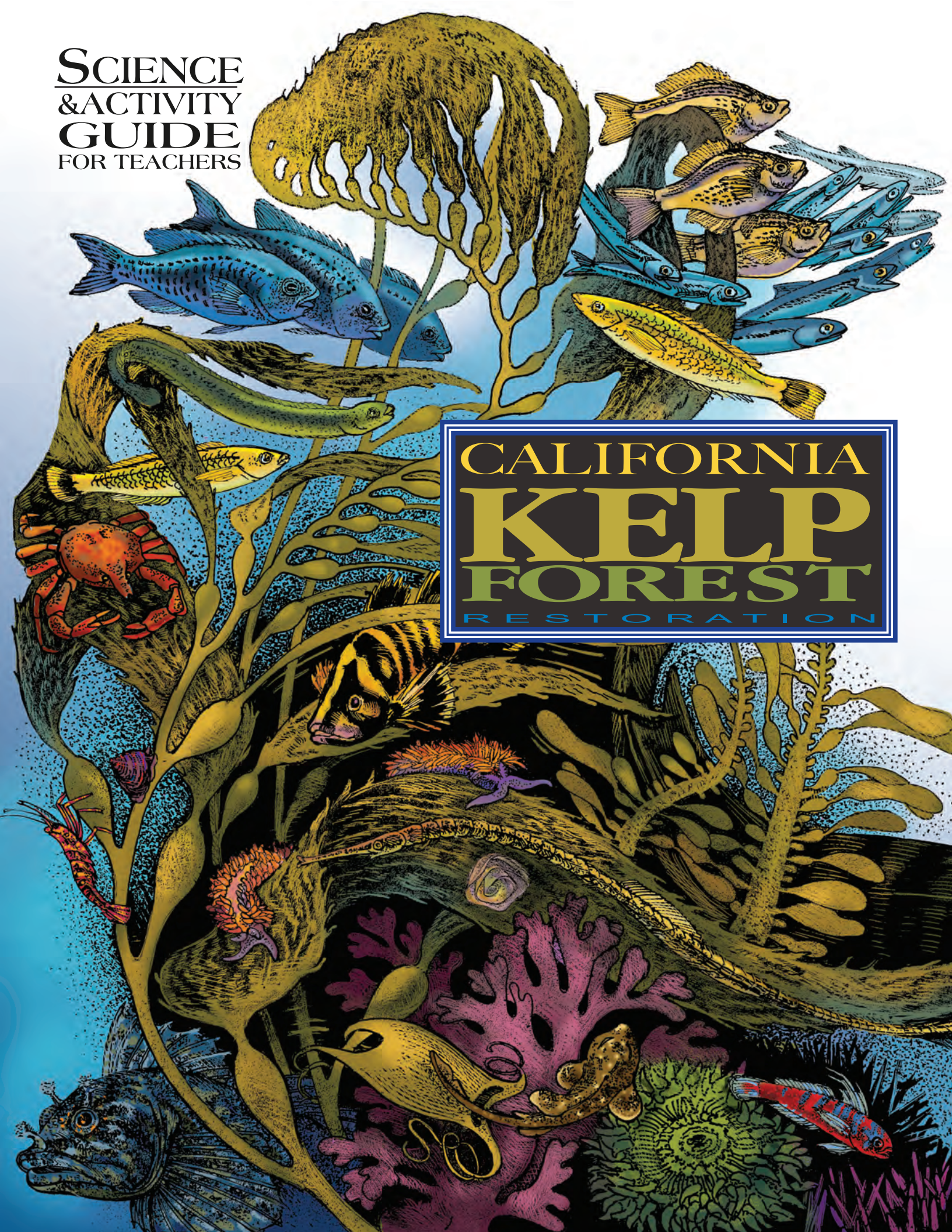


SCIENCE
& ACTIVITY
GUIDE
FOR TEACHERS

CALIFORNIA
KELP
FOREST
RESTORATION



CALIFORNIA SCIENCE CONTENT STANDARDS, with language arts, mathematics and history-social science standards.

The introduction to the California Science Content Standards defines the essential skills and knowledge in science that students are expected to acquire at each grade level in the State of California. The content within each grade level or span is organized into strands.

Science content strands for Grades K-5 are Earth Sciences, Life Sciences, Physical Sciences and Investigation and Experimentation. Science content strands are organized with a concentration for Grades 6-8 in Earth Science, grade 7 in Life Sciences, and Physical Sciences in grade 8.

SCIENCE SKILLS:

- ★ **Observing:** using all five senses:
seeing, hearing, touching,
smelling & tasting
- ★ **Classifying:** identifying like and
unlike objects, grouping
into sets
- ★ **Measuring:** using numbers to
describe size, weight,
quantity, volume or time
- ★ **Organizing:** analyzing and
interpreting data
- ★ **Inferring:** drawing conclusions
from data
- ★ **Predicting:** forming hypotheses
based on past observations
and results
- ★ **Experimenting:** identifying and
controlling variables in
testing hypotheses
- ★ **Deducing:** deriving a conclusion
from something known
or assumed
- ★ **Communicating:** verbal, written, or
other methods of informing
others about results
and conclusions



**Activities and Projects
providing science skills
are indicated with this
“seal” of approval.**

**California Kelp
Forests Restoration Project**

First Edition 2006
© Dawn N. Ericson
Publisher



Manta Publications
www.mantapublications.com



**CALIFORNIA
KELP
FOREST**
RESTORATION

The study of kelp and the kelp forest offers a unique opportunity to understand vital science concepts while having fun learning about our own unique California environment.

Kelp is a valuable resource and an ecological treasure of our state. Kelp forests provide food and shelter to vast and diverse species of animals and plant life both under the water and above.

With the increase of human demand and the pollution of our oceans, kelp forests and their delicate habitat are more vulnerable than ever and in dire need of protection and restoration.

This guide will help teach both the natural history and the current scientific understanding about this remarkable algae, and how we can preserve and restore the forests of our oceans.

To study nature is to encourage stewardship.

KELP CONTENTS

Kelp Forest Lesson Plan and Science Activities

<u>KELP FOREST CLASSROOM LECTURE</u>	3-7
<u>LIFE HISTORY of the GIANT KELP</u>	8-15
<u>WILDLIFE of the KELP FOREST</u>	16-18
<u>KELP RESTORATION</u>	20-22
<u>KELP VOCABULARY</u>	23
<u>KELP ORGANIZATIONS and PROGRAMS</u>	24

The CALIFORNIA KELP FOREST SCIENCE & ACTIVITY GUIDE FOR TEACHERS



is designed and written to assist teachers of grades K through 12. All black and white pages, diagrams and work-

sheets may be reproduced for use in your classroom.

Grade levels are indicated with type size and these codes:

LARGE TYPE:

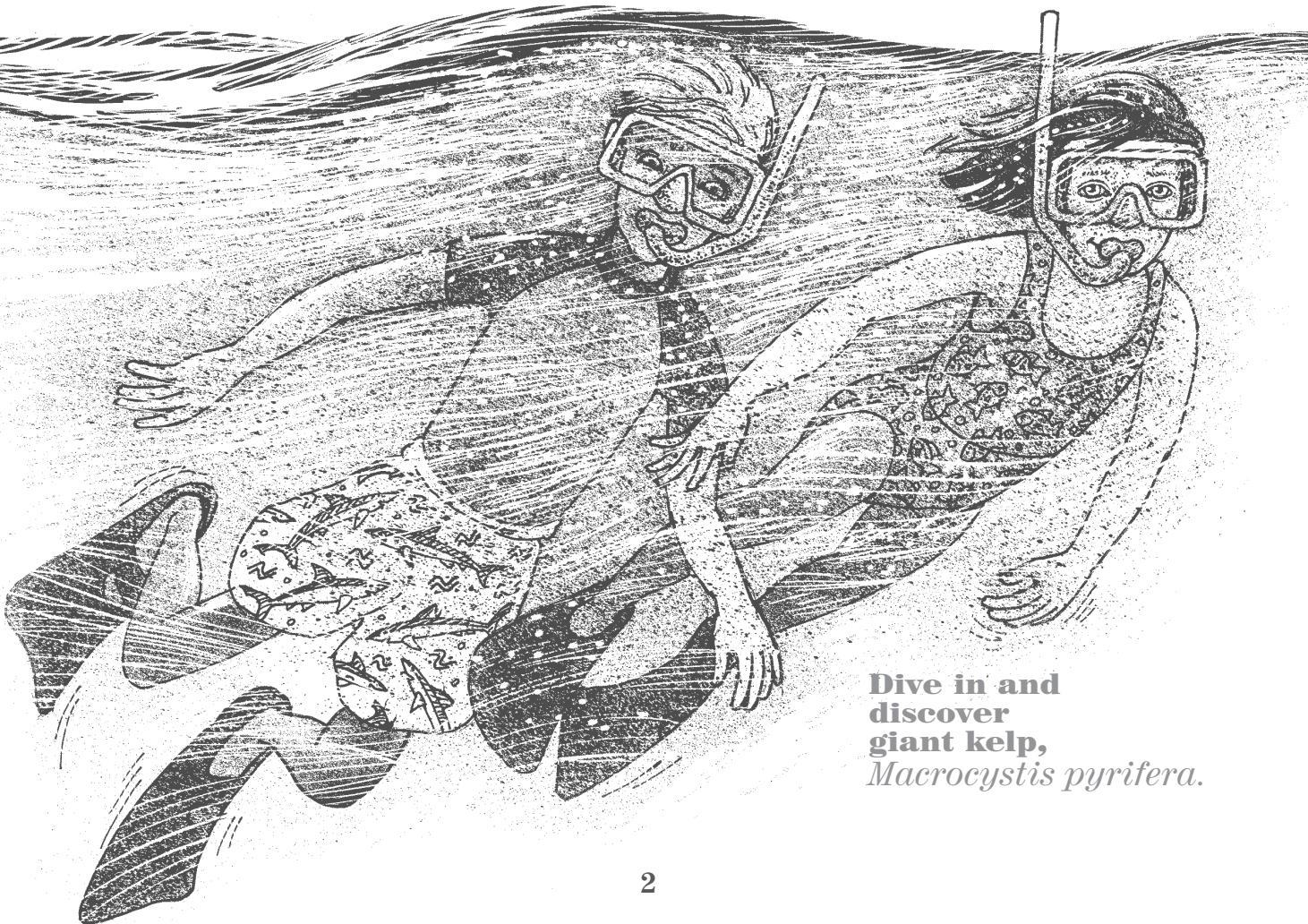
Primary Studies - (Pri.S) Grades K-5

SMALLER TYPE:

Secondary Studies - (Sec.S) Grades 6-7

SMALLER TYPE:

Advance Studies - (Adv.S) Grades 8-12



**Dive in and
discover
giant kelp,
*Macrocystis pyrifera.***

KELP FOREST CLASSROOM LECTURE

(Pri.S, Sec.S & Adv.S)

Kelp Introduction

California is a unique and amazing place on planet earth. Our state is rich with a variety of environments, from lush forests to vast deserts. However, just off the coast, only minutes from the city, is something even more extraordinary. Perhaps you have never even noticed it.

Have you ever gone swimming in the ocean and gotten tangled in a mass of brown seaweed, or stumbled over its twisting fronds while running on the beach? Perhaps you've noticed these same brown plants floating on the surface of the water all along the coast, with a pelican or sea otter floating nearby? What we see on the surface of the water, or washed up on the beach, are just parts of a vast underwater forest, existing beneath the waves, unseen and unnoticed by most of us.

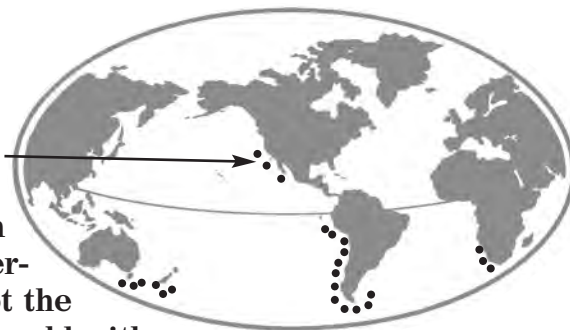
Divers have compared this unique underwater world to tropical rain forests because- like their land counterparts- kelp forests tower like trees, growing to great heights and providing food and shelter to an extensive variety of animals and life. These underwater plants are called kelp, and are not technically trees nor plants, but are classified as giant algae. There are many types of kelp, but the largest and most common algae here in California can grow from depths of 30 feet along the coast and up to 80 feet around California's offshore islands. Divers and scientists have counted more than 800 species of marine life that live in or depend on the kelp forests.

Giant
Kelp
Lecture

The great naturalist Charles Darwin noticed the ecological importance and value of the kelp forests as early as 1834, but to this day there is still much to learn and study about giant kelp, *Macrocystis pyrifera*, and there is a great need to protect it.

Kelp Forest Locations

California may be a unique environment, both on land and underwater, but it is not the only place in the world with kelp. There are a few other places with the necessary conditions for kelp growth, including the southern tips of Africa, Australia and New Zealand, along the west coasts of South America and, of course, North America. Along the coast from Baja California in Mexico, to San Diego up to Santa Cruz, are lush kelp forests growing uniquely above the equator. California's coastal waters provide just the right conditions for kelp growth including cool temperatures, plenty of nutrients, wave motion, rocky areas and clear, clean ocean water.



Of course, the less polluted an area is, the better the kelp forests can thrive. Today's healthiest kelp ecosystems are found outside such polluted and murky waters like the Santa Monica Bay. In the clearer waters off the coasts of Los Angeles, Oxnard and Santa Barbara lie the mostly uninhabited Channel Islands, surrounded by giant kelp. Catalina Island is easy to visit and enjoyed by many people for snorkeling and scuba diving amongst the swaying forests.



KELP FOREST CLASSROOM LECTURE



(Pri.S, Sec.S & Adv.S)

Kelp Introduction

Kelp Uses

The utilization of seaweed dates back to 600 B.C. when it was used as food for both people and their domesticated animals, and as soil fertilizer, called potash. Later, kelp was harvested and burned, with the ash used as a source of soda for pottery glazing and in the manufacturing of glass and soap. Kelp even 'fought' in the world wars, when the United States harvested the potash salt for explosives.

Today, kelp is a billion-dollar-a-year industry. Marine algae, or seaweeds, have so many uses that kelp is harvested by special barges out in the ocean equipped with large cutting racks which push through the kelp canopy. The kelp fronds are cut to a depth of four feet below the surface. In this way, only the mature, older fronds are harvested, and the kelp can quickly regrow. The cut kelp is gathered on conveyers which carry it aboard the barges, then it is unloaded on shore for processing.

From processed kelp, algin is derived. Algin is used as a thickener, emulsifier, gelling agent, and stabilizer in ice cream, beverages, drugs, cosmetics, paints, ceramics, insecticides, car polishes, adhesives, and dental gels like toothpaste. Kelp by-products put the head on beer, thicken milkshakes, and smooth ice cream. Kelp is also woven into surgical thread. Kelp is a rich source of iodine, potassium, phosphorus, and vitamins A, B, C, D, E and G. In fact, all of these vitamins and minerals are found in larger amounts in kelp than in any other vegetation on Earth. It is estimated that the average American consumer makes use of seaweed in one form or another every day, many times a day.

However, current demand for kelp algin exceeds supply. Therefore, careful management of the kelp forest has been developed with an understanding of its delicate ecology. Protection of kelp from over-harvesting is one way of keeping our oceans healthy and alive.

SEAWEED SHOPPING

name _____ date _____
Check list when finding products containing seaweed or algin.

	Brand Name	Algin	Potassium	Iodine
ice cream, puddings				
beverages, beer				
natural products				
cosmetics				
vitamins				
toothpaste				
paints				
insecticides				
other				

A seaweed shopping check list and a seaweed recipe.



KELP CHIPS

A seaweed recipe:

Seaweed as food goes back to 600 B.C.! Frying chips of vegetables in oil has remained a favorite way to prepare a quick snack.

1. Clean and dry *Macrocystis kelp* blades.
2. Cut the kelp into chip size pieces.
3. Heat a frying pan, add several tablespoons of canola oil. Fry the kelp until crisp. Place on paper.
4. Eat! No salt needed. Munch or add to a salad made with sea lettuce.

KELP FOREST CLASSROOM LECTURE

(Sec.S & Adv.S)

Kelp Environment

California has an abundance of giant kelp along its coast. Scientists estimate that 44,000 acres of ocean floor near California is covered by this marine ecosystem. But what makes this particular patch of the ocean so well suited for growing kelp? Giant kelp has several requirements that must be met in order to grow and flourish, and only a few places on the planet are lucky enough to provide for these needs:

1. Attachment Sites

Like trees, giant kelp has a kind of root system keeping it secured to one spot on the ocean floor. But unlike trees, kelp does not grow from out of the ground. Instead, its roots act like grasping fingers that create a holdfast, usually onto a rock. Thus, rocky areas in shallow coastal zones are the best places for the giant kelp to grow. How well an individual kelp grows depends on the quality and size of the rock a young kelp attaches itself too. If the rock is too small, it will not be able to support and weight down the buoyancy of the growing kelp, and the two will float away or wash ashore. Thus, a large, durable rock will give the growing plant a strong foundation from which to grow. Granite rocks are ideal, while softer rocks, like sandstone, present less secure attachment sites. The weak layers of sandstone break easily and can be further weakened by the burrowing action of clams and mussels into the rock. Such rocks often easily break apart, especially during large winter storms when waves thrash and pull at the kelp.

Occasionally, kelp can grow in sandy habitats as well. The Channel Islands act as a barrier to the Santa Barbara coastline, protecting it from large ocean swells and heavy currents. Its sandy outcrop once supported a dense kelp forest. In the sheltered waters, kelp plants could settle on small shells or worm tubes, and extend their holdfasts like roots into the sand. Each new kelp could then settle onto the holdfast of the adult plants, thus developing a kelp forest. However, in Santa Barbara, many of these kelp beds disappeared when they were uprooted by the unusually large storms that accompanied the "El Niño" of 1983, a phenomenon that produces destructively hot winds and

warm water. In the ever shifting sands, no one knows if the kelp forests will ever regrow.

2. Cold Water

Although too cold for human comfort, a kelp forest grows best where water temperatures remain below 70°F. Why does the water have to be so cold? The answer isn't certain. However, nutrients in the water vary when ocean waters warm up, and that's when the kelp forests appear to decline. Perhaps, in high temperatures kelp can't get the simple nutrients they need for photosynthesis and they starve. It is also possible that the warmer waters alter local winds and currents in such a way that they block the upwelling of cold nutrient-rich water. Research has shown that large adult kelp can withstand temperatures of up to 74°F, but the youngest plants perish when water temperatures rise over 68°F.

In Southern California, kelp forests follow a regular cycle of development, growing best during cold periods in the winter and spring, then deteriorating when water warms up in the summer and fall. Extended periods of warm water conditions, like El Niño weather, cause long-term damage to the kelp forests.

Rain Water Runoff

Measure changes in pH as water runoff travels from your school yard towards the ocean.

Materials: clean containers to collect water samples, pH testing kit, graph paper

Background: As rainwater falls and moves across a yard, down the driveway, and into a storm drain, it picks up pollutants. These pollutants come from many sources such as the exhaust and leaks from our cars, fertilizers on the lawns, soil and dirt, and wastes from animals. These pollutants can affect the pH of the water, making it more acidic. pH is the measure of how acidic or basic a solution is. Changes in pH can affect how chemicals dissolve in the water and whether organisms can use these chemicals to grow. Most aquatic organisms prefer a pH range of 6.5–8.0 (with 1 being most acidic, 14 being most basic, and 7 being neutral).

Hypothesis: State a hypothesis about how the pH readings of your water samples will change as the water flows from the school yard down to a storm drain.

Record your hypothesis.

The Clean Water Act 1972

The Clean Water Act is the cornerstone of surface water quality protection in the United States. Its intent is to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff.

The goal is to restore and maintain the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Remember, healthy water means healthy people.

Rain water runoff.



KELP FOREST CLASSROOM LECTURE OBSERVATION NOTEBOOK










NAME _____

GRADE _____

SCHOOL _____

TEAM MEMBERS _____

NAME	
GRADE	DATE _____ My kitchen tap water
SCHOOL	DATE _____ My home's outdoor water
TEAM MEMBERS	DATE _____ My city storm drain water
	DATE _____ Beach storm drain water
	DATE _____ Ocean water
	DATE _____ Animal sightings
	DATE _____ Bird sightings
	DATE _____ Types of kelp on beach or ocean waters
	DATE _____ Beach wildlife, crustacean or shell sightings
	DATE _____ People sightings
	DATE _____ POLLUTION sightings

SEEING	HEARING	TOUCHING	SMELLING	TASTING
				
				
				
				
				
				
				



*Don't do it!

An observation assignment.



KELP FOREST CLASSROOM LECTURE

(Sec.S & Adv.S)

Kelp Environment

3. Salinity (Salt Content)

Kelp is found only in the ocean. Rivers and lakes are freshwater with zero salinity, while the ocean has a salinity of around 35 parts per thousand (ppt) of water. From this we can conclude: kelp needs salty water in order to survive. If you were to place it in fresh water, kelp cells would quickly explode as the fresh water would rush into the cells and try to equalize the salt concentration. Reverse this effect and try putting kelp in super salty water (maybe 45 ppt) and the algae would quickly shrivel as the water from the kelp cells would rush out of the cell into the saltier water. Luckily, the ocean's salinity remains stable and kelp does not have to suffer from major salinity changes.

4. Clear Water

Like plants, kelp thrives on sunlight. But even on the most beautiful, sunny days, beneath the surface of the water it can quickly become dark. The canopy of the kelp alone shades out 90% of the sunlight from everything below it, including the plant itself. However, it is this same canopy that is reaching and growing upward to the surface water, so it can absorb as much light as possible.

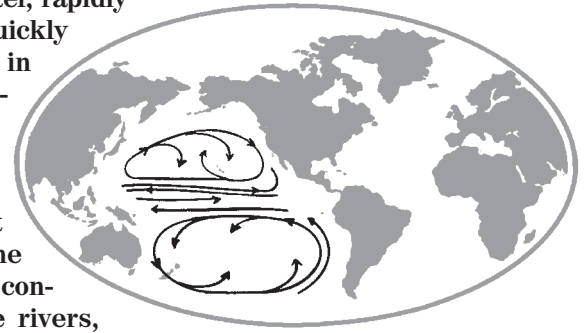
Thus, the clarity of the water is extremely important. Muddy, cloudy water and polluted water looks dark and prevents sun light from penetrating downward. Clear water ensures that the maximum amount of light can reach even the deepest depths of the ocean to the smallest kelp trying to grow 80 feet to the ocean surface.

The color of water is also an important indicator of water clarity. Throughout Southern California, the water appears dark and greenish. Greenish water is a sign that light is being blocked and reflected back to the surface. It may also be an indication of the pollution and sediment making the water murky and dark. Towards Palos Verdes or the Channel Islands, however, the water takes on an aqua color. This light, bluish tint is a sure indicator that light is penetrating deep into clearer waters.

5. Nutrient-Rich Water

In addition to light, kelp forests need a constant supply of fresh nutrient-rich water to survive. Kelp absorbs simple chemicals from the surrounding water, rich with oxygen, carbon, nitrogen, and phosphorus needed for growth and carbon dioxide needed for photo-

synthesis. In calm water, rapidly growing kelp would quickly deplete the nutrients in their immediate surroundings. But the motion of the currents, waves and upwelling throughout the ocean keeps the wealth of nutrients in constant circulation. Like rivers,



ocean currents push the cold, nutrient-rich water through the kelp forest, replacing and carrying away the warm, nutrient-poor water. The California Current brings cold, nutrient-rich water down from the north all the way to southern California. During the calm, warm periods of summer, these currents move less rapidly and the growth of the giant kelp often slows down or stops completely.

Pacific Ocean Currents

Cold, nutrient-rich water does not only move along currents from North to South along the California coast. Upwelling also replaces the warm, nutrient-poor water. Upwelling occurs when deep, cold water rises to shallower depths carrying upward the nutrient-rich decay of dead plants and animals, abundant with all the chemicals kelp forests need.

6. Waves and Water Motion

Waves benefit the kelp community by keeping in constant motion the cool, nutrient-rich ocean water. The entire kelp community depends on such water circulation to distribute the living plankton and decaying matter which filters down the water column to reach the smaller animals. Water movement also carries larvae and spores as they settle on the ocean floor and develop, helping to create such vast ocean "forests".

Moderate size waves also help to "weed out" older kelp growth, allowing more sunlight to penetrate down to new growth and creating a healthier forest. However, enormous surging waves can be very destructive to a kelp forest. Rapidly moving water during storms accompanied by thrashing, pounding waves, tugs and tears at kelp forests, stripping away fronds and sometimes ripping the entire hold-fast of a kelp plant away from the ocean floor. After such a storm, the beach will often transform overnight into masses of washed up and stranded seaweed, which provides shelter and nutrients to a whole new intertidal community of land-dwelling organisms.

GIANT KELP *Macrocystis pyrifera*

**Kelp
Canopy**

Kelp Frond
Blades and Stipe
may live up to 6 months.

••••• **Pneumatocysts**
Floats, or gas filled bladders.

••••• **Kelp Blade**

**Mid-Water
Zone**

••••• **Scimitar Blade**
Where new blades are formed.

Kelp Stipe

**Fron
Initial**

Sporophyll Blades

**Kelp Spores-
Sporangia**

••••• **Kelp Holdfast**
Can grow to 8 feet across.

**Sandy
or
Rocky
Bottom
Holdfast**

••••• **Haptera**

LIFE HISTORY of the GIANT KELP

(Pri.S, Sec.S & Adv.S)

GIANT KELP

Macrocystis pyrifera

California has up to twenty different species of kelp. As you already know, the largest of these is the giant kelp, *Macrocystis pyrifera*. In fact, this kelp is one of the most structurally complex marine “plant” on Earth, growing remarkably fast and reaching heights of up to 150 feet in less than a year.

Giant kelp usually grows in shallow depths ranging from 20 to 80 feet. Below 80 feet, light becomes limited, preventing the growth of most young *Macrocystis pyrifera*. Given the right amount of sunlight, temperatures between 50° F and 65° F, and ample cold nutrient-rich water, the “branches” or fronds of kelp can grow up to two feet per day! Fronds have an average life span of 6 months as they grow and converge at the surface of the water into a canopy, absorbing light, and finally being pulled away by ocean currents and waves. This process is called sloughing, and new fronds continuously develop and mature to replace the old. The kelp itself lives up to seven years, and it will continue to generate a stronger and bigger holdfast and new fronds throughout its life. Adult kelp also release hundreds of reproducing spores, helping to create an ongoing undersea forest of life.

Every winter the perennial *Macrocystis pyrifera* sloughs back, leaving only a few fronds on the kelp stipe and the kelp holdfast. Winter storms between October and March contribute to the decrease in size of the kelp canopy but generally spare the understory of fronds and blades which remain and regenerate.

Throughout the year, many species of fish depend on kelp forests as nurseries for their young and

habitats for adults. Nearby intertidal communities of animals also rely on the nutrients from the sloughing of blades and shedding fronds. Severe winter storms or an El Niño season can disrupt the entire ecology and food chain, often requiring two to three years to re-establish a disrupted ecosystem and kelp forest.

THE THREE BASIC PARTS OF THE GIANT KELP:

The Holdfast, Stipe and Blade make up the three basic parts of giant kelp. From absorbing sunlight and nutrients in the water, to hanging on for dear life, each component does its part to produce strong and healthy kelp.

(Sec.S & Adv.S)

1. Kelp Holdfast

Working like the anchor of a boat securing it against the surging waves, the holdfast secures the kelp in place. Root-like in appearance (but not a root, because it doesn't gather water and nutrients from the soil the way roots do) the holdfast holds tight to its rocky home. Anchored to the rocks, tubeworm reefs, or sandy ocean floor, the holdfast is a mass of tangled, brightly hued haptera. The haptera's stubby branches sprout from the bottom of the plant and intertwine and overgrow the older ones. They grow down over the rock surface, wedging themselves into any available crack or crevice giving the holdfast an upside-down cone shape. Snails, small crabs, shrimps, brittle stars and small worms take refuge from predators inside the cavities between branches. Some lodgers eat the older, inner haptera and hollow out the inside of the holdfast. In this way, the holdfast provides a secure home for a multitude of creatures.

As a kelp's holdfast ages, it may eventually lose its grip to the ocean floor. Hungry tenants may eat too many of the new branches, or the oldest branches in the center may decay and fail. If the remaining branches don't hold fast, surging storm waves will pull the weakened holdfast free, setting the kelp adrift.

Giant
Kelp
Life
History

A kelp stipe may grow up to 24 inches in 24 hours.



LIFE HISTORY of the GIANT KELP

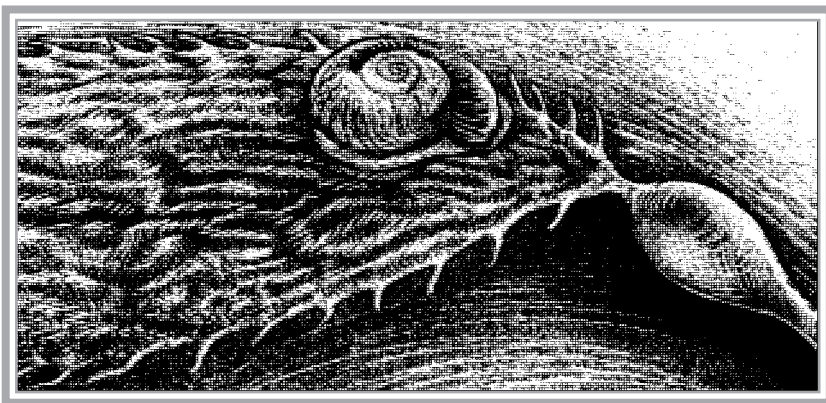
(Sec.S & Adv.S)

GIANT KELP (continued)

2. Kelp Stipe

Sturdy and resilient, kelp stipes rise like twisting vines to the surface of the water while holding the whole plant together. The kelp stipe is like the stem on a land plant but much more flexible like rubber so it can stretch up and down in the waves without breaking or tugging too strenuously on the holdfast gripping the ocean floor below. Besides being the sturdy anchor line for kelp, it is also an elevator for passing nutrients from one end to the other, running between the canopy above and the holdfast below. Kelp blades are attached to the stipe along its entire length. A collection of growing blades on the stipe is called a frond. Sugar energy (the product of photosynthesis) travels from fronds in the sunlit waters above down to the dimly lit lower portions of the plant. This process, called translocation, allows giant kelp to grow larger and faster than any other kind of seaweed or plant.

Kelp stipes develop enlarged hollow floats or pneumatocysts (pronounced “new-mat-o-sists”). A mixture of gases fills each balloon-like float, allowing the stipe and blades to float towards the sunlit ocean surface where the plant can collect the most sunlight possible for photosynthesis.



The marginal spines and textured surfaces of *Macrocystis pyrifera* blades increases turbulence as water flows over them and facilitates the uptake of carbon dioxide and other molecules from the water.

3. Kelp Blade

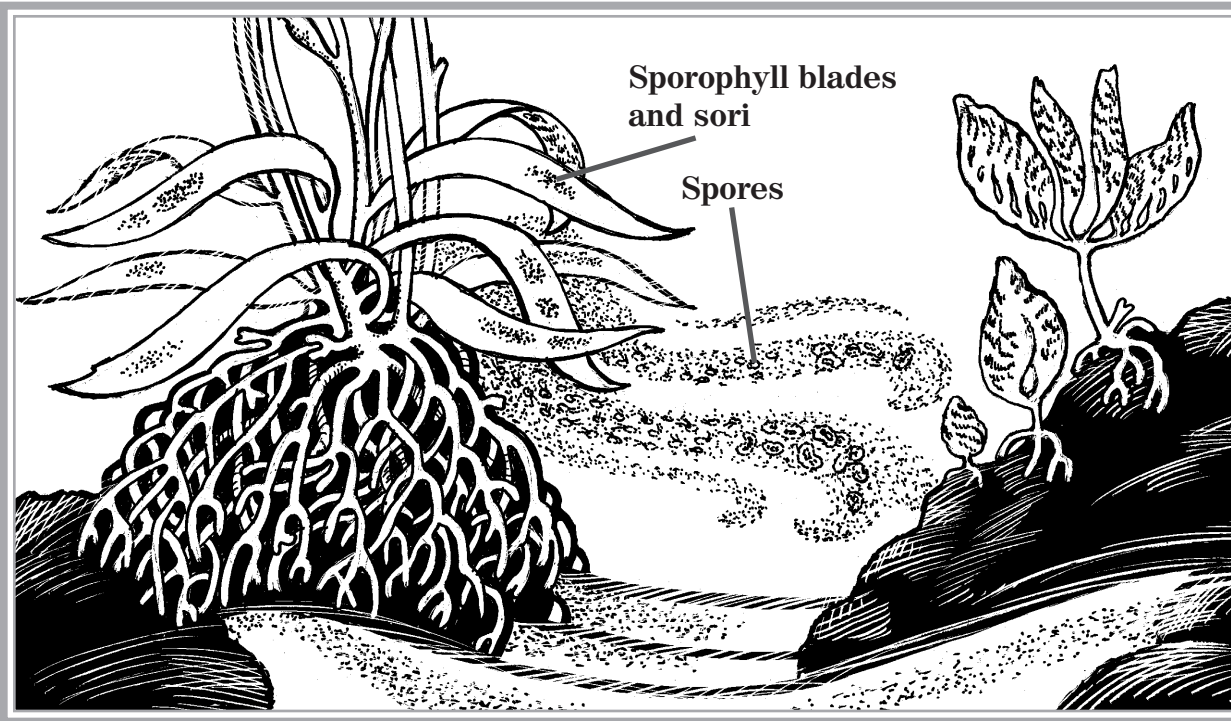
The flattened, broad blade of kelp grows rapidly. Like a leaf, its flat and wide surface area allows for a maximum absorption of sunlight. Pneumatocysts- the round hollow bulbs at the base of each blade, like little balloons- makes the blades buoyant so that they float toward the surface. Once at the surface, the kelp grows outward, creating a gorgeous canopy and absorbing the maximum amount of light. Through translocation, the energy from this sunlight is transferred to the rest of the plant, all the way down to its holdfast.

The kelp blade performs photosynthesis whenever light is available. The blade cells absorb water and carbon dioxide from the surrounding seawater and use energy they collect from sunlight to make oxygen and food compounds like sugar, amino acids and other building blocks of plants. The sugars provide nourishment for all parts of the plant, from the growing tips in the canopy to the established holdfast and developing fronds far below the surface. The stipe helps transport this food to wherever it is needed most. Surplus food is stored in the cells of the kelp plant, to be used later to make more blades, stipe and a thicker holdfast.

As a result of these stored sugars, kelp blades provide nutritious meals for countless kelp forest fishes that nip at the blades, getting little mouthfuls of the sweet-tasting blades. Snails and some other mollusks use razor-like teeth, or radula, to scrape over the blades and stipe. Even if the blades are not being directly eaten, they secrete nutrients into the water serving as an additional food source to the many microscopic plankton floating through the sea.

LIFE HISTORY of the GIANT KELP

Giant Kelp Life Cycle



(Adv.S)

Giant Kelp Life Cycle and Reproduction

Macrocystis pyrifera develops clusters of special reproductive blades called sporophylls near or above its holdfast. These sporophyll blades are responsible for spore production. By making spores, the first (microscopic) phase in the life cycle of the kelp begins. Dark patches known as sori on these fertile blades show the location of the spore-making cells called sporangia. Each sporangium (smaller than the eye can see) produces between 16 and 32 spores.

A kelp plant in its prime produces hundreds of sporophylls that generate billions of spores. Spores are tiny, smaller than the dot of a period on this page. Released into the surrounding water, they are lively swimmers yet at the mercy of currents. A swarm of the swimming spores travel away from the parent plant. Carried by the currents and water movement, spores may travel a few feet or several yards away. Many are lost at sea or eaten by animals. Only a few of the lucky spores find themselves stranded in calmer waters near the ocean bottom and settle down on a rock.

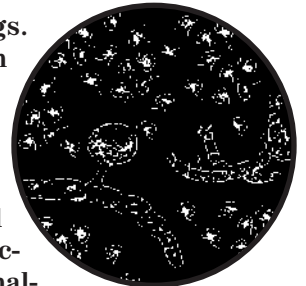
Once securely in place on the ocean floor, each spore will slowly, over the next few days, divide to form a tiny chain of cells. This small chain is the next stage of the "invisible" phase of the kelp's life story: the gametophyte phase. Some of the tiny chains will become male plants that produce sperm while the oth-

ers become females and produce eggs. Chemical signals from an egg cause sperm to be released from the male plant. Sperm swarm toward the female's egg, drawn by its chemical perfume. Only one sperm can successfully unite with the egg. Once fertilized, the egg grows into an embryo and eventually develops a single blade-like structure: a sporophyte. At this phase, one can finally witness the growth of the kelp with their naked eye, watching as the blade grows upward and produces other, newer blades.

The sporophyte will extend upward toward the sunlight at the surface of the water, creating new blades and stipe. The tip of each stipe, where tiny new blades are forming and are still attached to one another, is called the scimitar blade. It will continue to grow, repeatedly splitting and forming more blades and creating fronds, thickening and developing the buoyant pneumatocysts until eventually it becomes a mature kelp, reaching up to the surface.

At this stage, while it may appear that all young sporophytes will mature into giant kelp, the holdfasts of these young can crowd a rock like rival siblings. The fastest-growing plants shade out their neighbors in a race for sunlight and space.

In about one year, a 100-foot-tall mature giant kelp may preside over its kelp forest domain.



Gametophyte phase



A young sporophyte

Scimitar blade

LIFE HISTORY of the GIANT KELP

Giant Kelp Habitats



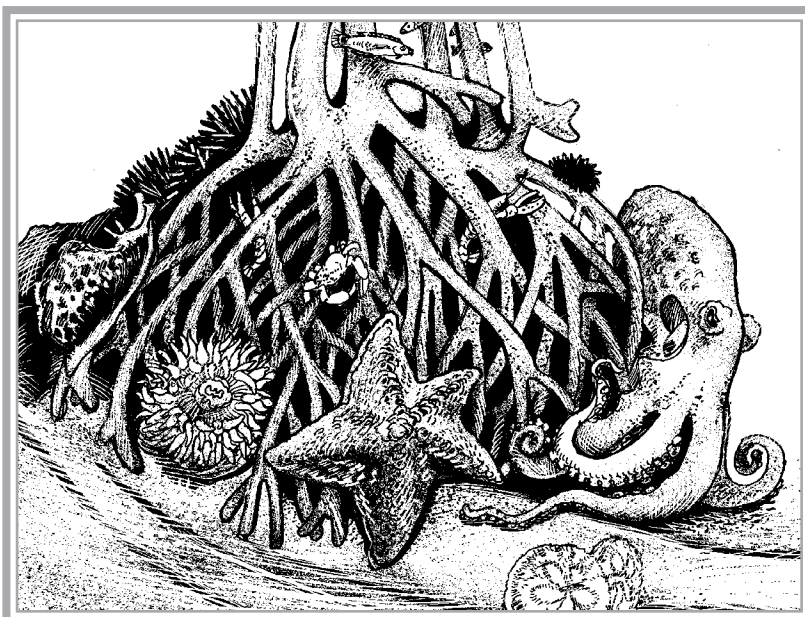
Kelp Canopy

(Pri.S, Sec.S & Adv.S)

HABITATS

A habitat is the part of an ecosystem where an organism spends its life: where it collects food and retreats for shelter. For the dolphin, the entire ocean makes up its habitat. For others, like the bryozoan, a single blade of kelp is its home. The kelp plant supports and sustains the habitats of a wide variety of unique animals. In fact, the kelp forests can be divided into three very different habitats: the kelp canopy, the mid-water zone, and the holdfast. Each zone throughout the

Sandy or Rocky Bottom Holdfast



kelp forest provides food and shelter for a completely different variety of animals. And many of the animals share habitats, interacting with one another and often influencing each other's kelp forest ecology and survival.

The Kelp Canopy

The canopy zone is at the surface of the water. This buoyant layer of kelp can grow to over 50 feet, sometimes twice the length of its height from the ocean floor, and is easily visible from the shore. The long fronds of the kelp spreads out and entwines to form a dense floating mat, creating a shadowy forest below. Thus, the canopy accounts for 95% of the kelp photosynthesis, absorbing the most direct sunlight.

The canopy provides shelter, hiding places, camouflage and food for a multitude of organisms, including frond dwellers: kelp crabs, *Melibe* nudibranchs, kelp isopods, hydroids, bryozoan colonies, black sea hares, pipe fish and Norris' kelp snails.

Surface-dwelling fishes like giant kelpfish, topsmelt, anchovies and sardines feed on the small snails, isopods and crabs that crawl about and feed on the blades and stipe of the canopy layer. Several species of young rockfish find food and protection from

LIFE HISTORY of the GIANT KELP

predators for a few weeks before they take up residence on the sea floor. The canopy also provides a resting place for sea otters and food for sea gulls, pelicans, great blue herons, great egrets and cormorants.

Mid-water Zone

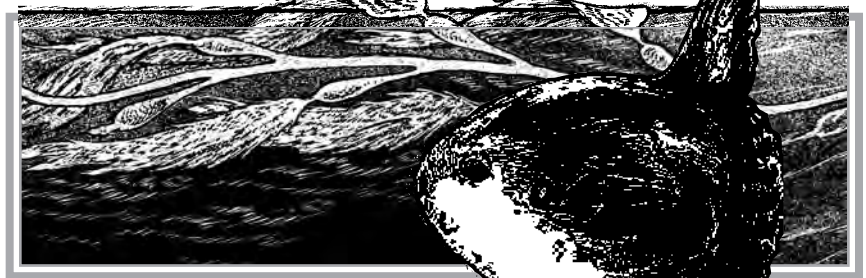
Beneath the sun-drenched canopy of kelp on the surface, we reach the mid-water zone where there are fewer hiding places. Here, the kelp is made up mostly of stipes connecting the canopy all the way down to the holdfast and creating an open zone for both predators and prey to swim throughout. Dolphins, sea lions, harbor seals, bat rays and other large predators search for food, chasing schools of fish all through the swaying kelp. Opaleye, senioritas and blacksmith are common fish that school together for protection, and feed on kelp blades and floating plankton. Kelp bass are both predators and prey, and easily find shelter in the kelp as camouflage, while snails make their homes gliding up and down and feeding on the stipes.

Kelp Holdfast

The holdfast at the base of the kelp does more than just secure it to the ocean floor: here we find the secret hiding places of many shy and secretive little animals, protected by the knotty branches and tangled fingers of the haptera. Anemones, brittle stars, juvenile kelpfish, bryozoans, hydroids, shrimp, amphipods and other young fish all take up residency in the safety of the holdfast, where there's always plenty of food drifting about at the bottom of the ocean.

Nearby, surrounded by rocky outcroppings and competing for crevices, there are even more dwellers. Lobsters, bat stars, octopus, sea urchins, and fish- like the bluebanded goby, garibaldi, moray eel, cabezon, and sheephead- make the rocky bottom

zone of the kelp forest their home. Sea anemones and plant-like gorgonians colorfully dot the ocean floor in rocky areas, while in more sandy zones of the kelp forest, bat rays, guitarfish, and round stingrays bury themselves in the sand for shelter. Bat stars and sea cucumbers move slowly across the sand or holdfast. Seniorita fish hide by quickly disappearing with a dive into the sandy bottom. At night, leopard sharks, swell sharks, horn sharks and others will ascend from resting among the rocks, and begin their hunts around the holdfast zone.



**Drift
Kelp**

(Pri.S, Sec.S & Adv.S)

California Coastal Kelp Habitats

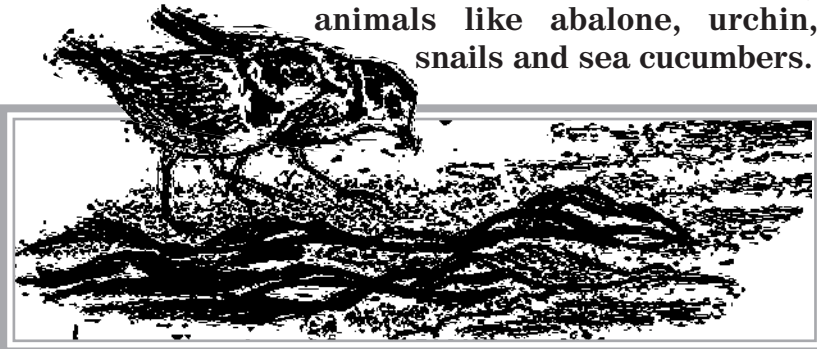
Along with attached-growing kelp, two other important kelp habitats include drift kelp and kelp wracks. These habitats, like the kelp growing in the forests, provide refuge and food to a variety of marine species.

Drift Kelp

The fronds and blades of the upper canopy are often pulled or ripped away from the body of the kelp during storms and heavy surge. Before these broken and floating masses of seaweed can be washed to shore, they sometimes create the basis of a transient marine community. Drifting off to sea, they become home to a variety of open water animals. Shrimp and small fish seek out the shelter they find beneath the kelp, which can also attract larger fish like tuna and sunfish. Fishermen

LIFE HISTORY of the GIANT KELP

drift- which they often call a kelp paddy- and take advantage by dropping their fishing lines nearby. If a kelp drift dies, losing its buoyancy, then it sinks to the ocean floor to become part of another important food chain, feeding animals like abalone, urchin, snails and sea cucumbers.



Kelp Wrack

Kelp wrack is an important element of the beach ecosystem.

But many of our local beaches are groomed or raked to look "pretty" for beach tourist and visitors while decimating the natural beach habitat.

Kelp Wrack

Walking along the beach, or exploring a tide pool, it's common to come across tattered kelp fronds - a kelp wrack washed up on the shore. As you come closer, dozens of kelp flies rise up and then return to feeding on the rotting kelp. Such kelp also attracts beach hoppers and other small shore animals. These become prey to crustaceans and mollusks that reside along the surf, attracting in turn, the many birds that feed on them. Meanwhile, the kelp wrack breaks down from the beating of the waves and bleaching of the sun, becoming food for bacteria and smaller animals. Its nutrients continue to be recycled into the subtidal community over a 20 to 23 day decomposition.

(Pri.S, Sec.S & Adv.S)

Kelp Classification

There are at least 20 different species of kelp growing along the California coastline. There are large kelp, like the giant kelp, while others are smaller and may live in shallower waters among the crashing, surging waves along rocky shores. One of the more common companions to the giant kelp is called the feather boa which can grow up to 30 feet in length. It is often found around the outer and inner

fringes of giant kelp forests. Because of its more rugged structure, it can handle the pounding and thrashing of waves much better than the larger kelp.

Even more hardy in the rougher water is a palm-tree-looking kelp, aptly named the sea palm. Small in size- growing up to 3 feet in height- it is very flexible and can bend completely over, allowing it to withstand the pounding surf of even the largest waves. It is the hardest kelp, growing where others can't in shallow, sunlit waters off the coast.

Along the floor of the kelp forest, and covering both rocks and shells all along the coast, are several species of red algae. Their abundance gives the ocean floor a red appearance. Giant kelp appears brown, and there are some algae species that are green.

(Adv.S)

Algae

Giant kelp is just one member of the group of "plants" called algae. Algae are different than vascular land plants, which have roots, stems, leaves and flowers. Algae have no leaves, no stems or flowers, and no roots. Kelp, also called seaweed, is an algae- nonvascular and living in water.

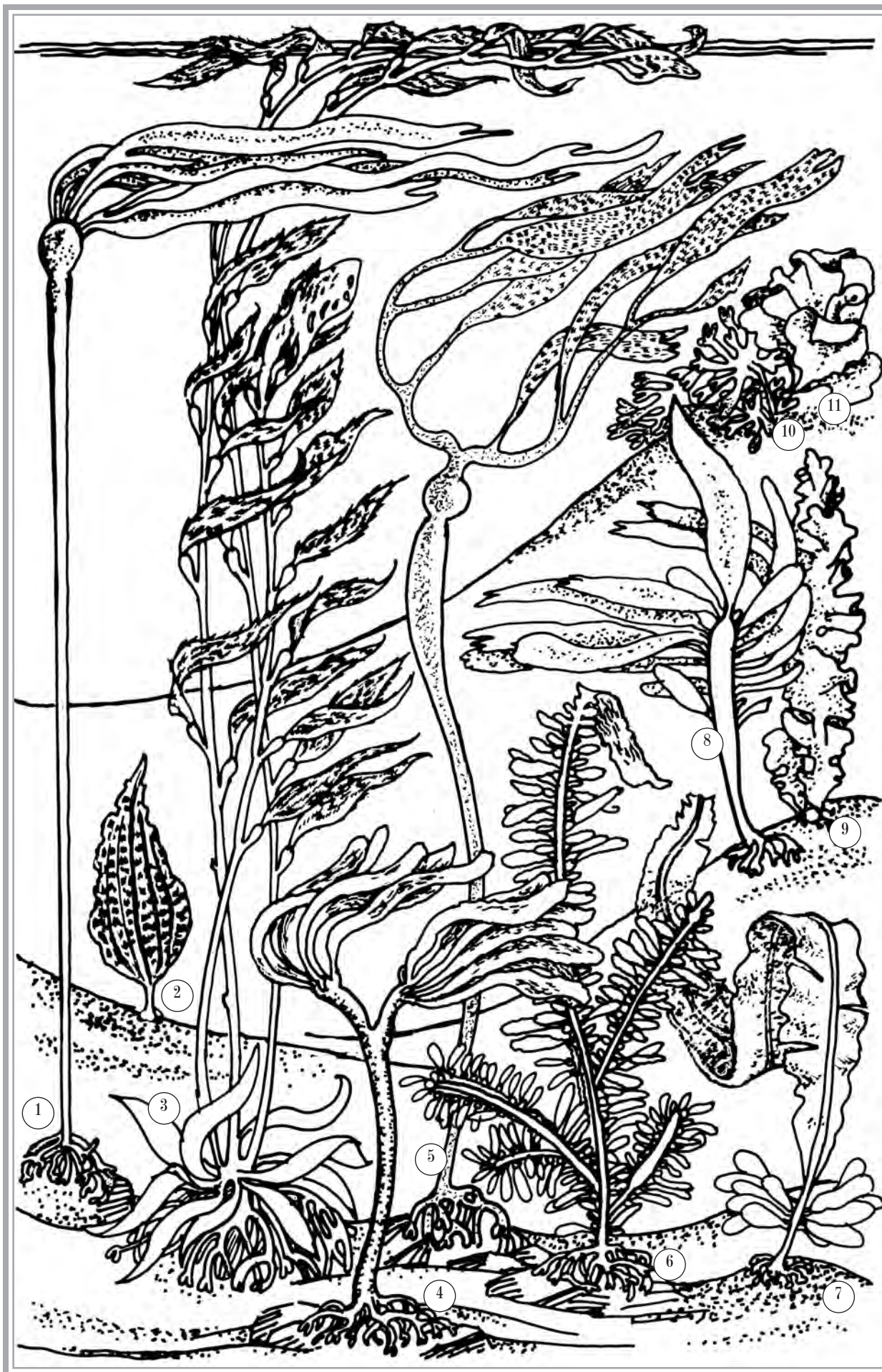
Water-dwelling "plants", such as giant kelp, are entirely exposed to water at all times. Also, all of their parts can perform photosynthesis, unlike the trunks, stems and roots of a land plant or tree. That's the difference between vascular plants and nonvascular algae.

There are three kinds of algae: red, green and brown, so named because of the primary color they appear to our naked eye. Their colors are determined by the pigment the plant produces to catch sunlight.

Giant kelp are in the order of brown algae called the *Laminariales*. These brown algae all share the same life cycle and begin as a single leaf-like blade from which they grow into different forms.

There are at least 20 different species of kelp (members of the order *Laminariales*) growing along the California coast. These magnificent amber brown seaweeds form some of the most structurally complex habitats in the ocean making homes for thousands of species.

LIFE HISTORY of the GIANT KELP



KELP COLOR & QUIZ

1. **Bull kelp**
Nereocystis luetkeana
2. **Seersucker kelp**
Costaria costata
3. **Giant kelp**
Macrocystis pyrifera
4. **Sea palm**
Eisenia arborea
5. **Elk kelp**
Pelagophyceus porra
6. **Feather boa kelp**
Egregia menziesii
7. **Ribbon kelp**
Astartia marginata
8. ***Pterygophora californica***
9. ***Ulva augusta***
10. ***Rhodymenia californica***
11. **Sea lettuce**
Ulva californica

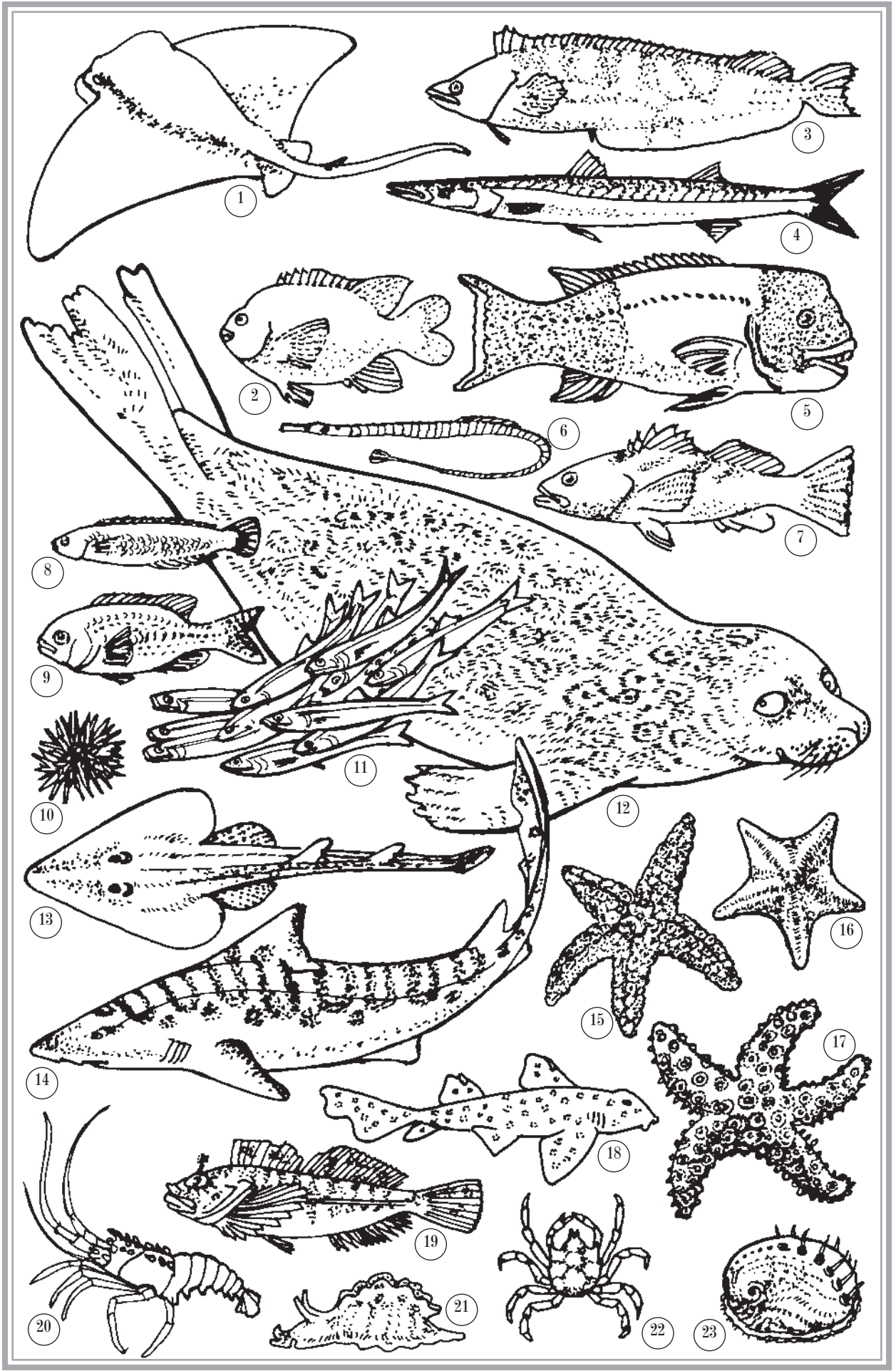
Enlarge this illustration
155% and print on
11 x 17 paper -
as a QUIZ &
COLORING PAGE



WILDLIFE of the KELP FOREST

WILDLIFE COLOR & QUIZ

1. **Bat ray**
Myliobatis californica
2. **Garibaldi**
Hypsypops rubicundus
3. **Kelpfish**
Heterostichus rostratus
4. **Pacific barracuda**
Sphyraena argentea
5. **Sheephead**
Semicossyphus pulcher
6. **Bay pipefish**
Syngnathus leptorhynchus
7. **Kelp bass**
Paralabrax clathratus
8. **Senorita**
Oxyjulis californica
9. **Blacksmith**
Chromis punctipinnis
10. **Sea urchin**
Strongylocentrotus purpuratus
11. **Northern anchovy**
Engraulis mordax
12. **Harbor seal**
Phoca vitulina
13. **Shovelnose guitarfish**
Rhinobatos productus
14. **Leopard shark**
Triakis semifasciata
15. **Ochre sea star**
Pisaster ochraceus
16. **Bat star**
Asterina miniata
17. **Giant sea star**
Pisaster giganteus
18. **Horn shark**
Heterodontus francisci
19. **Cabezon**
Scorpaenichthys marmoratus
20. **California lobster**
Panulirus interruptus
21. **Sea hare**
Aplysia californica
22. **Kelp crab**
Pugettia producta
22. **Red abalone**
Haliotis rufescens



Enlarge this illustration
155% and print on
11 x 17 paper -
as a QUIZ &
COLORING PAGE



WILDLIFE of the KELP FOREST

(Sec.S & Adv.S)

Kelp Isopods, Bryozoans and Hydroids

Kelp blades provide a home for a group of microscopically small animals called bryozoans. Plant-like in appearance, the bryozoans attach themselves in large interconnected colonial groups to their blade home. The bryozoan is a filter feeder. It captures food by expanding a funnel-shaped set of tentacles called the lophophore which draws in small plankton to the bryozoan's mouth.

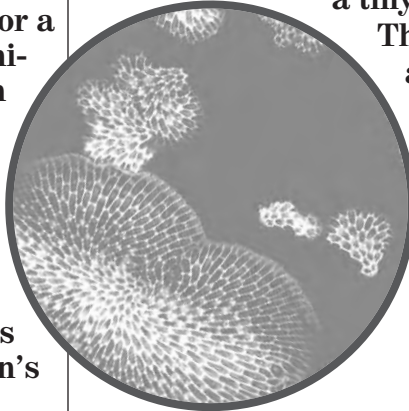
Bryozoans begin their lives as free-swimming larvae and are a part of the ocean's zooplankton. They settle on a kelp blade to live their entire lives attached there. In colonies, these bryozoans then reproduce by budding. In budding, the adult organism grows a small copy of itself on the side of its body. This new animal builds its own home next to its parent. Then the process is repeated over and over again until a colony of bryozoans begins to develop in a circular pattern on a blade. Eventually the bryozoans produce eggs and sperm and create free-swimming larvae which leave the kelp blade in search of a new blade to live on where they will create yet another colony.

Another common kelp blade inhabitant is the kelp isopod, *Idotea*. Usually an inch in size, these animals scoot around on the blades that float on the ocean surface. If you were to swim through a canopy of kelp, you might find yourself covered in these tiny organisms. They march around on the floating blades eating holes in the kelp and blending in perfectly, camouflaged and unseen by their predators: rockfish, kelp bass and other kelp forest fish.

Drifting through a kelp canopy are a vast variety of microscopic animal

larvae waiting discovery under the microscope. Many settle into place and secure themselves onto a blade. The tiny hydroid, *Eucopeella Sp.*, appears like a tiny stalked flower.

The hydroid divides and spreads across a kelp blade like a microscopic garden.



Bryozoan colony

Giant
Kelp
&
Wildlife



Under
the
Microscope



WILDLIFE of the KELP FOREST

(Pri.S, Sec.S & Adv.S)

PREDATORS of the KELP FOREST



Purple sea urchin
Strongylocentrotus purpuratus
4 inches

Sea Urchins

Predators, like wolves on land or sharks in the ocean, play an invaluable role in their environments, keeping populations in check and creating a more healthy ecosystem of life by weeding out the sickly prey. Sea otters, spiny lobsters and sheephead- the primary predators of sea urchins- used to keep the urchin populations at a controlled and healthy number, ensuring a healthy kelp forest. But as early as the 1800s, hunters had driven otters to near extinction, and today they can no longer be found in Southern California. Spiny lobsters and sheephead have also become scarce from over-fishing around our California kelp forests.

Without their key predators, sea urchins have become overpopulated. With their incessant appetites, they can destroy a kelp forest leaving desert-like areas known as urchin barrens. Where once there was an entire ecosystem of life thriving amongst a kelp forest, now there are desert-like barren reefs, rocks and sand beds.

Sea urchins have been especially troubling to Southern California's kelp forest since the 1950s, when cities along the coast began pumping untreated sewage directly into the ocean. This raw pollution decreased water clarity and inhibited kelp growth. Meanwhile urchins prospered, impervious to the filthy water.

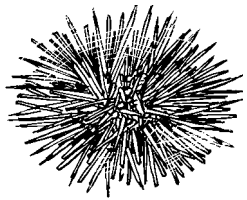
Normally sea urchins hide in the cracks and crevices of rocks, eating the bits of kelp that float by. But with the shortage of kelp plants, urchins began a slow-motion march in search of food. Battalions as dense as 200 urchins per square yard munched on the holdfasts of surviving kelp, setting entire kelp forests adrift.

Biologists have tried to control sea urchin populations by poisoning them with quicklime, and even sending volunteer divers on killing missions. But these efforts are generally unsuccessful. However, it now appears that human appetites are the best hope for kelp. In recent years, the Japanese desire for urchin roe (a delicacy called uni) has turned the creatures into a thriving fishing industry in California. Unfortunately, these divers collect only the larger red urchins, leaving behind the small purple urchins which continue to feast on the kelp. The problem is far from solved.

It's important to see how everything is connected, and how our decisions- like pumping sewage into the ocean- affects hundreds of other species down the line.

A number of human factors set in motion the decline of the kelp forests: the over-hunting and over-fishing of urchin predators, the harvesting of kelp, and the pollution of coastal waters. Polluted urban runoff and coastal development can also impair the successful proliferation of kelp due to the burial or scouring of juvenile kelp by sedimentation.

People clearly play an important role in the health of our kelp forest environment.



Red sea urchin
Strongylocentrotus franciscanus
5 inches

Sea Otter



KELP RESTORATION

(Adv.S)

CLEAN WATER and KELP FOREST CONCERNS

There has been growing concern among scientists about the overall decline of kelp and animal species along our California coast. Clearly, we are able to see changes in the environment. But how do scientists prove this? What do scientists measure to see if their hypotheses are correct?

Temperature - When you don't feel well, chances are the first thing someone does is take your temperature. Scientists measure water temperature for several reasons. First, the temperature of a habitat determines the kinds of animals that can survive there. If the temperature gets too hot or too cold for some organisms, they die. Temperature also can affect the chemistry of the water. For example, warm water holds less oxygen than cold water. (And everybody needs oxygen!)

Dissolved oxygen - Just like human beings, aquatic life needs oxygen to survive. Scientists measure DO (pronounced dee-oh) - dissolved oxygen. This tells them how much oxygen is available in the water for fish and other aquatic organisms to breathe. Healthy waters generally have high levels of DO (some areas, like swamps, naturally have low levels of DO). Several factors can affect how much DO is in the water including temperature and pollution in the water.

pH - The p stands for "potential of" and the H is for hydrogen. Scientists measure pH to determine the concentration of hydrogen in the water (pH ranges from 0 (very acidic) to 14 (very basic), with 7 being neutral. Most waters range from 6.5 to 8.5. Changes in pH can affect how chemicals dissolve in the water and whether organisms are affected by them. High acidity can be deadly to fish and other aquatic organisms.

Nutrients - Just as nutrients are critical for you to grow (check out the nutrition label on a box of cereal- all essential nutrients), nutrients are critical to plants and animals, too. The two major nutrients scientists measure are nitrogen and phosphorus. The presence of too many nutrients can hurt aquatic organisms by causing too much algae to grow in the water. Nutrients can also affect pH, water clarity and temperature, and cause water to smell and look bad.

Toxic Substances - Scientists also test for many harmful (toxic) pollutants like metal, pesticides, and oil. For example, scientists are finding mercury in certain types of fish. Such toxins get into our

waters from rain run-off and storm drains. When we carelessly pollute, such toxins come back to harm us down the line, like when we get sick from eating sick fish.

Turbidity - Scientists measure the clarity of water to determine how many particulates (tiny little particles of stuff) are floating around. If you're standing in the surf on a calm summer day, you might be able to see to the bottom. That's low turbidity. On the other hand, if you visit the beach after a rainstorm when all the particulates and muck has been stirred up, you won't be able to see the bottom; that's high turbidity.

Bacteria - Scientists sample for certain types of bacteria that are found only in the intestinal tract of animals and humans. These bacteria, called fecal coliforms, are not necessarily harmful, but they usually hang out with some bad characters like viruses and pathogens, which can make you sick. The major sources of fecal coliforms are people's failing septic systems, wastewater treatment plant discharges, and animal waste (including cow manure and your doggy's droppings).

Visual surveys - Not all measurements are chemical or physical. Scientists take measurements of the landscape surrounding a wetland to determine things like the amount of trees and shrubs along a waterway, the amount of shade that is created by trees overhanging streams, and woody debris (sticks and leaves) in the streams. The more vegetation, tree cover, and woody debris, the more healthy a habitat is for wildlife and fish. Vegetation can trap pollutants before they enter the ocean. And tree cover can help regulate a healthy water temperature, which is important to trout and other fish that need cold water to survive.

Biological sampling - Scientists determine the health of waters by counting individual fish, plants and by taking samples of smaller organisms called macroinvertebrates (mack-row-in-ver-tuh-bretts). Macroinvertebrates include things like snails, worms, fly larvae, and crayfish ("crawdads"). You can find them under rocks and tree roots in the water. These critters tell a story about the health of the stream. Some of them love to live in water that's dirty, so if scientists find a lot of those in a sample, they know there's a problem. Other organisms can survive only in water that's very clean, so finding those means the water is probably healthy.

Giant
Kelp
Concerns

EPA
United States
Environmental
Protection
Agency

WETLANDS,
OCEANS and
WATERSHEDS

www.epa.gov



Red abalone
Haliotis rufescens

KELP RESTORATION

Giant Kelp Cultivation

(Adv.S)

Kelp Cultivation

In order to culture giant kelp, an "Eco-Kart" (a specially designed cold-water aquarium system) is utilized. The system's compact and mobile profile is perfect for a classroom setting.

Attempting to mimic the natural marine conditions along our coast, the aquarium system incorporates wide-spectrum and fluorescent lighting, a timer, a water chiller and thermostat, and a submersible pump.

Water is re-circulated through a "Sump to Tray" system. An additional tray (used for spring) creates a cold water bath complex. For more detailed information concerning the Eco-Kart, please refer to its operating manual.

One of the biggest obstacles in culturing algae in a laboratory or classroom setting is the presence of contaminants. Once introduced, these unwanted organisms (both animals and algae) can out-compete giant kelp for space, light, and nutrients. For this reason, it is imperative that every effort is made to keep the aquarium system and the following culturing materials clean. Only nutrient-enriched artificial seawater made from deionized water should be used for cultivation.

Some other simple tips for reducing the possibility of contaminant's include:

- All glassware should be sterilized in boiling water.
- Wipe down work areas and Eco-Kart system with a 10% bleach solution.
- Keep students fingers and hands out of the Eco-Kart's water.
- Keep the system's trays covered with acrylic sheets.

Materials:

Chilled aquarium system, or an "Eco-Kart"
Refrigerator (15° C)
Artificial, nutrient-enriched seawater *
Ceramic tile strips
Compound microscope
Scissors
Aluminum foil
Paper towels
Squeeze bottles
Plastic tubs or trays
Slides (scraped on one side)
Mason jars
50ml graduated cylinder
500ml Erlenmeyer flask
1ml pipettes
Hemocytometer
Toothbrushes

*Artificial Seawater:

To artificial seawater with a salinity of ~35ppt, 50µM of Nitrates (NO₃) and 6.25µM of Phosphates (PO₄) should be added.

Example: For 100 liters of artificial seawater, 0.425 grams of NO₃ and 0.135 grams of PO₄ would be added.

Methods:

Day 1 - Sporophyll Preparation

Numerous healthy sporophylls of a giant kelp (*Macrocystis pyrifera*) will be delivered to your classroom by the Keeper program staff in your area. Most likely, these sporophylls were collected the day before and possess noticeable Sori (dark stains containing zoospores) on their surface.

These sporophylls must be kept in cold seawater in order to avoid excessive premature spore release.

1. Once in the classroom, place the sporophylls into a clean plastic tray or tub.
2. Using a toothbrush, lightly scrub the sporophylls to ensure removal of all debris, removing all diatoms, bryozoans, and other encrusting organisms.
3. Using chilled artificial seawater in a squeeze bottle, rinse the sporophylls off over the plastic tub. It is imperative that the now clean sporophylls are not placed back in the tub.
4. Next, take a paper towel and gently dry the sporophylls.
5. Wrap the dry sporophylls in a fresh paper towel making a kelp burrito and moisten the towel with seawater.
6. Wrap again in aluminum foil and place in a refrigerator (15° C) overnight, allowing for photoshock to occur.

Biological Significance of Photoshock

Kelp wrack that was washed ashore becomes stressed because of the dry conditions. The overnight light-cycle, combined with the stressful desiccation situation, induces the kelp plant to release zoospores upon water contact. Waves washing on shore during high tide will carry the zoospores out to sea and ensure the kelp's germ-line survival.

Day 2 - Spore Release & Count

1. Remove the sporophyll from the refrigerator and place in mason jars filled with chilled artificial seawater. After 2 hours, the seawater will begin to turn yellow-brown due to the release of zoospores. Under the microscope, these zoospores will appear as bean-shaped, flagellated organisms. Zoospores are only capable of swimming for approximately 24 hours.
2. Remove the sporophylls from the mason jars, but allow the jars to sit for another hour to allow algal mucous and contaminant's to settle to the bottom.
3. Decant the top half of the jar's contents into a 500ml Erlenmeyer flask. This is the spore solution that you will use to make the appropriate inoculum dilution.



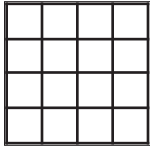
KELP RESTORATION

Day 2- (continued)

4. Obtain a clean hemacytometer and some sterile pipettes.

5. Withdraw one pipette-full of spore solution and fill the hemacytometer in the following manner: place a cover slip on the hemacytometer. Carefully touch the edge of the cover slip with your pipette tip and allow the chamber to fill by capillary action.

6. Place the hemacytometer under the microscope. Count the number of spores found on the grid in the following manner:



This is the small 4x4 grid in which you count!

1. Count enough of these squares until you think you have a representative number of counts. Clean your hemacytometer.

2. Put another sample in and count the number of spores. Do enough samples until you feel that the numbers you are getting are in the same range.

3. Obtain an average of all these numbers. Use the following calculation as a guide:

Example:

Sample #1 count average = 16

Sample #2 count average = 19

Sample # 3 count average = 22

Average: $(16 + 19 + 22) / 3 = 19$

If you obtained four samples, divide the sum of your numbers by four, if five samples, by five etc.

4. Divide the average number of spores per grid by 4 and this will give you the number that is the number $\times 10^6$ of spores per milliliter.

Example:

Average spore count was 19 (see above), so $19/4$ is 4.75. The initial concentration of the spore solution will then be 4.75×10^6 spore/ml.

5. Dilute your spore solution to 1×10^4 . You can use the following equation to make the dilution:

$$\frac{\text{Concentration of B} \times \text{Volume of B (ml)}}{\text{Concentration of A} \times \text{Volume of A (ml)}}$$

Example: Concentration of B

(final concentration you want) = 1×10^4

Volume of B

(final volume you want) = 6,000ml

Concentration of A

(concentration you have now) = 4.75×10^6

Volume of A (unknown) = ???

Therefore $(1 \times 10^4)(6,000) = (4.75 \times 10^6)(\text{Unknown Volume})$
Unknown Volume = 12.6ml

This means that to 5,987.4 ml (6,000-12.6) of artificial seawater, you would add 12.6ml of spore solution creating the appropriate inoculum solution.

6. Place the 6,000ml inoculum solution into the "Sporing Tray" of the aquarium along with ceramic tile strips and a few scraped slides. The sporing tray

acts as a cold-water bath system and minimizes disturbance to settling spores. The aquarium thermostat should be set to 15°C with a 1° deviation. Also, the aquarium lights should remain off for this initial 24-hour period.

Day 3 - Waiting 24 hours

Day 4 - Tile Transfer

1. After 24 hours, the tiles and slides are transferred out of the sporing tray and into the regular, circulating tray. Additional artificial seawater should be added at this time to compensate for removal of the sporing tray.

2. The light source should be turned on and set to a 14 hr on/10 hr off light cycle.

3. The aquarium thermostat should remain set at 15°C with a 1° deviation.

Day 5-30 - Kelp Growth & System Maintenance

1. Water changes of approximately 2 gallons should be made to the culturing system twice a week. It is best to add new artificial seawater directly to the system's sump after draining out the "old" water.

2. Kelp growth and development can be monitored through the use of the inoculated slides. The inoculated slides should be removed carefully by the teacher or supervising adult in order to avoid accidentally wiping off the settled kelp spores.

WARNING!!! Keeping inoculated slides out of the Eco-Kart or aquarium system for more than a few minutes will kill the developing kelp plants.

Within a few days, zoospores should begin to show formation of a germination tube. At first, this appears simply as a bump, but eventually elongates to form a tube. Within two weeks, male and female gametophyte appear from a bulge at the end of the germination tube. The gametophyte will appear as spherical, oval, or teardrop shaped forms. The male gametophyte tends to be small, lumpy and pale green. The more conspicuous female gametophyte is large and has rounded blobs that are yellow or golden. The females will produce eggs after 10-14 days. These eggs will protrude out of an empty cell wall. Fertilization will occur after the egg is extruded and a resultant embryo is formed. As the embryonic sporophyte develops, mitotic division is rampant resulting in a "corn on the cob" microscopic appearance. Within a month, kelp sporophyte in the form of a single blade should be visible with the naked eye.



First blade split

KELP RESTORATION
Kelp Cultivation Data Sheet

NAME: _____

GRADE: _____
SCHOOL: _____
TEAM of OBSERVERS: _____

Date _____ Time _____ Temperature of the tank (°C): _____

Using a microscope, look at a slide from the tank using the 10x objective lens.



Draw your observations :

Now switch to the 40x lens.



Draw your observations :

Can you identify what stage of development the microscopic kelp is in?

Circle One:

Zoospore Male Gametophyte Female Gametophyte Sporophyte

Can you detect any contaminants (organisms that we don't want growing) on your slide?



Draw your observations :

Date _____ Time _____ Temperature of the tank (°C): _____

Using a microscope, look at a slide from the tank using the 10x objective lens.



Draw your observations :

Now switch to the 40x lens.



Draw your observations :

Can you identify what stage of development the microscopic kelp is in?

Circle One:

Zoospore Male Gametophyte Female Gametophyte Sporophyte

Can you detect any contaminants (organisms that we don't want growing) on your slide?



Draw your observations :



KELP VOCABULARY

**Giant
Kelp
Vocabulary**

algae	single or multicellular photosynthetic organism; primarily aquatic, such as seaweed	invertebrate	animals without a spinal column or backbone such as jellyfish, urchins, sea stars
algin	substance found in marine algae, especially giant kelp; used as a stabilizer, emulsifier, and thickening agent in foods such as ice cream and toothpaste	kelp	large brown algae, sometimes called seaweed
blade	leaf-like appendage of algae	kelp wrack	dying or dried kelp that has been pushed ashore by waves, winds and currents
bryozoan	microscopic aquatic invertebrates that live in colonies on rocks or seaweed	photosynthesis	process by which plants and algae use solar energy (sunlight) to convert carbon dioxide and water into oxygen and the chemical energy of sugars
canopy	upper growth of kelp blades that reaches the water surface	plankton	free-floating aquatic lifeforms that are often microscopic in size
crustacean	external skeleton arthropods like lobsters, crabs, shrimp	phytoplankton	planktonic plants
detritus	dead organic material	zooplankton	planktonic animals
echinoderms	marine invertebrates with a "spiny-skin" or skeleton plates which support the animals body; can be fused together as in a sea star or joined into a rigid shell as in a sea urchin	pollution	contamination by manmade waste
ecosystem	components of the environment including the living and non-living parts of land, streams, rivers, and oceans	predator	an animal that preys on other animals for food
habitat	the home or environment where a plant or animal lives	pneumatocyst	gas-filled bladder or float that gives buoyancy to giant kelp
food chain	ongoing cycle in which each organism or animal eats the next one in the sequence and is in turn eaten by another further up the chain	sanctuary	a protected habitat
haptera	branching root-like strands that anchor a kelp plant to the substrate	scimitar blade	the tip of a blade with newly forming blades
holdfast	haptera base which secures kelp to the substrate, usually a rock	seaweed	general term for marine algae
		spore	a cell that can germinate into a new individual plant
		sporophyll	specialized reproductive kelp blades that produce spores
		stipe	stem-like part of the kelp
		upwelling	the movement of deep cool, nutrient-rich ocean water up to the surface waters

CALIFORNIA KELP FOREST

KELP ORGANIZATIONS & PROGRAMS

Reference Books

& Writings:

Marine Algae of California

by Abbott and Hollenberg
Stanford University Press

SeaLife, Smithsonian

by Waller, Dando and Burchett

The Amber Forest

by McPeak, Glantz and Shaw
Watersport Publishing, Inc. 1988

Kelp Forest

by Connor and Baxter
Monterey Bay Aquarium

Seaweeds of the Pacific Coast

by Mondragon and Mondragon
A Sea Challengers Publication

KELP ORGANIZATIONS & KELP EDUCATION



California Science Center
700 State Drive
Los Angeles, CA 90037
323-724-3623
www.californiasciencecenter.org



Natural History Museum of Los Angeles
900 Exposition Boulevard
Los Angeles, CA 90007
213 -763-3348
www.nhm.org



Cabrillo Marine Aquarium
3720 Stephen White Drive
San Pedro, CA 90731
(310) 548-7562
www.cabrilloaq.org



Heal the Bay
3220 Nebraska Avenue
Santa Monica, CA 90404
(800) HEAL-BAY
www.healthebay.org



Channel Island National Marine Sanctuary
3600 S. Harbor Boulevard Ste.217
Oxnard, CA 93035
(805) 382-6151
www.cinms.nos.noaa.gov



Aquarium of the Pacific
100 Aquarium Way
Long Beach, CA 90802
562-590-3100
www.aquariumofpacific.org



COSEE-West: A Center for Ocean Sciences Education Excellence

The Division of Ocean Sciences in the National Science Foundation

funds the Centers for Ocean Sciences Education Excellence (COSEEs) nationwide to facilitate collaborations and communications between ocean science researchers and educators. One of these centers is COSEE-West, a collaboration between the University of Southern California and the University of California Los Angeles. Research-oriented marine science faculty at USC and UCLA partner with local school districts and informal science centers to create a network of oceanographic researchers, K-12 educators, and informal science educators to disseminate information about ocean sciences as broadly as possible throughout the greater Los Angeles area.



Project AWARE and Kids AWARE

Aquatic world awareness, responsibility & education.
www.projectaware.org



Enter the River of Words Environmental Poetry and Art Contest.

River of Words® promotes watershed awareness and environmental literacy through art and poetry. Their "Watershed Explorer" curriculum (K-12)

supports their free, annual youth poetry and art contest, conducted in affiliation with The Library of Congress. Girl Scouts can also earn two patches, the Water Drop Patch and the Watershed Patch, developed by River of Words and the US EPA. This innovative non-profit organization was founded in 1995 by then-US Poet Laureate Robert Hass and writer Pamela Michael. Visit <http://www.riverofwords.org>, send an email to info@riverofwords.org, or call (510) 548-POEM

California Coastal Art & Poetry Contest

The California Coastal Commission invites California students in kindergarten through 12th grade to submit artwork or poetry with a California coastal or marine theme to the annual contest. For contest deadlines, rules, entry form and awards, visit <http://www.coastal.ca.gov/publiced/poster/poster.html>, email coast4u@coastal.ca.gov, or call (800) Coast-4U.



California Coastkeeper Alliance
2515 Wilshire Blvd.
Santa Monica, CA 90403
www.cacoastkeeper.org



Santa Monica Baykeeper
P.O. Box 10096
Marina del Rey, CA 90295
(310) 305-9645
www.smbaykeeper.org



San Diego Baykeeper
2924 Emerson Street, Suite 220
San Diego, CA 92106
(619) 758-7743
www.sdbaykeeper.org



Ventura Coastkeeper
3600 S. Harbor Blvd. Suite 218
Oxnard, CA 93-35
(805) 382-4540 www.wistoyo.org

At the California Science Center we aspire to stimulate curiosity and inspire science learning in everyone by creating fun, memorable experiences, because we value science as an indispensable tool for understanding our world, accessibility and inclusiveness, and enriching people's lives.

The mission of the Natural History Museum of Los Angeles County is to inspire wonder, discovery and responsibility for our natural and cultural worlds.

**CALIFORNIA KELP FOREST
PROJECT PARTICIPANTS:**

**Scientific Advisors,
Contributors and
Acknowledgements:**



www.santamonicabay.org



www.californiasciencecenter.org



www.blueocean.org



www.nhm.org



www.smbas.org



www.laaudubon.org



www.projectaware.org



www.healthebay.org



www.smeprd.org



www.usc.edu/org/seagrant



www.cabrilloaq.org



www.cacoastkeeper.org



www.smbaykeeper.org

"Keepers do what we do because we recognize that nature enriches us. It is our infrastructure. It enriches us aesthetically and recreationally, culturally, and spiritually, and historically. It connects us to our history, and to who we are as a people, to the common bond that we have as Americans. When we destroy nature, we diminish ourselves and we impoverish our children."

*Robert F. Kennedy, Jr.
Founder and President of the Waterkeeper Alliance*

**CALIFORNIA KELP FOREST,
Science and Activity Guide
for Teachers
was funded by the
Santa Monica Bay
Restoration Commission
PIE GRANT 2005-2006**

SCIENTIFIC ADVISORS:

CHARLES D. KOPCZAK PH.D.: KELP ECOLOGY
JEFFREY A. SEIGEL PH.D.: VERTEBRATES-FISHES
DANIEL GOTSHALL: FISHERIES BIOLOGIST

BOOK EDITING: DR. KELP CHARLES D. KOPCZAK PH.D.
WRITING AND EDITING: DOMINIQUE NAVARRO
ILLUSTRATIONS: DAWN E. NAVARRO

PROJECT ADVISOR: TOM FORD: CAPTAIN KELP
LAURA BODENSTEINER
KELP CULTIVATING ADVISOR: COLLEEN WISNIEWSKI
DESIGN & BOOK PRODUCTION: MANTA PUBLICATIONS
ELECTRONIC PRODUCTION: MORGAN GARRARD
PRINTING CONSULTANT: PETER PRAED

KELP FOREST LESSON PLAN
A SPECIAL THANK YOU TO KEN VANDERVEEN,
SCIENCE TEACHER AT LINCOLN MIDDLE SCHOOL SMSD

PRINTED IN THE USA BY OJAI PRINTING, OJAI, CALIFORNIA



© 2006-Dawn Navarro Ericson



Los Angeles Unified School District Instructional Support Services Division

Administrative Offices: 233 So. Broadway, 25th Floor, Los Angeles, CA, 90071
Mailing Address: P.O. Box 337, Los Angeles, CA, 90001
Telephone: (213) 241-6444 Fax: (213) 241-3444

Ray Kaper
Department of Schools
Ronald Edmund
Chief Instructional Officer
James Morris
Assistant Superintendent
Norma Baker, Director
Elementary Programs
Todd Ullah, Director
Secondary Science

January 2006

Dear School Principals,

The California Kelp Forest Program features California's kelp forest marine ecosystem. The study of kelp and the kelp forest offers a unique opportunity to understand vital science concepts while having fun learning about the Southern California environment.

Each school will receive four natural history posters of the California Kelp Forest. The posters display logos and web sites of organizations in Los Angeles and Santa Monica that can support science teachers with classroom activities. Additionally, the posters provide information on comprehensive study programs within the Los Angeles area. Please distribute these posters to science teachers, the school librarian, and other appropriate staff.

Schools will also receive one single copy of the Science and Activity Guide For Teacher-California Kelp Forest. The guide provides current educational information. While this guide is very useful, alignment of this resource to the grade level science California content standards is essential. For additional resources to support the science content standards, please contact a Mathematics Science Technology (MST) Center or local district Science Expert/Specialist. It is recommended that the Science and Activity Guide For Teacher-California Kelp Forest be placed in the professional resource library.

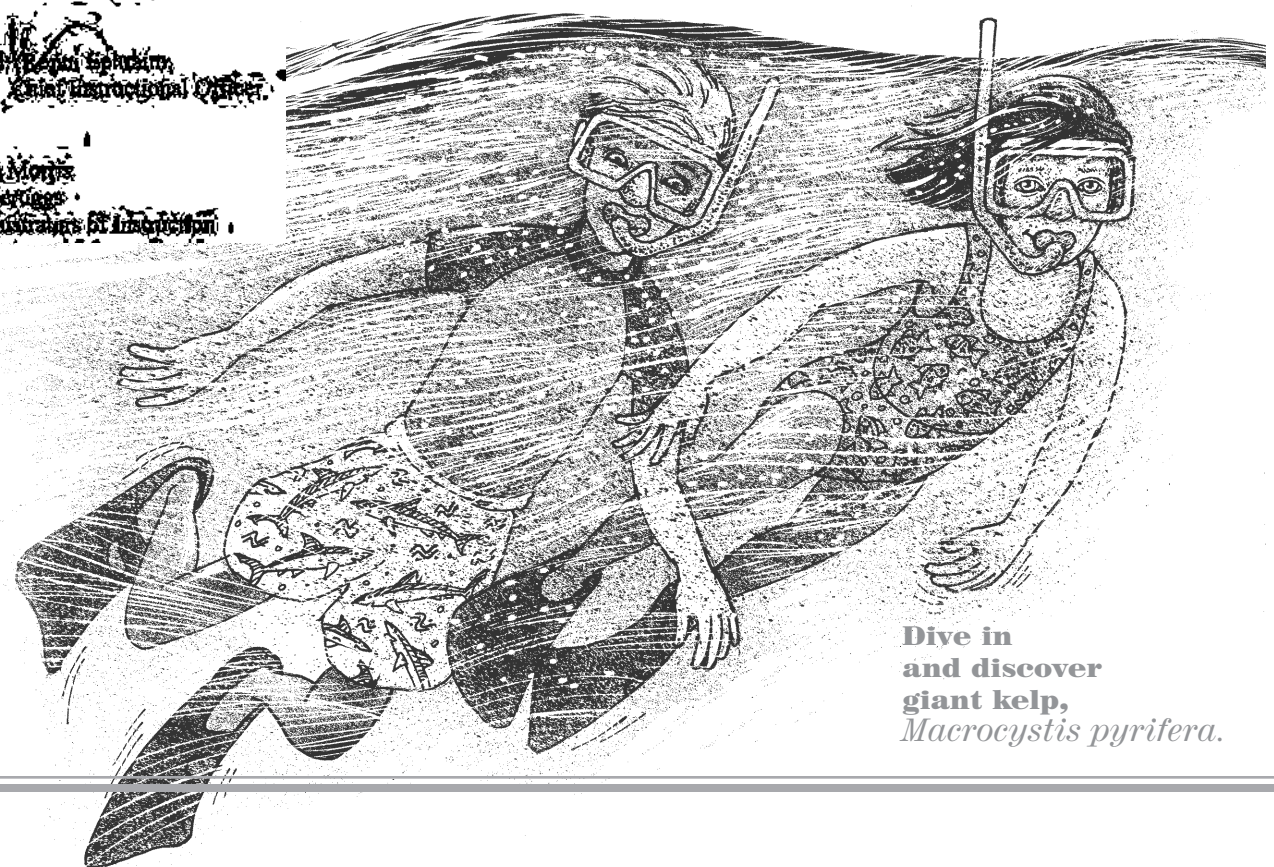
For assistance or further information please contact Norma Baker, Director, Elementary Programs at (213) 241-6444 or Todd Ullah, Director, Secondary Science at (213) 241-6880.

Norma Baker, Ed.D.
Director, Elementary Programs

Todd Ullah, Ed.D.
Director, Secondary Science

Ronald Edmund
Chief Instructional Officer

James Morris
Assistant Superintendent



Dive in
and discover
giant kelp,
Macrocystis pyrifera.