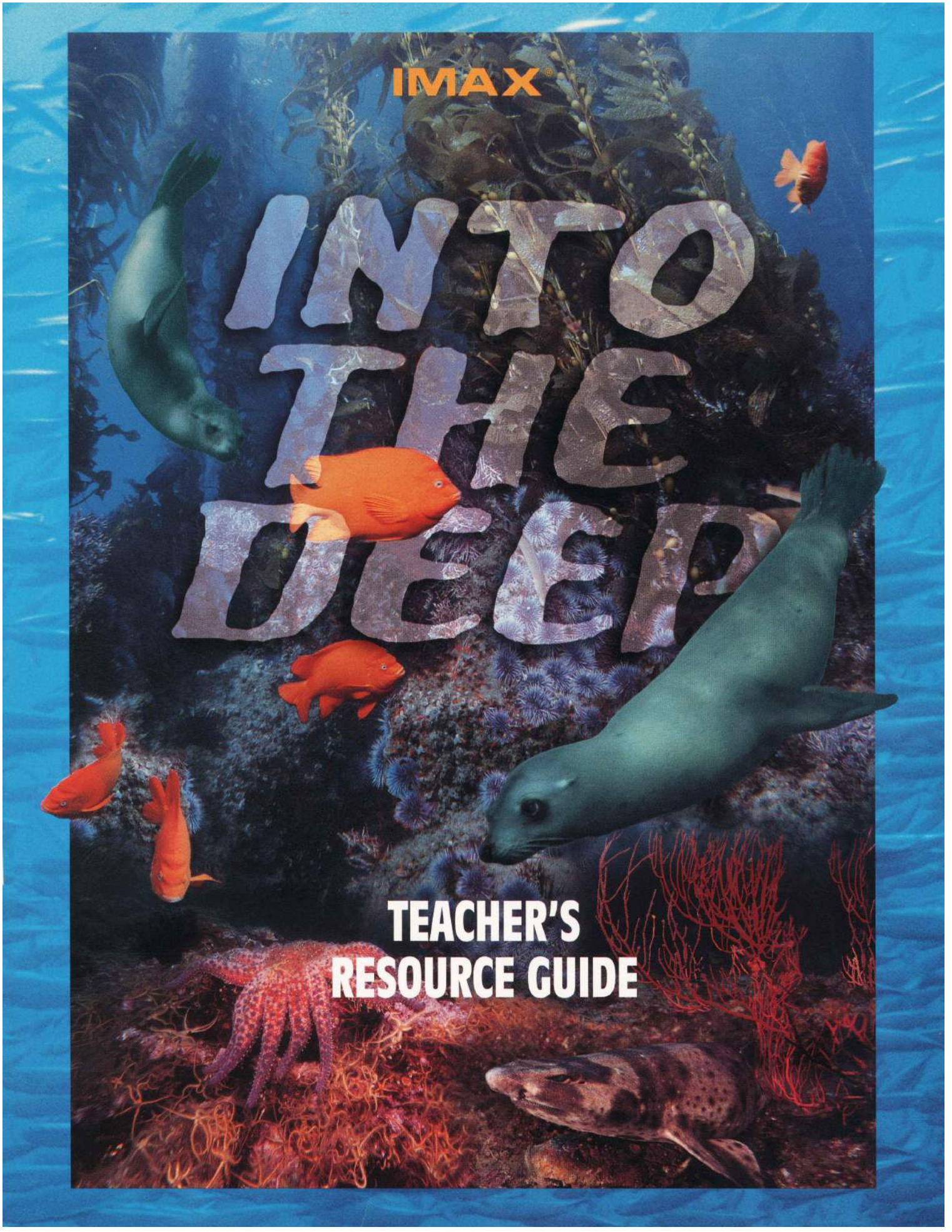
IMAX
INTO THE DEEP
TEACHER'S RESOURCE GUIDE

Welcome to one of the most intriguing habitats on Earth — the **kelp forest**. Growing a few hundred meters off the southern California coast, this great, golden wilderness is a rich, crowded community of colorful fishes, invertebrates, marine mammals and seaweeds. Towering kelp plants give structure to this ecologically and economically vital undersea forest.

Recent advancements in underwater cinematography enabled production crews to film this fascinating marine world for the first time for the giant-screen format. The IMAX film *Into the Deep* gives students the opportunity to see and explore the unique underwater wilderness of the kelp forest.

This Teacher's Resource Guide has been developed as an educational supplement for *Into the Deep*. The materials are designed to use with upper elementary and middle school students in life and environmental sciences. Background information expands on concepts introduced in the film and is followed up with discussion and activity ideas. We encourage you to modify these materials to suit your individual curricular needs.

ACKNOWLEDGMENTS

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FILM CREDITS

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PHOTOGRAPHS

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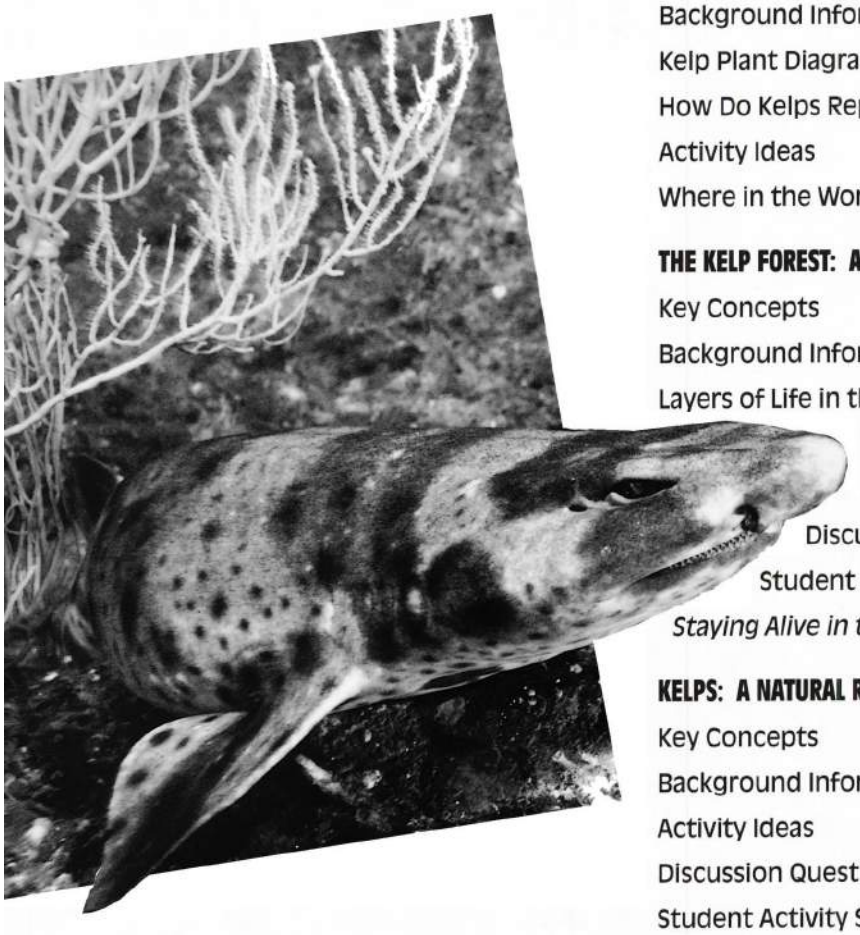
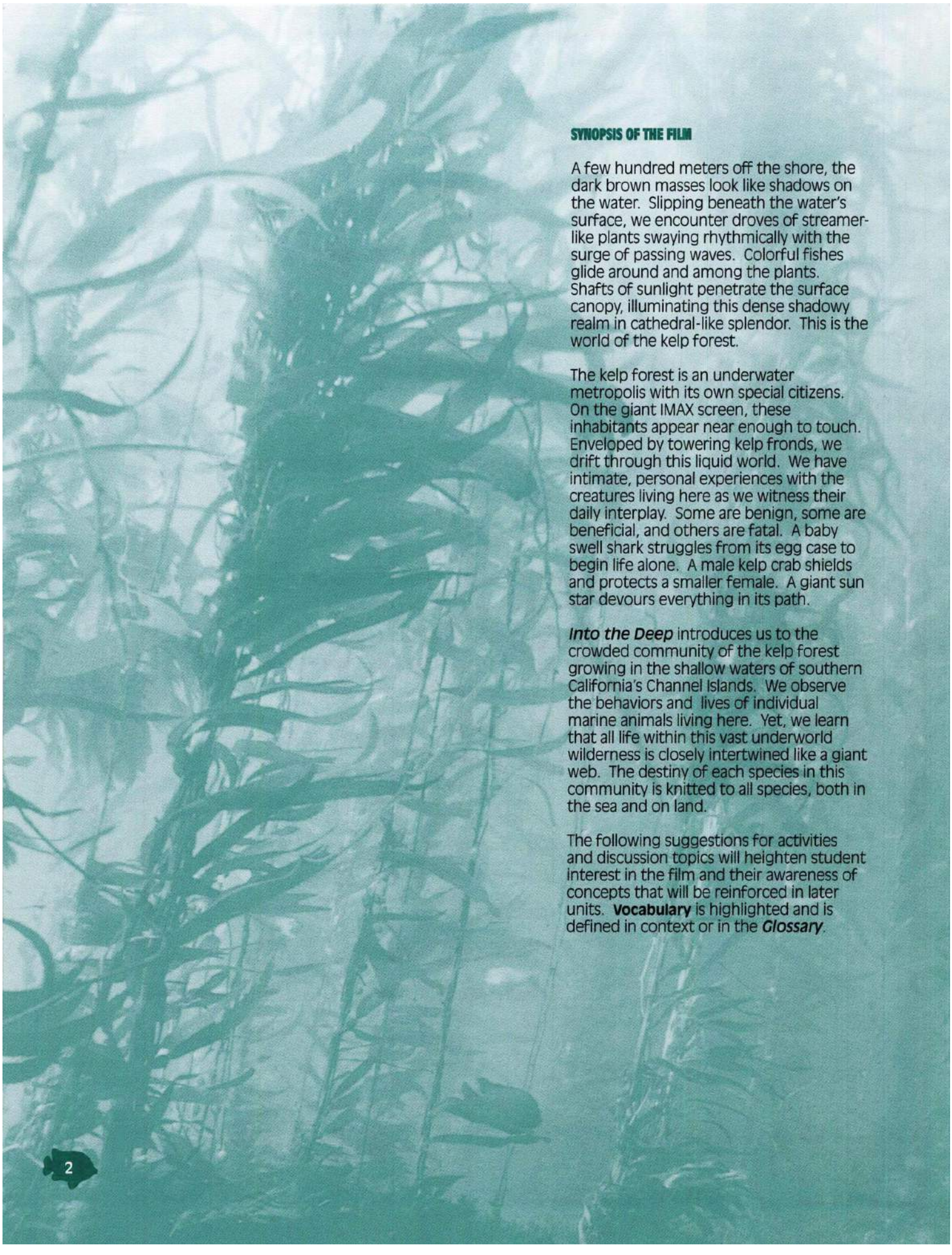




SYNOPSIS OF THE FILM

A few hundred meters off the shore, the dark brown masses look like shadows on the water. Slipping beneath the water's surface, we encounter droves of streamer-like plants swaying rhythmically with the surge of passing waves. Colorful fishes glide around and among the plants. Shafts of sunlight penetrate the surface canopy, illuminating this dense shadowy realm in cathedral-like splendor. This is the world of the kelp forest.

The kelp forest is an underwater metropolis with its own special citizens. On the giant IMAX screen, these inhabitants appear near enough to touch. Enveloped by towering kelp fronds, we drift through this liquid world. We have intimate, personal experiences with the creatures living here as we witness their daily interplay. Some are benign, some are beneficial, and others are fatal. A baby swell shark struggles from its egg case to begin life alone. A male kelp crab shields and protects a smaller female. A giant sun star devours everything in its path.

Into the Deep introduces us to the crowded community of the kelp forest growing in the shallow waters of southern California's Channel Islands. We observe the behaviors and lives of individual marine animals living here. Yet, we learn that all life within this vast underworld wilderness is closely intertwined like a giant web. The destiny of each species in this community is knitted to all species, both in the sea and on land.

The following suggestions for activities and discussion topics will heighten student interest in the film and their awareness of concepts that will be reinforced in later units. **Vocabulary** is highlighted and is defined in context or in the ***Glossary***.

PRE-SCREENING AND POST-SCREENING ACTIVITIES

1. Before viewing ***Into the Deep***, review or introduce the concept of **adaptations**. Plants and animals are adapted or suited to their **habitats**. Plants and animals share their habitats with other **species** which means they compete for food, shelter and other means of survival. For example, an animal's adaptations help it to find food and shelter, to reproduce and to avoid **predators**. Adaptations may be physical (e.g., body structure or covering, color pattern, etc.) and behavioral traits.

After viewing ***Into the Deep***, ask the students to give examples of adaptations they saw in the film. Was the adaptation a physical or behavioral trait? (Note: organisms may have several adaptations.) Create a chart of kelp forest animals seen in the film, list their individual adaptations, and describe how each adaptation helps the animal to survive. **You may also use the reproducible student activity sheet on page 15.**

2. Before viewing ***Into the Deep***, review or introduce the concept of **ecosystems**. An ecosystem is a community of all the living organisms (plants, animals) and non-living elements (gases, water, light, temperature, minerals, etc.) of a physical environment. All members of an ecosystem are interdependent. Life forms are linked through **predator-prey** relationships (**food chains** and **food webs**). Changes to the physical environment or to any of the organisms living there can adversely affect the natural balance in the ecosystem and cause its collapse.

After viewing ***Into the Deep***, have the students discuss how the kelp forest is an ecosystem. What are the living and non-living components of this ecosystem? How do the plants and animals interact with each other in the kelp forest? Give examples from the film.

3. Prior to viewing ***Into the Deep***, create an "experience list" focusing on kelp and the kelp forest. Record students' thoughts about the subject. Also record what they think might be true or what they have heard (e.g., misconceptions). Generate a list of questions students may have about kelp and kelp forests.

After viewing ***Into the Deep***, review the kelp "experience list" with the class. Make additions to the list and correct misconceptions. Which questions could be answered after viewing ***Into the Deep***? Use unanswered questions as a springboard for individual or group investigations.

4. Using a North American or world map, locate the Channel Islands off the coast of southern California. This is where ***Into the Deep*** was filmed. This chain of eight islands is located north of Los Angeles and west of Santa Barbara. Five of the islands comprise the Channel Islands National Park. Their surrounding waters are protected as the Channel Islands National Marine Sanctuary. This marine sanctuary contains the giant kelp forest.

After viewing ***Into the Deep***, use the map included in this study guide to locate other areas where kelp forests grow. What countries and continents do they border? Using a map or globe that shows major ocean currents, follow the route of cold water currents as they flow from higher latitudes to the equator. Are there kelp forests in these areas? Investigate if other nations protect their offshore kelp forests.

KELPS: PLANTS OF THE OCEAN FOREST

Kelps are members of a diverse group of simple water plants called **algae**. Kelps and other large **marine** algae are commonly called "seaweeds," but they are not weeds at all. These aquatic plants grow in the ocean attached to rocks, shells or other hard surfaces. Most seaweeds are found in tidal areas. Other species can be found growing as far down as 130 feet (40 meters) or deeper, if sunlight can reach them.

KEY CONCEPTS

☆ Kelps are part of a family of marine algae. They include some of the world's largest and fastest growing plants.

☆ Kelps have special structures which enable them to grow in the ocean. Kelps also need certain conditions in order to survive.

☆ Like green land plants, kelps perform **photosynthesis**.

☆ Large kelps create dense ocean "forests" that are home to hundreds of different kinds of marine organisms.

Kelps, a type of brown algae, are common along stretches of open coast in many parts of the world where certain conditions exist.

❑ Kelps grow only in clear temperate sea water (41° – 72° F/5° – 22° C). Compared to warm water, cool sea water contains more dissolved gases (carbon dioxide, nitrogen), **detritus** (decayed plant and animal matter), and other nutrients fast growing kelps need to survive.

❑ Kelps may grow at depths of 80 to 125 feet (25 to 38 meters), if sunlight can penetrate the water.

❑ Kelps also need moderate water movement. Waves, currents and **upwellings** from the ocean floor keep fresh, nutrient-rich sea water moving through the plants.

❑ Because kelps grow where there are currents, these plants need rock beds or other hard surfaces on which to anchor.

Although they resemble green plants growing on land, kelps are quite different. They lack the structures associated with land plants: roots, stems, leaves, flowers and seeds. One important feature kelps have in common with green land plants is their ability to convert sunlight into food (**photosynthesis**). Kelps grow best where sea water is clean and clear enough to admit sunlight. Unlike most land plants, the entire kelp plant is capable of photosynthesis and absorbing vital nutrients directly from sea water.

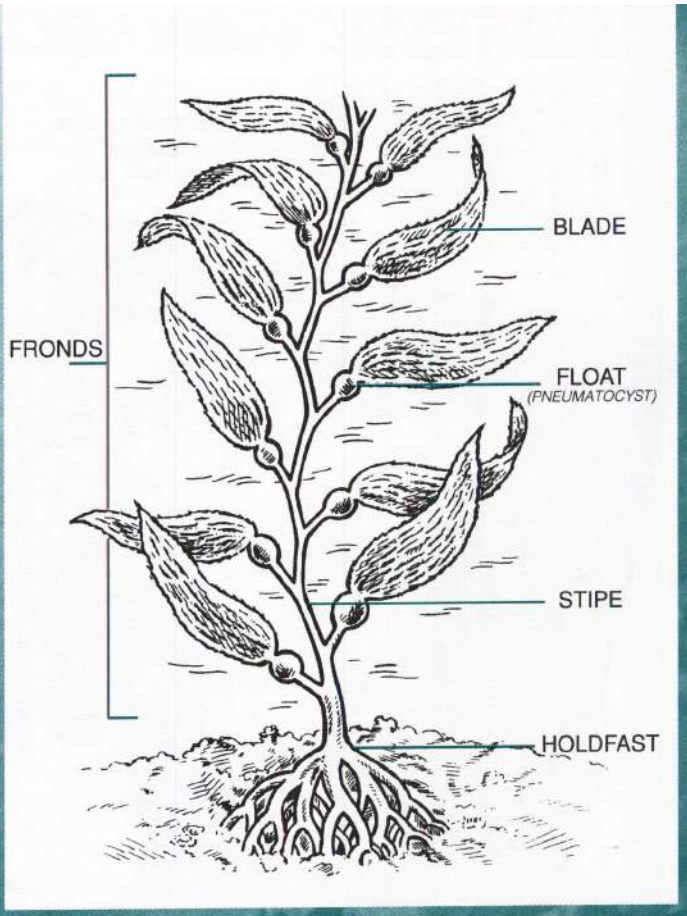
There are several different **species** or types of kelps. The best-known species is giant kelp (***Macrocystis pyrifera***). It grows in the cold waters off the western coasts of North America (Alaska to Baja California) and South America (Peru to Chile).

Giant kelps rival the largest land plants in size. This species may grow to 150-200 feet (45-60 meters) in length and is sometimes called the "Sequoia of the Seas." Under good growing conditions, the **blades** of giant kelps reach four feet (1.2 meters) in length and 12 inches (30.5 centimeters) in width. Giant kelp is one of the fastest growing plants. During the summer months, a single giant kelp plant may grow 12-24 inches (30-61 centimeters) in twenty-four hours.

Kelps grow in crowded groves called "forests" or "stands". Here the kelps' branch-like **fronds** create a dense canopy as they continue to grow across the surface of the water. Beneath this tangled brown mat exists a fascinating, diverse yet delicately balanced marine community.

HOW DO KELPS REPRODUCE?

Kelps reproduce by shedding millions of microscopic spores produced in special tissues on the mature adult plant. These spores develop into tiny plantlets that release male and female gametes, or sex cells. When male and female gametes combine, they form a zygote which continues to develop through embryonic and juvenile stages. If sufficient light is available and other conditions are good, this tiny zygote will rapidly grow into a mature plant.



Aquatic acrobats — a herd of sea lions twist and turn at play in the kelp forest.

Instead of branches, kelps grow long, slender **fronds** that include a stipe and its attached blades.

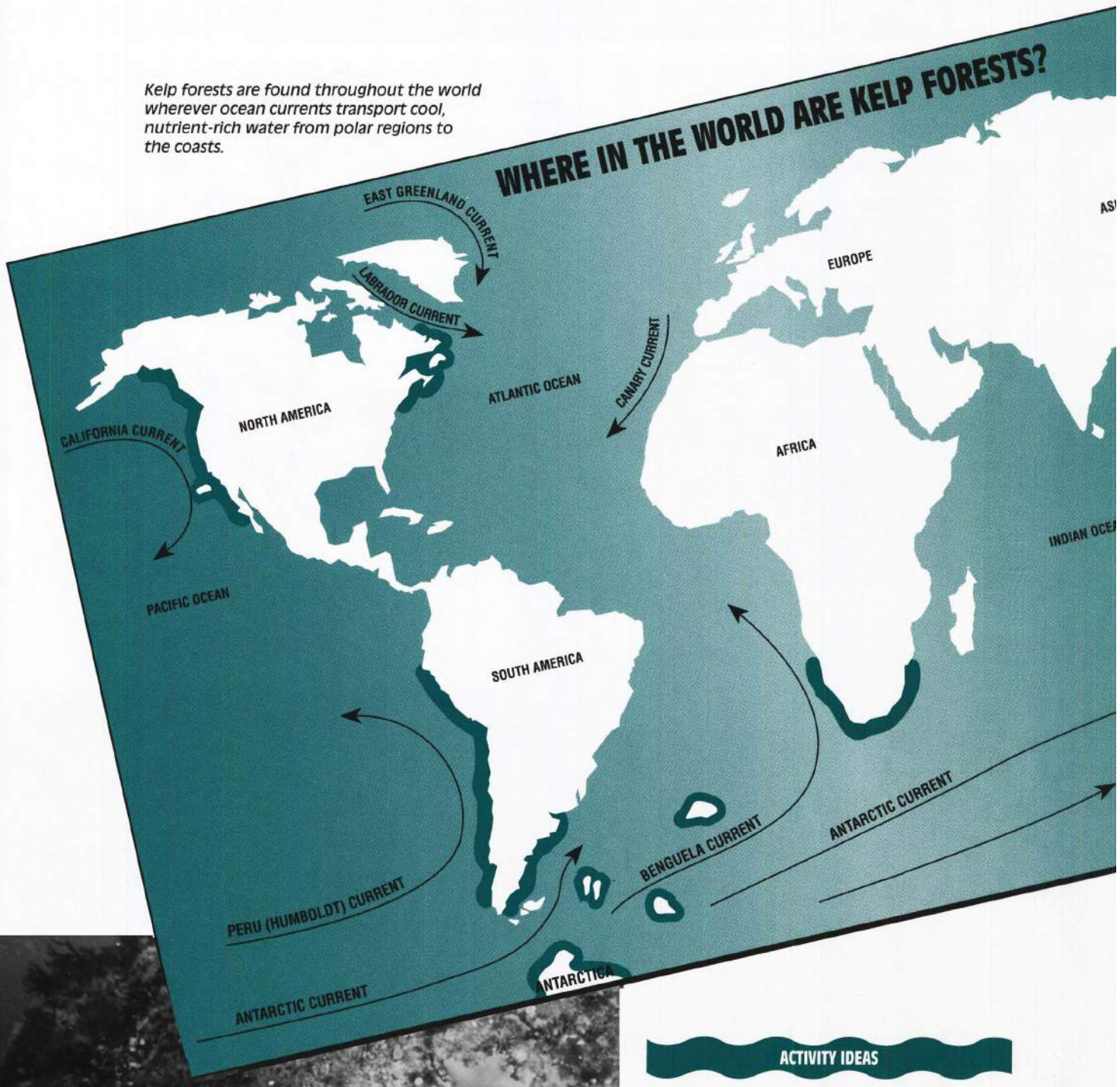
Blades function like tree leaves. They collect sunlight and absorb water chemicals and carbon dioxide. Photosynthetic cells in the blades produce oxygen and food compounds to nourish all parts of the kelp.

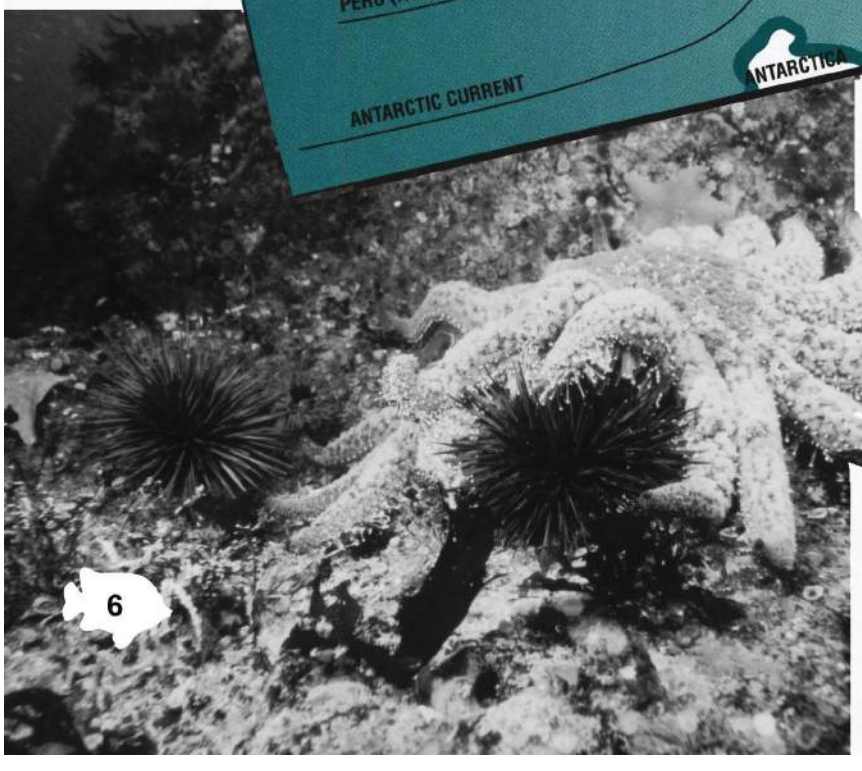
Tough, flexible **stipes** support the kelp and can bend with the waves without breaking. Stipes also conduct the products of photosynthesis from the blades at the ocean's surface to the holdfast at the seafloor. This long-distance circulation of vital nutrients enables some kelp species to grow into giants.

Gas-filled floats, or **pneumatocysts,** hold the kelp plant upright toward the surface where blades harvest sunlight for photosynthesis.

The root-like strands of the **holdfast** anchor the kelp to a rock or other hard surface on the seafloor. Without the holdfast, kelp would be washed away by storms, tides and waves.

Kelp forests are found throughout the world wherever ocean currents transport cool, nutrient-rich water from polar regions to the coasts.

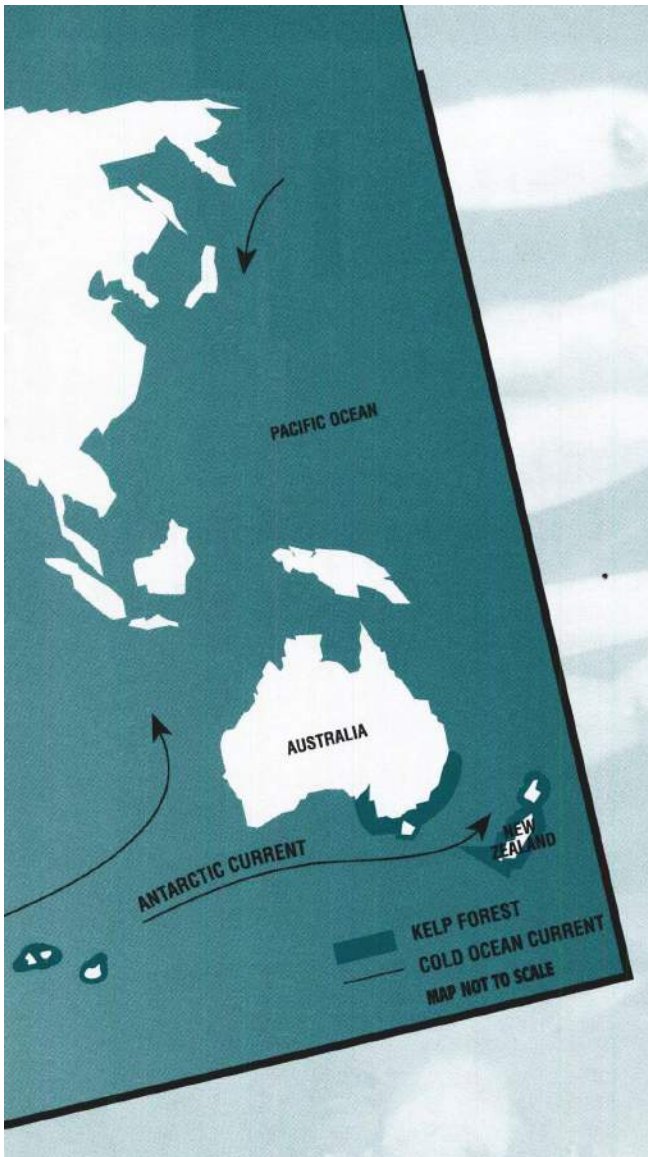




ACTIVITY IDEAS

Giant kelps are sometimes called "Sequoias of the Sea." Have students create a bulletin board display or written report comparing giant kelps to sequoias or redwoods, the largest trees in the world. How are these plants alike or different with regard to height, structures, growth rates, requirements for growth and reproduction?

Checks and balances. Hungry sea urchins that devour kelp are themselves attacked and eaten by a sun star.



Many public aquariums exhibit kelp forest animals: garabaldi, sea urchins, sea stars and kelp fish. The kelp and seaweeds added to the displays are artificial because real kelp and most seaweeds need natural sunlight to perform photosynthesis. However, two aquariums, the Monterey Bay Aquarium (Monterey Bay, California) and the Stephen Birch Aquarium-Museum (La Jolla, California), display living kelp stands. Investigate how scientists, engineers and divers re-create this marine community complete with rocks, sand, plants, animals and living kelp. What technologies were used to build these huge displays and to keep kelp alive and growing? How do aquarists maintain the exhibits and their residents? Why do you think it is important to display a living kelp forest?

How long do redwoods and giant kelps live? How is each plant important to its respective ecosystem?

Algae have been called the "green plants of the seas." Have students report on the important role of algae, including kelps, in the oceanic foods chain. Describe and illustrate different types of brown, red and green algae. Where do they grow? What are "algal blooms?" What causes them? How do they affect other marine life?

Rooted to the rock, multibranched gorgonian corals look like plants, but they are actually animals.

THE KELP FOREST: A COMMUNITY BENEATH THE SEA

The kelp forest is a complex, crowded community and home to more than 750 species of marine life. Like a forest on land, the kelp forest is a collection of several habitats, from the sunlit canopy at the surface to the holdfasts at the bottom. Each zone or layer supports its own characteristic inhabitants. Survival for these creatures depends upon finding food, shelter and space.

KEY CONCEPTS

- Kelp forests shelter and nurture a complex, diverse community of marine life.
- Like terrestrial forests, kelp forests are composed of several stratified habitats or "layers of life."
- Kelp forests also provide associated food sources thus enabling hundreds of species of animals to exist in this marine ecosystem.
- Plants and animals of the kelp forest have an array of adaptations that help them to survive here.

To accommodate its growing body, a California spiny lobster must periodically shed its protective exoskeleton.

FROM TOP TO BOTTOM

Kelps provide the framework to this underwater community. They extend a third dimension into an otherwise open, featureless ocean. Giant kelp ***(Macrocystis)*** and bull kelp ***(Nerocystis)*** create the **canopy** or top layer. Their buoyant, matted fronds filter the sunlight reaching the seafloor, thus influencing what other kelps and algae will grow in the understory. Collectively, these marine plants, along with water depth, rocky outcrops and sandy patches form a diversity of habitats which, in turn, attract a multitude of creatures.

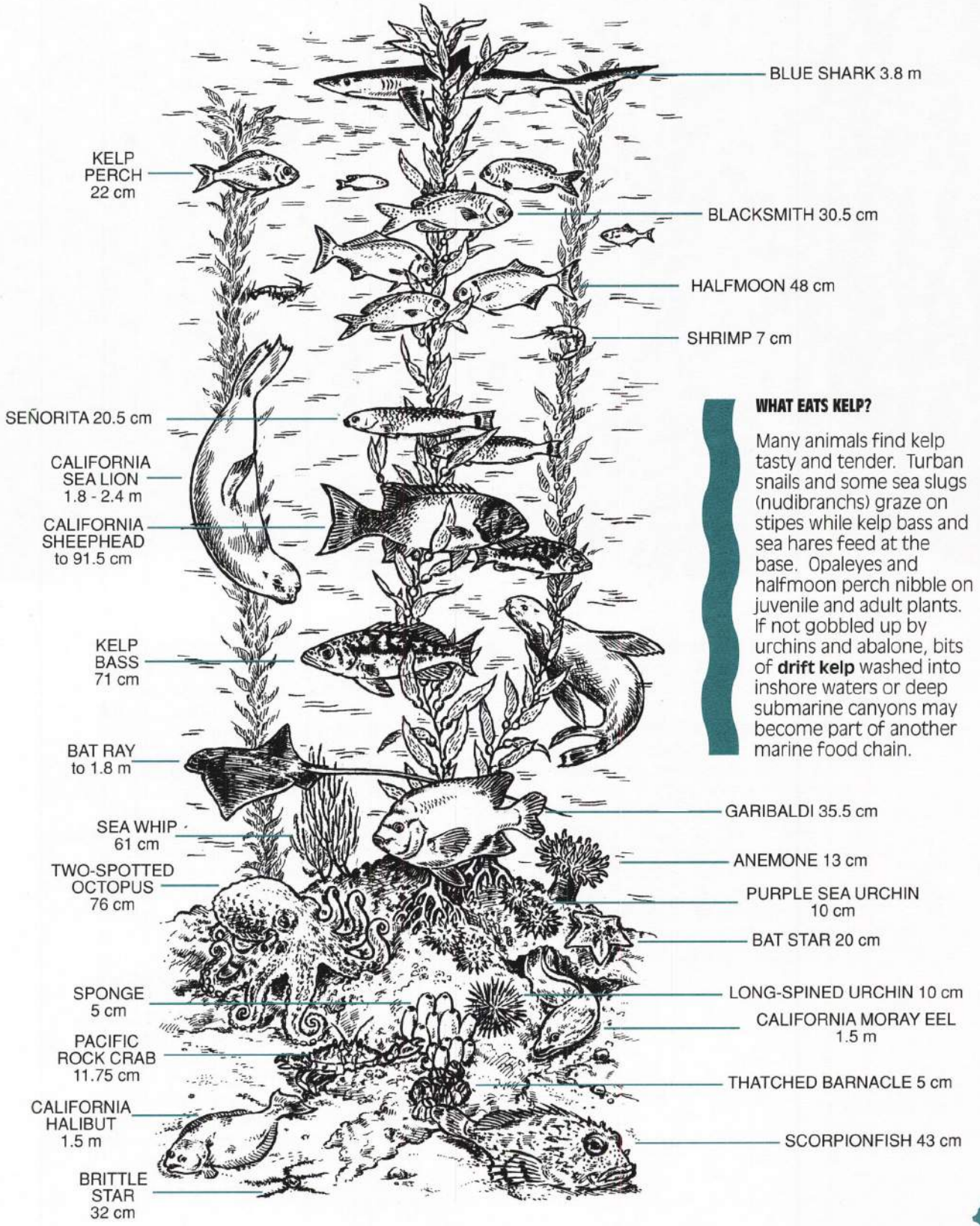
Within the sunlit canopy, surf perches, halfmoon perches and blacksmiths feed, court, mate and spawn. The canopy is also a nursery and hiding place for young animals too small to fend for themselves in the open ocean or inshore waters.

These waters are also rich in microscopic life forms. These minute organisms, collectively called **plankton**, are tiny floating plants and animals, invertebrate **larvae** and young fish. Only a few will reach maturity as they continuously drift with the currents. Most become food for the **filter feeders** and other creatures of the kelp forest.

In the middle zone, interlocking stipes and blades furnish hiding places for small fish and many kinds of shrimp. Black surf perch, kelp bass, señoritas and sheep-head fish slip between the fronds. Stipes are highways for turban snails, kelp crabs and other crawling **invertebrates**. The kelp plant itself becomes living space on which barnacles, tube worms and other small animals anchor themselves. Many fish in the middle layer feed on the animals clinging to the kelp.

Competing for a foothold at the bottom, corals, anemones, sponges and other **sessile** animals carpet every available inch of hard surface. Here, male garabaldis make nests of red algae and invite females to lay their eggs.
The holdfast's tangled tendrils furnish hiding places for tiny crabs, worms, urchins, mussels, clams, brittle stars and

LAYERS OF LIFE IN THE KELP FOREST



WHAT EATS KELP?

Many animals find kelp tasty and tender. Turban snails and some sea slugs (nudibranchs) graze on stipes while kelp bass and sea hares feed at the base. Opaleyes and halfmoon perch nibble on juvenile and adult plants. If not gobbled up by urchins and abalone, bits of **drift kelp** washed into inshore waters or deep submarine canyons may become part of another marine food chain.

A bright orange male garibaldi guards its eggs among the coral.

baby octopi. Bottom-dwelling rockfishes, moray eels and scorpionfish feed on these invertebrates and smaller fish.

Like a terrestrial forest, the kelp forest has clearings. These patches of open, sandy seafloor attract their own inhabitants. On the featureless bottom with few solid surfaces, many animals live just above the sand or burrowed into the bottom. Flatfishes (flounders, halibut, turbot, angel sharks) conceal themselves in the sand. Bat rays cruise the sandy bottom searching for buried prey. Here, masses of deep-water squid come to mate, lay their eggs and subsequently die.

Because the kelp forest shelters so many marine organisms at all levels, it is a rich feeding ground for other creatures. Perched on the canopy's thick buoyant fronds, herons, egrets, gulls and other seabirds stalk the fish below. Many predatory fish are full-time residents of the kelp community. Others from closer inshore waters or deep ocean (blue and mako sharks) hunt at the edges of the kelp forest when they are hungry. Marine mammals (harbor seals, sea lions, sea otters) find the kelp forest a bountiful feeding area. Grey whales pass through on their annual migration from calving grounds.

At night a different community replaces familiar daytime residents. At twilight, **diurnal** fishes retreat into the shadows or settle into crevices. Soon night prowlers - moray eels, octopi, bat rays and sharks - emerge to begin foraging. Armies of crustaceans (crabs, spiny lobsters, coonstripe shrimp) search the bottom for food. In turn, they become the meals of **nocturnal** fishes. In the kelp forest, living in shifts helps to ease the competition for food and space.

DESIGNS FOR SURVIVAL

Competition is the way of life in the kelp forest as groups struggle for limited resources. Kelp forest creatures face the same survival challenges as terrestrial animals do: finding food; securing shelter; and staying alive long enough to reproduce. These marine animals have an array of physical and behavioral adaptations which help them to compete in the kelp forest.

Finding food is paramount to survival, and kelp forest animals have a variety of strategies to land a meal. Gliding over the sandy bottom, a bat ray's undulating "wings" expose buried shellfish. Powerful jaws and grinding teeth crack open tough-shelled prey. Sleek sea lions use their speed and keen eyesight to catch squid and small fish. Moving more than a foot (30 centimeters) per minute, a huge ***Pycnopodia*** sun star easily overtakes snails, crabs and brittle stars and devours them.

Nearly invisible to prey, gelatinous jellyfish feed by the "bump and sting" method. Unsuspecting fish become entangled in trailing, stinging tentacles. Sessile anemones and corals must wait for food to drift in their direction. Both use stinging tentacles to stun and reel in small prey.

The secret to finding a meal is not to become another's meal. Staying alive may require a few tricks or disguises.

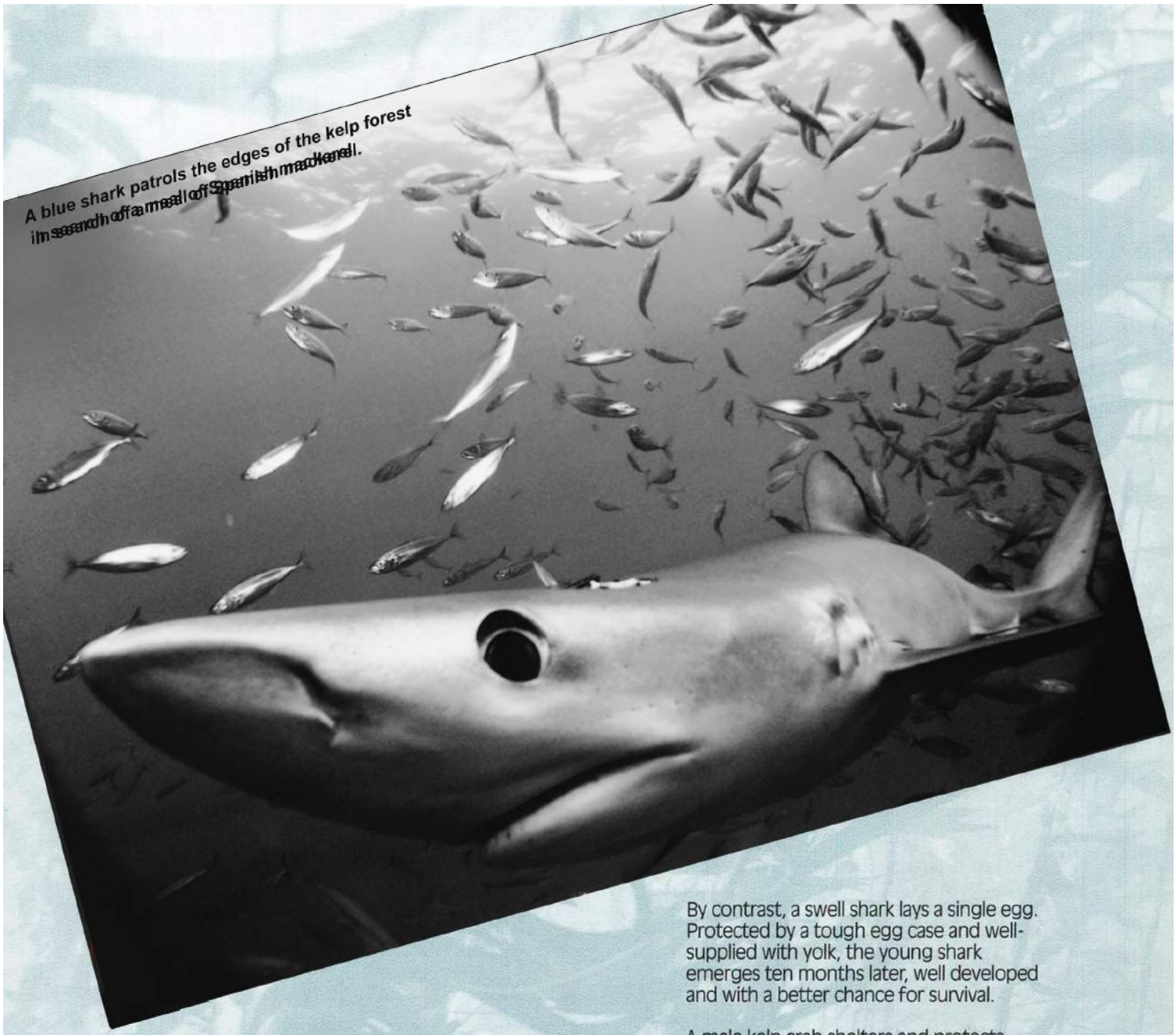
In a pinch, a brittle star can break off one of its "arms" to escape a predator. A tough **exoskeleton** shields a spiny lobster like a suit of armor, but it must be periodically moulted, or shed, as the animal grows. A sea urchin's prickly spines and tough shell, or test, deter most would-be predators. However, they are no match for the sheephead's crushing teeth or the sun star's powerful tube feet.

There is strength in numbers. Appearing to move as one individual, Spanish mackerel swim together for protection. Schooling also helps these fish to find mates and food.

Kelp fish mimic the size, shape and color of the kelp blades. The kelp crab may attach bits of algae to its shell to blend with the kelp.

A master of disguise, an octopus changes color and shape to avoid detection by prey or to conceal itself from predators. Its squirt of ink deadens a moray's sense of smell while the mollusk makes a jet-propelled get away.

Every spring, deep-water squid come to mate and spawn at the edge of the kelp forest. Before dying, females anchor their eggs in the sandy bottom.



A blue shark patrols the edges of the kelp forest in search of a meal of Spanish mackerel.

A kelp forest may appear vast, but in this crowded community each inhabitant needs its own territory or bit of space. A territorial sheephead's colors warn other fish to stay off its turf. Staking his claim, a sarcastic fringehead evicts a rival male with fierce but non-lethal threats.

Survival not only entails the daily struggle to stay alive but also the need to perpetuate the species. In the kelp forest, animals have a number of strategies to ensure another generation of their own kind.

Millions of squid egg cases, laid during a mass spring mating ritual, quickly mature and hatch without parental protection. It's a numbers game. Not all these tiny progeny reach adulthood, but the surviving few guarantee another generation of squid.

By contrast, a swell shark lays a single egg. Protected by a tough egg case and well-supplied with yolk, the young shark emerges ten months later, well developed and with a better chance for survival.

A male kelp crab shelters and protects the smaller female as she carries a brood of eggs.

A male garabaldi's courtship dance of loops and clicks entices females to lay their eggs in his nest. He aggressively guards the nest against intruders. Once hatched, the swarm of **fry** become part of new life in the kelp forest.

THE WEB OF LIFE

The kelp forest is a dynamic community, forever in flux. It changes daily and with the passing seasons. What remains constant is the haven these aquatic plants create for over 750 marine species. Without the giant kelp this marine ecosystem would collapse.

The natural community of plants and animals in the kelp forest is like a web. Each species follows its own thread. Yet each thread is interwoven and linked to the threads of other species. Every organism, no matter how small, is a part of this community web. The destiny of each species is tied to all.

ACTIVITY IDEAS

If students have studied deciduous or tropical rain forests, have them compare these terrestrial forests with the underwater kelp forest. How are these ecosystems similar or different with regard to stratified habitat zones (e.g., "layers of life") and diversity of species? What are typical **producers**, **herbivores**, **carnivores** and **scavengers** in each ecosystem? How do these communities change with the seasons? How are these ecosystems important to life on Earth? How has man affected or changed these ecosystems?

Turn your classroom into a kelp forest. Invite students to design and construct a kelp forest community in a corner of the classroom. Use the floor as the sea floor and ceiling as the surface of the water. Decide which animals and plants will be represented. In which zones do they live: canopy; middle layers; sea floor? Use string or yarn to suspend the animals at their proper levels from the ceiling. Hang streamers from the ceiling to represent kelp fronds. What physical features of the kelp forest might be included (rocks, sand)? How could students simulate wave action (box fan)? Challenge the students to use only recycled or recyclable materials to create the kelp forest (e.g., egg and milk cartons, paper tubes, fabric scraps, used aluminium foil, buttons, etc.). For more ideas about creating a classroom kelp forest, please refer to: "Forests of the Sea," Nature Scope's ***Diving into the Oceans***, National Wildlife Federation, 1988.

Kelps grow in cool water below 70° F (22° C). The body temperatures of "cold-blooded" fishes adjust to the surrounding water temperature. However, cold water robs "warm-blooded" mammals of body heat. What adaptations do seals, sea lions and sea otters have to protect themselves from heat loss? How do scuba divers cope with the cold water of the kelp forest?

Schedule a program on marine ecology, ecosystems or other ocean-related subjects at your local public aquarium. If the aquarium displays kelp forest animals, encourage students to create a "field notebook": observe and sketch the animals; include notes about each animal's appearance and behavior. Compare these aquarium specimens with animals seen in ***Into the Deep***.

Investigate another brown algae community. The Sargasso Sea, located south of Bermuda in the mid-Atlantic, supports a free-floating community of sargassum seaweed. What animals live among the "algal islands?" How are they adapted to live here? Compare the open-ocean sargassum community with the coastal kelp forest.

DISCUSSION QUESTIONS

In 1834, naturalist Charles Darwin wrote about the kelp forest: ***"... if in any country a forest is destroyed, I do not believe so many species of animals would perish as would here, from the destruction of kelp."*** Invite students to debate Darwin's statement. Ask them to explain what this statement means. Do they agree or disagree with Darwin? Have them support their arguments with information from their research and from viewing ***Into the Deep***.

After emerging from its egg case, a baby swell shark begins life well-developed and alone.

In the film, we witness sea lions returning each day to chew on a clump of kelp stipes. Scientists do not know why sea lions do this. Ask the students to give possible explanations for the stipe-chewing behavior. How would they proceed to verify or prove their hypotheses? How do biologists and naturalists learn more about an animal's behavior and way of life?

The behavior and physical adaptations of kelp forest animals may appear strange and different. However, many land animals have similar adaptations. Brainstorm with students about terrestrial animals that may have survival strategies similar those seen in ***Into the Deep***. Some examples are included here but there are many possible answers: "chemical warfare" (skunk); "safety in numbers" (antelopes, zebras, herd animals); "courtship dances" (cranes); "male tends the nest" (ostrich); "spiny covering" (porcupine); "suit of armor" (armadillo; insects). How do each of these adaptions help both terrestrial and marine animals to survive?

ADAPTATIONS: STAYING ALIVE IN THE KELP FOREST

Name _____

Adaptations are special features or traits that help an animal to find food and shelter, to win a mate or to avoid a predator. Adaptations can be a body part or covering, color pattern or how the animal acts or behaves.

Select five animals seen in the film, ***Into the Deep***. List and describe an adaptation for each animal. Write your answer in the chart below. Remember, an animal may have several adaptations.

Some animals featured in ***Into the Deep***: garabaldi; moray eel; octopus; sea urchin; jellyfish; corals; spiny lobster; sarcastic fringehead; bat ray; Spanish mackerel.

ANIMAL	ADAPTATION	HOW IT HELPS THE ANIMAL
EXAMPLE: Sea lion	Torpedo-shaped body	Streamlined body helps the sea lion to dive and swim quickly to catch fish.
1.		
2.		
3.		
4.		
5.		

What are some of your adaptations for eating, moving, keeping warm, staying cool, etc.?

Compare your adaptations with those of kelp forest animals. How are your adaptations similar or different?

KELPS: A NATURAL RESOURCE

The kelp forest is an important and comparatively accessible natural resource. It has recreational and commercial value to people. However, many natural and human-induced environmental changes threaten this vital marine community. Although new technologies have enabled scientists to study the kelp community, we still have much to learn about this last wilderness.

KEY CONCEPTS

- Kelp forests are vital commercial and recreational sites. They provide us with many economically important fin fishes and shellfish.
- Kelp is an important renewable resource. **Algin**, an extract from kelp, is used in hundreds of products.
- Natural environmental changes continually threaten kelp forests. Human activities also have directly and indirectly affected this marine community.
- Kelp forests are the focus of ongoing research. Recent advances in technology have enabled scientists to explore and study kelp communities.

A VALUABLE NATURAL RESOURCE

Because they attract and sustain a large, diverse marine community, kelp forests are important sport and commercial fisheries. This key habitat supplies our dinner tables with rock fishes, kelp bass, perch, croaker, halibut and shellfish (spiny lobster, rock scallops and abalone).

Kelp forests are also favorite recreational diving sites. Scuba divers and snorkelers who brave the chilly waters can explore a fascinating underwater wilderness.

Near the coast, kelp forests act as natural breakwaters. They help protect beaches from erosion by reducing the intensity of incoming ocean waves.

People have gathered kelp for centuries. The plant has been used as animal feed, fertilizer and a source of iodine. The Coastal Indians of British Columbia plaited together kelp stipes to make nets, ropes, fishing and harpoon lines. Chemicals from kelp were used at one time to make glass and soap. During World War I, potash and acetone were processed from kelp to manufacture explosives. Today kelp is an important source of **algin**.

Algin is a remarkable substance. It gives kelp its slippery feel and the resilience to withstand wave surge. Extracted algin is used in many processed foods, beverages and pharmaceuticals that need to be thickened, stabilized (to prevent deterioration) or emulsified (to keep ingredients from separating). Algin gives ice cream its smooth texture and binds oil and water in bottled salad dressing. Algin is also used in the production of cosmetics, paints, ceramics, paper and textiles.

And the only place in the world to find algin is in the brown algae, kelp!

A COMMUNITY IN DANGER?

Severe weather can disrupt the kelp community. Ocean swells and storms rip up and drag away kelp plants with their encrusted animal residents. Other marine creatures are scattered or deprived of shelter and food.

El Niño, a periodic oceanic phenomenon in the eastern Pacific, can ravage the kelp forest community as warm equatorial waters replace the normal, cooler currents. These warm, nutrient-poor currents inhibit kelp growth and reproduction. Rising sea temperatures also cause high plankton and fish kills. These warm currents can also adversely affect the weather. During a severe El Niño episode in 1982-83, violent storms wiped out 90 percent of California's giant kelp forests.

The greatest natural threat to the kelp forest is the sea urchin. These spiny **echinoderms** graze on algae and **drift kelp**. During the 1950s, California's kelp forests suffered severe urchin grazing episodes. Hordes of hungry urchins attacked and devoured kelp holdfasts. As a result, whole forests were set adrift, creating lifeless areas called "urchin barrens." When severed fronds drift away, so do many other animals now deprived of food and shelter.

Under normal conditions in a balanced marine community, sea urchins cause little damage. Their numbers are kept in check by natural predators: sun stars, sheephead fish, spiny lobsters and sea otters. However, the overharvesting of lobsters and sheephead fish and the near extermination of sea otters for their fur created an imbalance in the kelp forest. With fewer predators, urchin populations grew too large for the available drift kelp supply, causing these hungry animals to attack attached plants.

To correct the imbalance, biologists tried poisoning urchins with quicklime. The re-introduction of sea otters provided some relief. The development of a sea urchin fishery in the 1970s also helped to re-establish a balance in the kelp community.

Kelp forests may still be directly threatened by human activity. Sewage pumped into the ocean and oil spills from offshore drilling rigs cloud and poison the clear, clean water kelps need to survive. The tragic result of our activities could be the loss of an important marine ecosystem and valuable natural resource.

Although scientists are optimistic about the future of kelp forests, we do not fully understand the complex interaction among species living within this marine community. As we learn more about kelp forests we will be better able to preserve and to protect one of the most productive communities on earth.

WHAT'S LEFT TO LEARN?

We still have much to learn and to understand about the kelp forest. Only within the last few decades have we been able to fully explore this last wilderness. Recent advances in technology (scuba, remotely operated vehicles and manned submersibles) have enabled scientists to observe, photograph and record the structure, organization and dynamics of the kelp community. They also study the kelp forest's biology, chemistry and molecular biology.

Ongoing research addresses many questions about the kelp forest. Tons of kelp are severed or sloughed off every year. What happens to this drift kelp? Where does it go? How do species interact and co-exist in the kelp forest? What oceanic conditions affect them? How do climatic and physical environmental changes affect kelp reproduction? How do kelp communities differ around the world? The answers to these questions may help us to keep this vital marine community alive and healthy.

ACTIVITY IDEAS

Using the Activity Sheet on page 21, challenge students to consider if they eat or use kelp everyday. (All the illustrations on the activity sheet contain algin.) Instruct the students to find processed foods and household products containing algin and other algal derivatives. They should check ingredient labels for "algin," "sodium alginate," "agar" and "carrageenan." (The last two derivative are from red algae.) Compile a list of these products. Have students describe the properties or characteristics shared by these products containing algal derivatives by allowing them to examine, smell and feel product samples.

What are some unusual ways in which algin is used? Have students write to pharmaceutical companies, food manufacturers and processors to inquire how they use algin in various products.

Have students investigate and report on how kelp is harvested and processed. What types of equipment and machinery are used? How is algin extracted? Are there uses for the left-over kelp materials?

Investigate the "sea otter-urchin-kelp" link. Some scientists believe the sea otter is a "keystone species" in the kelp forest community. (A "keystone species" is a dominant or critical member of an ecosystem. Its decline or elimination may cause a serious imbalance in that ecosystem.) Why do some scientists believe the near extermination of the sea otter contributed to the decline of kelp forests? What has been the outcome of sea otter re-introduction programs? What problems have been created by re-introduction programs (e.g., effects on the shellfish industry)? What other questions or issues must scientists consider regarding the re-introduction of sea otters to their former range?

El Niño not only affects the kelp forest of California, but it can adversely impact the fishing industry off Peru and Ecuador. Have students investigate how ocean currents, prevailing winds and weather are interlinked. How does El Niño change weather patterns?

Invite a certified scuba diver to talk to the class about diving into the ocean. What equipment and gear are needed to dive safely? What training is needed to become a certified diver? What safety measures do divers observe?

Equipped with powerful jaws and sharp teeth, a moray eel lays in wait for its favorite food – octopus.

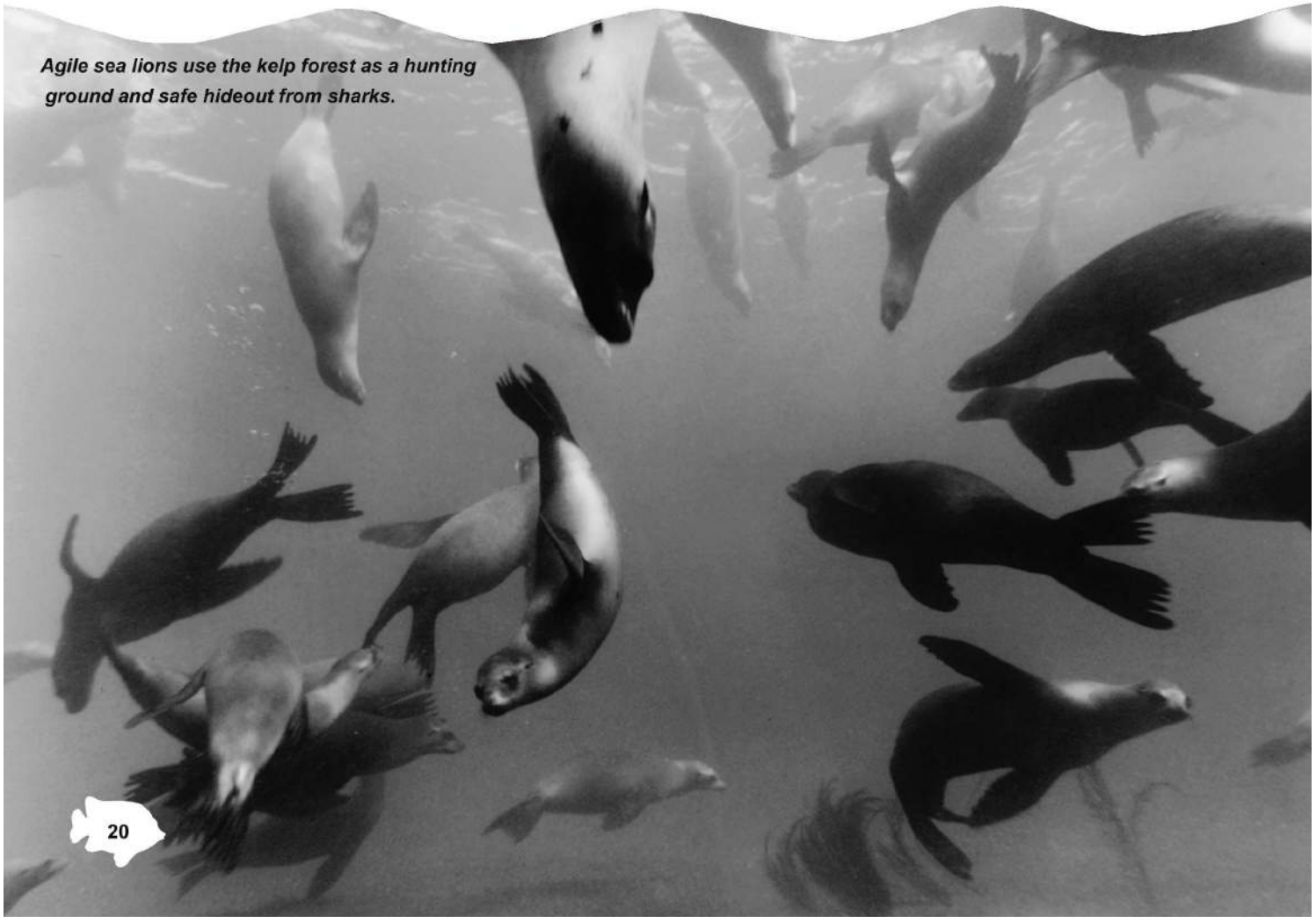
Food for Thought. The kelp forest supplies us with a number of important finfish and shellfish. Have you considered eating these kelp forest products: sea slugs; sea hares; dried seaweed; or powered jellyfish? In Asia, the roe (eggs) of the red urchin is a delicacy. Have students check markets, restaurant menus and ethnic grocery stores for unusual seafoods that may originate in the kelp forest. How are these seafoods prepared? What do they taste like?

(Note: some public aquariums offer classes on preparing seaweeds and other unusual seafoods.)

As the human population continues to increase so does the demand for food. Some scientists believe the oceans will become more important as a source of food. Have students investigate "mariculture" or "aquaculture" (farming in the oceans). Is this a new concept? (Asians have been raising and eating seaweeds for centuries.) What "sea crops" are now being raised? What technologies are needed for large-scale farming in the sea? What environmental problems

DISCUSSION QUESTIONS

The development of a sea urchin fishery has helped to maintain a balance between kelp and one animal that feeds on it. More than 895 tons (812 metric tonnes) of urchins are harvested each year from California's kelp forests. Have the students discuss the possible effects of removing so many urchins from the kelp forest. Could we be creating another imbalance in this ecosystem?



Agile sea lions use the kelp forest as a hunting ground and safe hideout from sharks.

KELP AND YOU

Name _____

Did you know that you may eat or use kelp every day? **Algin**, a by-product of kelp, is added to many prepared foods and household products. **Circle the items pictured below you think contain algin.**

At home, look for products that may contain algin or other seaweed by-products. Check ingredient labels for *algin*, *sodium alginate*, *agar* and *carrageenan*. List those products here.

Examine and describe how these products smell, feel and taste (if a food product). What similarities or characteristics do these products share?

GLOSSARY

Adaptation
Special features or traits that enable an organism to live and reproduce in a particular environment.

Algae (AL-jee)
Simple, non-seed bearing plants growing mostly in water.

Algin (AL-jin)
A natural substance found in the cell walls of kelps.

Blade
The leaf-like part of kelp or seaweed.

Canopy
The top layer of the kelp forest where fronds float on the ocean's surface or the upper layer of branches of a forest on land.

Carnivore
An animal that eats other animals.

Detritus (dih-TRY-tuhs)
Bits and pieces of decayed plants and animals.

Diurnal
Active during the day.

Drift kelp
Kelp clusters that break free of their holdfasts and float with ocean currents.

Echinoderm (e-KI-na-derm)
A group of invertebrates with hard spiny skeletons, radially symmetrical bodies and a water vascular system. Includes sea stars, sea urchins and sand dollars.

Ecology
The study of the relationships of organisms to one another and to their environment.

Ecosystem
A community of organisms interacting with each other and the physical environment in which they live.

El Niño
A warm oceanic current in the eastern Pacific equatorial region.

Exoskeleton
The skeleton or hard covering on the outside of an animal's body.

Filter feeders
Animals that strain bits of food out of the water.

Food Chain
A sequence of organisms in which members of one link eat members of the link below them, and are eaten by members of the link above them.

Food Web
A complex feeding system containing many food chains.

Frond (FRAHND)
A kelp stipe and its attached blades.

Fry
Recently hatched fish.

Habitat
The immediate physical surroundings of a plant or animal.

Herbivore
An animal that feeds on plants.

Holdfast
The part of the kelp that holds the plant to a hard surface on the ocean floor.

Invertebrate
An animal without a backbone or spinal column.

Larva (pl. Larvae)
The immature or early stage of an animal; it differs significantly from the adult stage.

Marine
Pertaining to or living in the ocean.

Nocturnal
Active at night.

Photosynthesis
The process by which green plants and some algae use sunlight to convert water and carbon dioxide into sugar and oxygen.

Plankton
The mass of tiny plants and animals floating in the sea, many of which are microscopic.

Pneumatocyst (new-MAT-oh-sist)
The gas-filled bladders on a kelp plant that serves as a float.

Predator
An animal that kills and eats another organism.

Prey
An animal that is killed and eaten by another animal.

Producer
An organism that produces its own food through photosynthesis.

Scavenger
An animal that feeds on dead animals.

Sessile (SES-ihl)
Permanently attached, not free to move about.

Species
A group of organisms with common physical structures that can interbreed and produce fertile offspring.

Stipe (STYP)
The central stalk or stem-like part of a kelp plant.

Upwelling
A natural, upward movement of cold, nutrient-rich sea water from lower depths to the surface.

EDUCATIONAL RESOURCES

EDUCATIONAL RESOURCES

The resources listed below represent a small selection of many publications available on ***kelp forests***. The list is by no means complete and inclusion on the list does not constitute endorsement by IMAX Corporation. You will find a wealth of information in your school and public libraries. When researching ***kelp forests***, be sure to check the card catalogue and periodical guides for these reference headings: ***oceans; oceanography, marine biology; marine ecology***; and ***seaweeds***.

BOOKS

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Brauer, Judy, editor. ***Diving into the Oceans***. Ranger Rick's Nature Scope Series. Washington, D.C.: National Wildlife Foundation, 1985. (Grades K-8)

Brown, Joseph. ***Wonders of a Kelp Forest***. New York: Dodd, Mead, 1974. (Grade 7-Adult)

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Conner, Judith and C. Baxter. ***Kelp Forests***. Monterey Bay, CA: Monterey Bay Aquarium Foundation, 1989. (Grade 7-Adult)

Daegling, Mary. ***Monster Seaweeds: the Story of the Giant Kelp***. San Francisco: Dillion Press, 1986. (Grade 5-Adult)

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Wu, Norbert. ***Beneath the Waves: Exploring the Hidden World of the Kelp Forest***. San Francisco: Chronicle Books, 1992. (Grade 3-Adult)

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PERIODICALS

Ashkenazy, Ken. "Kelp Farms: Cultivating Energy in Ocean Plankton." ***Oceans***. May-June 1981.

Booth, William. "The Otter-Urchin-Kelp Scenario." ***Science***. July 8, 1988, p. 157.

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Funston, Sylvia. "The Keystone Connection." ***Owl***. April 1993, Vol. 18, No. 4, pp. 26-27.

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North, Wheeler. "Giant Kelp: Sequoias of the Sea." ***National Geographic***. August, 1972, pp. 251-269.

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"Sea Otters Help Fishermen." ***Oceans***. July/August 1986, Vol. 19, p. 3.

Sleeper, J. B. "How to Dive in Kelp Forests." ***Skin Diver***. July 1993, pp. 24-27.

Tennesen, Michael. "Kelp: Keeping a Forest Afloat." ***National Wildlife***. June/July 1992, pp. 4-11.

Wu, Norbert. "Fish Faces in the Kelp Forest." ***Sea Frontiers***. November/December 1989, pp. 36-40.

FILMS

Seasons in the Sea (WNET Nature Series) P.O. Box 2284, South Burlington, Vermont 05407. (California marine life and kelp forest habitat)

ORGANIZATIONS

The following institutions offer educational publications and curricular materials on ***kelp forests***. Please contact their Education Departments for prices and ordering information.

Monterey Bay Aquarium
886 Cannery Row
Monterey Bay, California 93940-1085

Santa Barbara Museum of Natural History
2559 Puesta Del Sol Road
Santa Barbara, California 93105

SeaWorld of California
1720 South Shores Road
San Diego, California 92109-7995

Vancouver Aquarium
P.O. Box 3232
Vancouver, British Columbia V6B 3X8

Oregon Coast Aquarium
2820 S.E. Ferry Slip Road
Newport, Oregon 97365

Stephen Birch Aquarium-Museum
9500 Gilman Drive
La Jolla, California 92093-0207

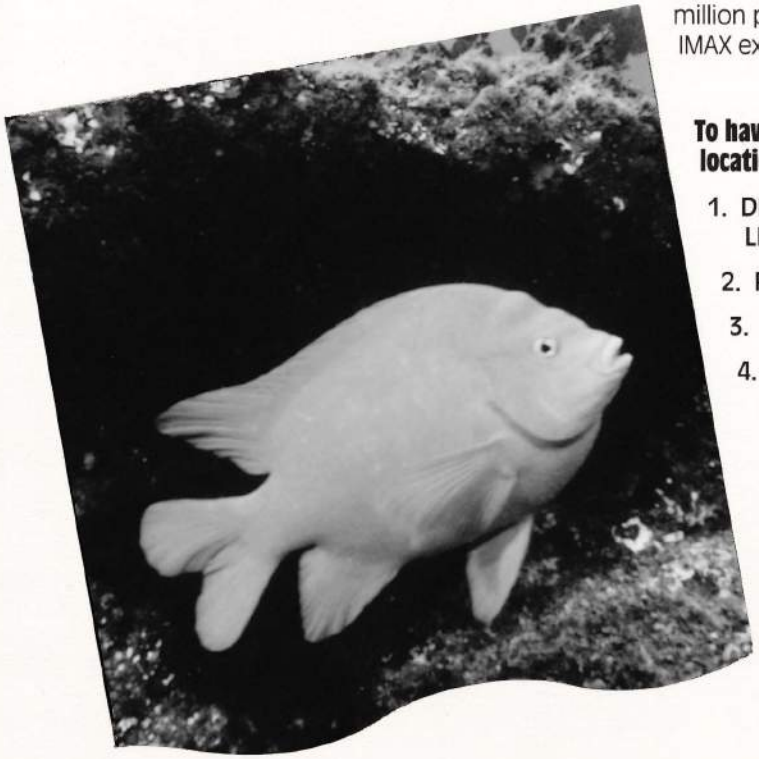
For additional information on kelp forests, you may want to contact these institutions, organizations and agencies in your area:

- Public aquariums and oceanariums
- Maritime science centers
- College and university departments of marine science or oceanography
- State sea grant programs
- State or provincial departments of marine resources

IMAX CORPORATION

IMAX Corporation, the inventor and developer of IMAX and IMAX 3D, is the leader of the giant-screen, large-format film industry.

IMAX uses the largest film frame in motion picture history (ten times the size of 35mm and three times the size of standard 70mm), together with the state-of-the-art sound systems, and the most advanced projector ever built, to support a network of more than 125 specially-designed theaters around the world. Since IMAX technology had its premiere in 1970, more than 440 million people have enjoyed the IMAX experience.



To have a list of IMAX theater locations faxed to you:

1. DIAL 1 (416) 960-9005 and LISTEN for voice instructions.
2. Press 5
3. Press 1
4. And follow instructions for entering your fax number.

Please note this is a long-distance telephone charge.