the 20th century, otter populations have declined to one tenth of their former numbers in some areas, with resultant loss of kelp forest habitat due to destruction by sea urchins.

p. 31/32 *The otters dived in the waters of the inlet.*

Though sea otters as a species have a very varied diet, individual otters show preferences for only two or three kinds of prey, which they specialize in. Otters who favour purple sea urchins eat so many over their lifetime that their teeth, skull and skeleton become stained purple.

p. 33/34 *Gradually, very gradually,*
as the otters ate more and more ...

The extermination of the sea otter had a major impact on what had previously been a very profitable industry, the harvesting of kelp. Kelp is the source of algin, a substance used in food products such as ice cream and beer, and in the manufacture of a whole range of products from drugs to textiles to paint and paper products. Due to careful management, this industry is now in a state of recovery.

p. 35/36 *Once again, there were clingfish ...*

Using the previous illustration as a guide, can you identify the animals in this picture? In addition to the fishes mentioned in the text, there are red garibaldis and schooling fish, which could be rockfish or jack mackerel.

p. 37/38 *There were all kinds of shellfish ...*

Sometimes, when a major disruption of a habitat occurs, such as the one described in *Sea Otter Inlet*, it is recolonized by different species. This picture shows one animal not previously seen; the northern horse mussel, lying just below the large frond of kelp. The fish at the back, which you may not recognize, is our old friend the black and yellow rockfish - seen front view instead of side view (p. 13/14), and the small red and white club-tipped or strawberry anemones are seen close-up for the first time (they are shown p. 19/20 in the background).

p. 39 *There were even*
Some spiny purple sea urchins ...

Every animal has a role to play in the environment in which it lives. Sea urchins only become a problem when their natural checks and balances are removed.

FOLLOW UP ACTIVITIES

1) THE DANCING KELP FOREST – AN EXERCISE

For this exercise, you will need a CD or tape of appropriate music; something gentle but rhythmic, and of course, something to play it on. There are many "New Age" relaxation tapes on the market which work well. If you can precede this with a video tape of kelp forest, so much the better, but this is not essential.

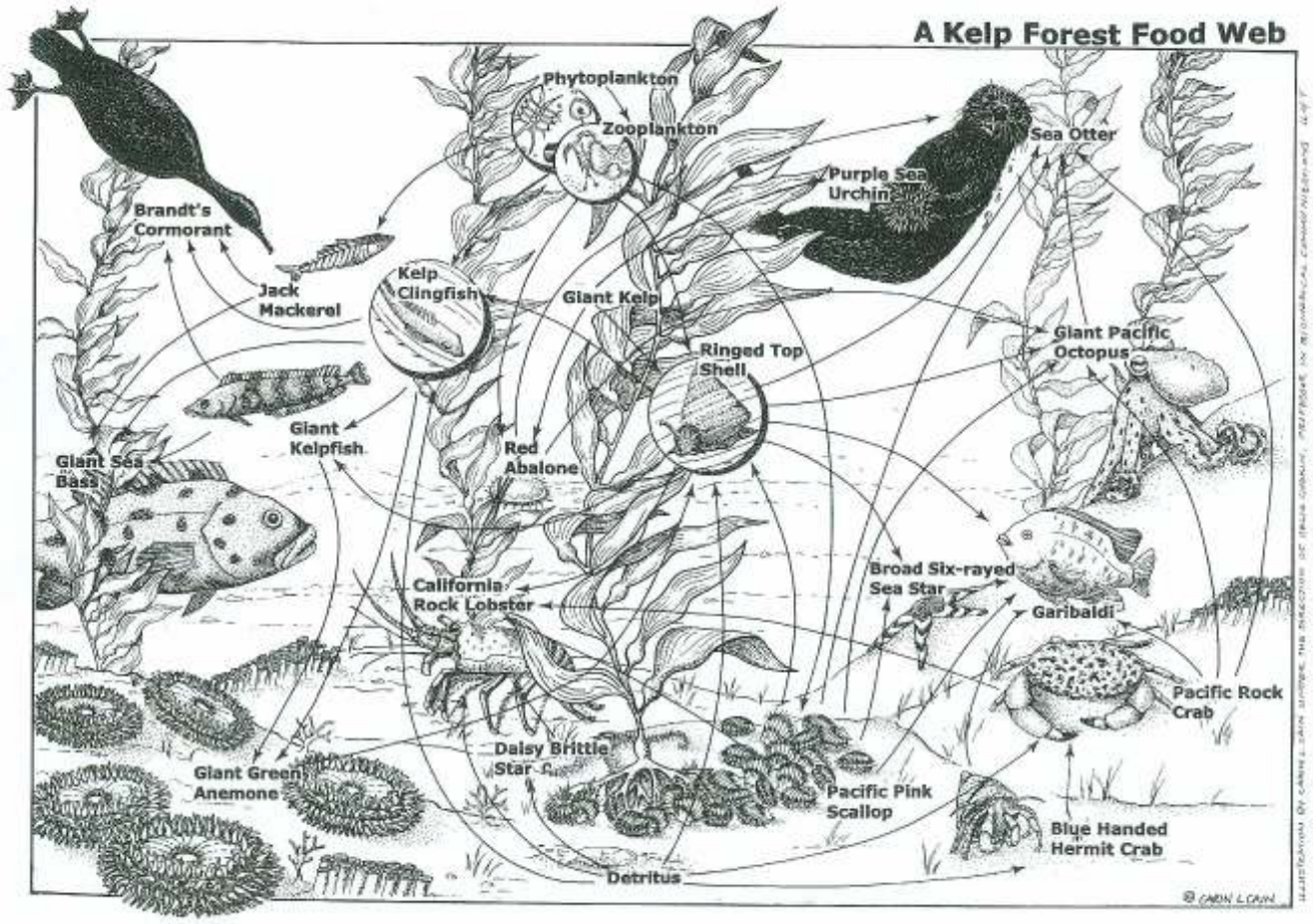
You may wish to do this exercise for the first time after reading *Sea Otter Inlet* to the class, when they have been sitting still for a while and need to stretch. Thereafter it may be used at any time to settle a restless class. In order to keep this fresh, however, it's best to change the imagery and music from time to time.

Ask the children to stand quietly, with their feet slightly apart and eyes closed. Start the CD or tape, and, in a quiet, steady voice, read the following to them, allowing time (indicated by ...) for them to accomplish the suggestions. As you reach the last suggestion, slowly turn down the volume on the CD or tape, until there is no sound.

imagine you are standing on the bottom of the ocean ...
cool blue water is washing over you, pushing gently against you ...
you are a kelp plant ...
your feet are the kelp holdfast, holding you fast to the rock ...
feel how they anchor you firmly in place with the world's strongest glue...
your backbone is the flexible kelp stem, reaching up towards the light ...
feel it swaying gently in the current ...
allow your body to sway gently from side to side with the current ...
your hands and arms are the leaf-like blades of the kelp plant ...
let them reach upward to the light…
feel them fluttering gently ...
picture the little fishes swimming in and out among your fronds ...
feel them tickle your arms as they swim by ...
picture a sea otter exploring the bottom, looking for food ...
watch the sea otter pick up a sea urchin and rise up to the surface with it ...
follow the sea otter up to the surface ...
your head breaks the surface and you are in bright sunlight ...
you may open your eyes when you are ready to return to everyday reality ...

2) A KELP FOREST FOOD WEB

Sea otters eat sea stars. Sea stars eat scallops. Scallops eat plankton. Zooplankton eat phytoplankton. This is a food chain. At the bottom of every food chain there are plants, because plants manufacture their own food, using the energy of sunlight. In this example the plants are minute floating algae called phytoplankton. These are eaten by herbivorous zooplankton, minute floating animals of many different kinds, including crustaceans and larval fishes and invertebrates. Next in this food chain are the filter feeding scallops, omnivores because they ingest both plant and animal plankton. At the top of the food chain are the carnivores, in this case sea stars and sea otters. When any of these plants or animals die, their bodies decompose, forming detritus that is eaten by animals such as brittle stars and hermit crabs. Thus nothing in nature is wasted and everything is recycled.

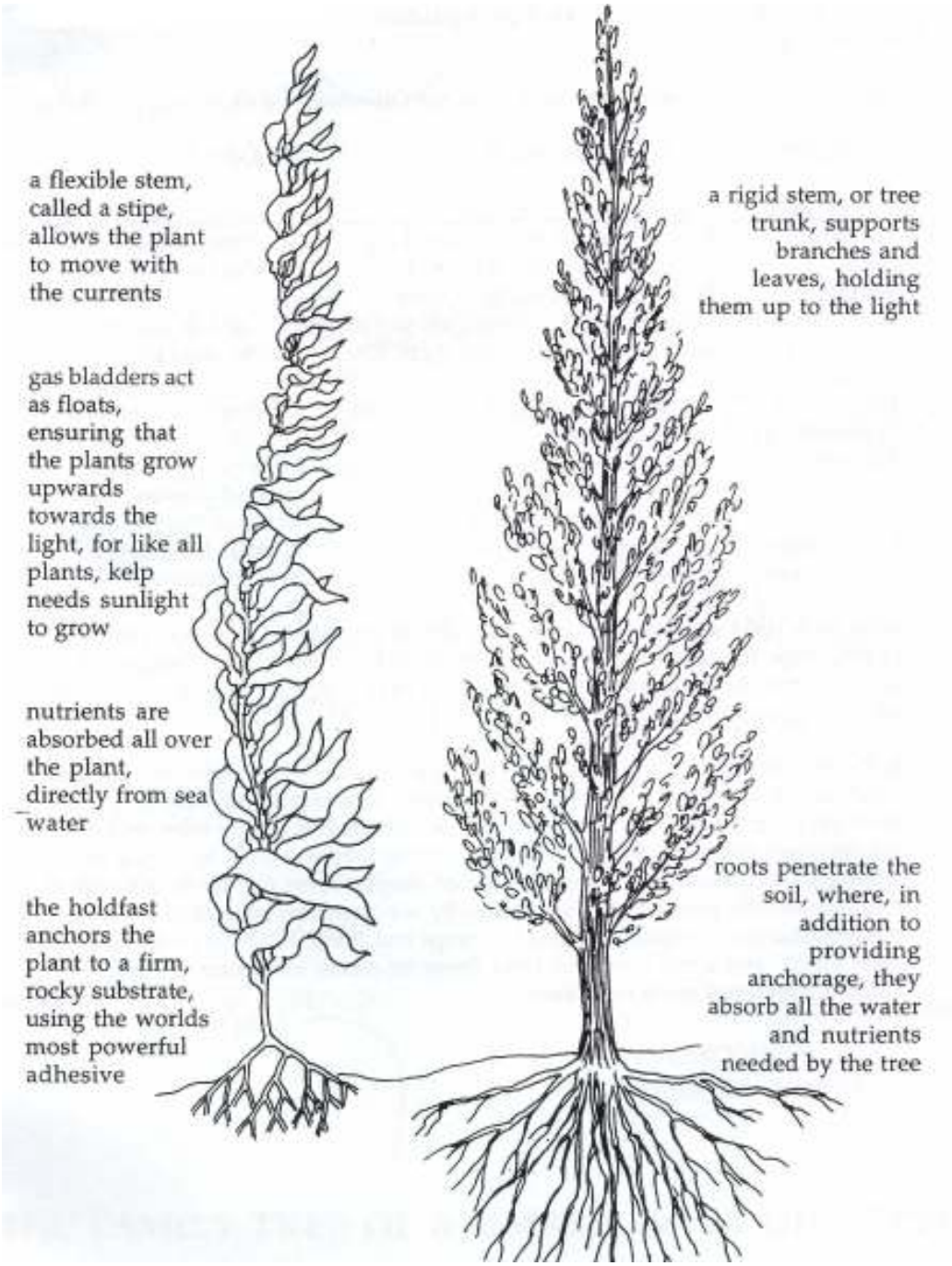


The illustration above shows how, in a natural environment, food chains are linked together into a food web. For simplicity's sake, only a small sample of the animals which live in the kelp forest are depicted; a real life food web would be far too complex to describe in a single illustration. The arrows go from the plant or animal being eaten to the animal that eats it. Trace the various food chains through the web, and see how everything is interconnected.

3) A COMPARISON OF KELP TO TREES

Compare giant kelp with a tree; they are similar in size and both are plants, needing sunlight to provide the energy which fuels them. But they live in very different environments. Study the illustration below to see how many of the differences between kelp and trees are a reflection of the different demands their environments make on them.

KELP TREE



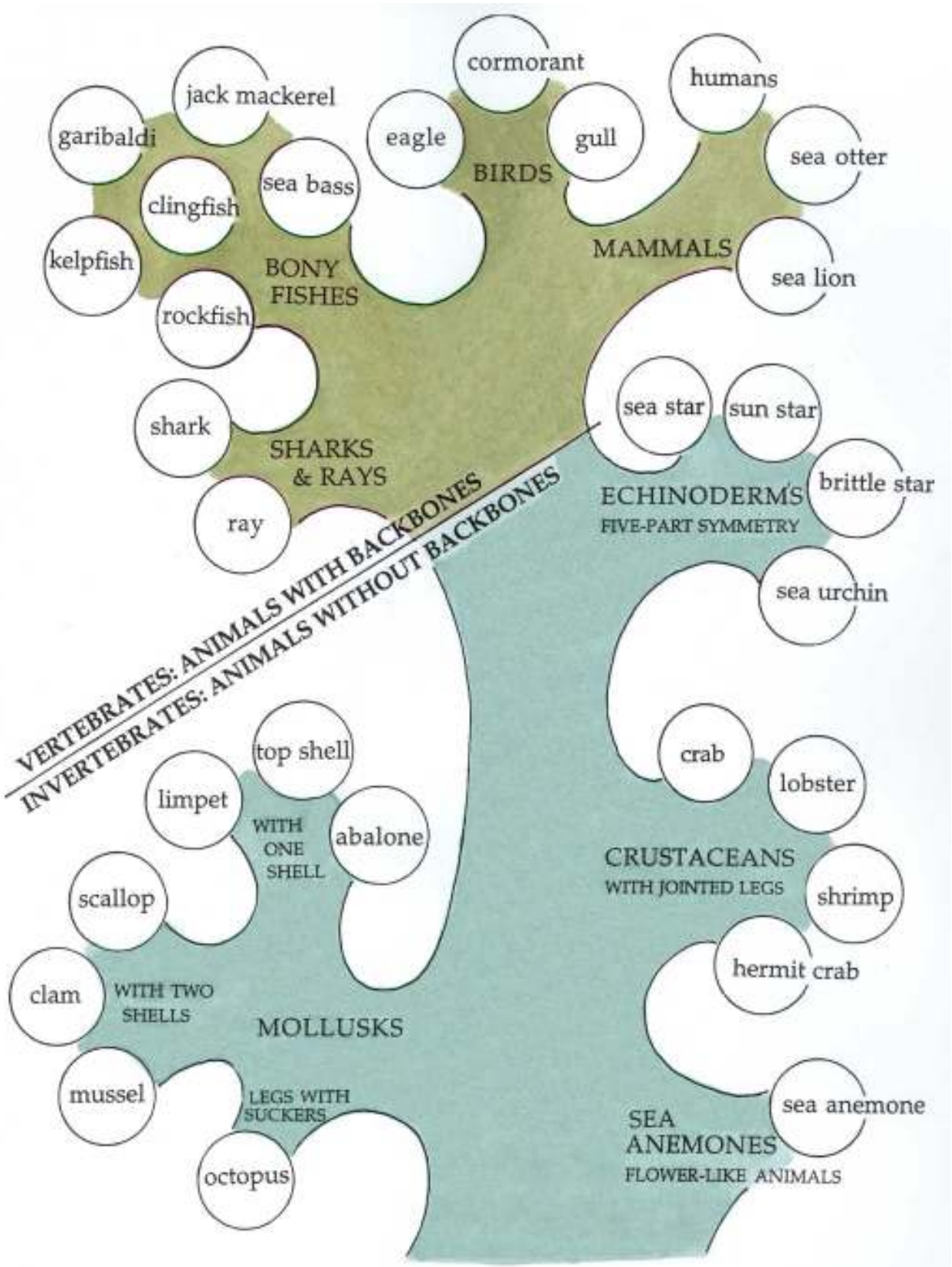
4) ZOOLOGY: THE STUDY OF ANIMALS

Many of the animals in *Sea Otter Inlet* may be new to you, but they are only a very small sampling of the more familiar of the animals which live in the kelp forest, which is only a small sampling of all the animals on earth. Because there are so many different kinds of animal species (and plants too), biologists organize them into a classification system, based on similarities, which are thought to reveal relationships. The animals mentioned or illustrated in *Sea Otter Inlet* are classified as follows:

GROUP	CHARACTERISTICS	EXAMPLES
VERTEBRATES	ANIMALS WITH BACKBONES	
Mammals	four legs, fur or hair, air breathing	sea otter, sea lion, humans
Birds	wings and feathers, air breathing	cormorant, gull, eagle
Fishes	fins, live and breathe in water - bony fish (one exterior gill slit) - cartilaginous fish (many gill slits)	 clingfish, kelpfish, sea bass sharks and rays
INVERTEBRATES	ANIMALS WITHOUT BACKBONES	
Echinoderms	five-part symmetry	sea urchins, sea stars etc.
Mollusks	one shell (cupped or coiled) two shells (hinged together) eight legs with suckers	top shell, abalone, limpet scallop, mussel, clam octopus
Crustaceans	joint-legged marine animals	shrimp, lobster, crab
Sea Anemones	flower-like animals	sea anemones

Give each child an animal to draw from the list provided. Enlarge the family tree shown below and print on a large sheet of paper. (Most copy shops can do this for you.) Cut out the children's drawings and paste in the appropriate place. Write the name of the animal beside it. If there's an aquarium in your area, take the children to see these animals first hand.

A SEA OTTER LUNCH
Some fish markets carry, in addition to fish, many of the items eaten by sea otters: mussels, clams, scallops, oysters, abalone, octopus and squid, shrimps and crabs. Why not cook up a sea otter lunch and serve it to your class? Serve ice cream for dessert: it contains algin, a substance made from kelp.



THE FAMILY TREE OF ANIMALS IN *Sea Otter Inlet*

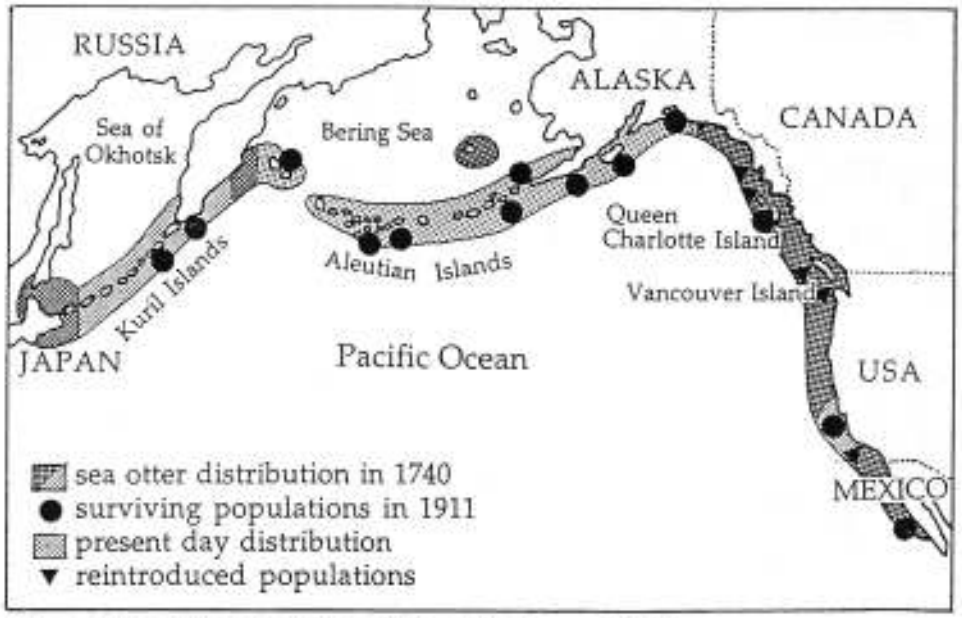
5) MATH QUESTIONS

1) If there are 1,000,000 hairs per square inch in a sea otter pelt, how many hairs are there per square centimeter?

2) Using a dressmaker's tape, measure the number of square centimeters covered by hair on your partner's head.

3) There are approximately 100,000 hairs on the average person's head. Divide this number by the answer from question 2 to get the number of hairs per square centimeter.

4) Now calculate how much thicker sea otter fur is than human hair.
   Express your answer a) as a ratio
   b) as a percentage



Sea Otter Distribution (after Riedman 1990)

6) HISTORY, GEOGRAPHY and NATURAL RESOURCES

During the 18th and 19th century, sea otter fur was one of the most lucrative of West Coast resources, and the sea otter hunt was a prime factor in opening up the West. Use the sea otter hunt as a point of departure for studying West Coast history and geography. Consider how the over-exploitation of natural resources continues today. Clear-cutting of forests is very much like what happens to the kelp forest in *Sea Otter Inlet*. The near-extermination of the sea otter, is very much like the recent collapse of the cod fishery on the East Coast. For more information on the sea otter hunt, see the bibliography.

BIBLIOGRAPHY

SEA OTTERS

Sea Otters: A Natural History and Guide by Roy Nickerson
Chronicle Books, San Francisco, 1984. ISBN 0-87701-567-8

The Nature of Sea Otters: A Story of Survival by Stephani Payne
Greystone Books, Douglas & McIntyre, Vancouver, 1993. ISBN 1-55054-085-8

Sea Otters by Marianne Riedman
Monterey Bay Aquarium, Monterey, California, 1990. ISBN 1-878244-03-5

Zoo Books: Sea Otters by Beth Wagner Brust
Wildlife Education Ltd. San Diego, 1990. ISBN 0-937934-70-4

KELP FORESTS

Kelp Forests by Judith Connor and Charles Baxter
Monterey Bay Aquarium, Monterey, California, 1989. ISBN 1-878244-01-9

The Kelp Forest by Howard Hall
Blake Publishing, San Luis Obispo, California, 1990. ISBN 0-918303-21-4

The Audubon Society Nature Guides: Pacific Coast by Bayard H. McConnaughey and Evelyn McConnaughey
Alfred A. Knopf, New York, 1985. ISBN 0-394-73130-1

SUMMING UP

After reading *Wolf Island, Ladybug Garden* and *Sea Otter Inlet* to your students, ask them how the three stories are alike. Most children see the parallels. They understand that the departure of wolves, ladybugs or sea otters triggers an imbalance in their habitat. They will also see that deer, aphids or sea urchins multiply in the absence of predators and cause problems. They see how the balance of nature may be disrupted by the removal of a single species.

Ask them: who are the good guys and who are the bad guys in each story? They may have difficulty answering this question and being consistent for, while aphids and ladybugs fit our good guy/bad guy stereotypes, wolves and deer do not. In communities where hunting is common practice there may be reluctance to cast the hunters as bad guys, while children raised in cities are more likely to have a negative view of hunting. This makes for an interesting and lively discussion topic, and raises the question: should we even be making value judgments of this sort?