FORESTS

Lesson Plans

A CURRICULUM IN MARINE SCIENCES

CAN BE MODIFIED FOR GRADES 4 - 12

UNIVERSITY OF CALIFORNIA, LOS ANGELES
MARINE SCIENCE CENTER

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KELP FOREST LESSONS

Introduction to Kelp Forests

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Oceanic currents and nutrient upwelling are primarily responsible for the geographically asymmetrical, world-wide distribution of kelp forests. Kelp forests occur only in relatively cool marine habitats, in temperate zones and polar waters cooler than approximately 21° Centigrade, about 70° Fahrenheit. Cool surface waters do not occur at the same latitudes on opposite sides of the oceans. The rotation of the earth drives warm oceanic waters toward the poles along the eastern shores of the continents, whereas Coriolis effects bring cold, polar water toward the equator along the western sides of the continents (Castro and Huber, **Marine Biology**, Chapter 3). Thus, there are kelp forests along the coasts of California and Chile, but on the opposite side of the Pacific, along the coasts of Asia and Australia, there are no kelp forests to be found at these latitudes. Kelp forests occur far south along the west coast of North America, to Baja California at about 28° north latitude, but on the east coast of North America kelp forests occur primarily north of 40°.

Kelp plants grow rapidly and these often enormous brown algae require a steady supply of nutrients. Nutrients are supplied by upwelling, promoted by the offshore movements of eastern boundary currents such as the California Current and the Peru Current, due to the Coriolis effect, and the replacement of these surface waters from below by water rich in nutrients. These nutrients, primarily nitrogen and phosphorous, are fertilizers that stimulate rapid growth of the kelp, at rates of up to 50 cm/day, almost 2 feet per day! The fronds of the giant kelp *Macrocystis* can reach lengths of 65-100 feet, but unless the plants grow toward the surface they will not have sufficient sunlight for photosynthesis. Since plant tissues are denser than seawater, without buoyancy of some kind kelps can not grow upward. Buoyancy is provided by structures called pneumatocysts, gas filled bladders at the base of each frond, that lift the plants toward the surface where the fronds produce a dense canopy. Lift from the pneumatocysts is counteracted by the holdfasts which grip the rocks. Holdfasts are the structures that attach the kelp to the rocks, but holdfasts are not completely analogous to the roots of terrestrial flowering plants. Although both holdfasts and roots grip the substrate, holdfasts do not supply water or nutrients to the rest of the plant. Instead, nutrients, water and carbon dioxide are directly absorbed from the surrounding seawater.

Kelp forests produce unique habitats in the sea. Whereas most of the algae in the ocean are tiny, single-celled, and planktonic, kelp are huge, multi-celled plants anchored to the bottom, producing dense 3-dimensional forests. Like the tree canopy in mature terrestrial forests, the dense, floating kelp canopies absorb so much sunlight that other marine algae do not grow well in the dim light below. As a result not many other species of algae can exploit the understory beneath the canopy. On the other hand, the species diversity of animals within the kelp forest is very high because the kelp plants provide an enormous amount of protective cover and food. Indeed, kelp forests are among the most diverse habitats in the world for temperate zone marine animals. Communities of animals live among the surface canopy, communities of animals live attached to the fronds of the kelp, communities of animals live in midwater, swimming amid the fronds and stipes, and communities of tiny animals live deep within the interstices of the

holdfasts. It is important to emphasize the absolute dependence of these animal communities upon the kelp itself. The kelp plants provide the very fabric within and about which all of these animals live. When the kelp forest is destroyed by storms, by the warm waters of an El Niño event, or by overgrazing by sea urchins, then the animals that depend upon the structure or nutrition of the dominant species of giant kelp are all eliminated as well.

Kelp forests are surprisingly unstable ecosystems. This has been demonstrated along the west coast of the North America when the animals communities within the kelp forests have been altered by human activity. For example, several hundred years ago Russian sealers discovered the large populations of sea otters that lived amid the kelp forests of the northwest coast. Sea otters have the densest, most beautiful, warmest, and ultimately most expensive of all animal pelts. Not surprisingly, sea otters were soon harvested to the point of near extinction, and then slowly the kelp beds began to disappear. One of the favorite foods of sea otters is the sea urchin, and in the absence of otters the urchin populations expanded rapidly. The urchins soon exhausted all of the smaller algae upon which they normally fed and they turned to eating the less nutritious holdfasts of the giant kelp. When the holdfasts were destroyed, the buoyant fronds floated away, and entire kelp forests simply vanished. During the past 50 years marine biologists have documented the return of many of these kelp beds because populations of sea otters, now a protected species, are extending slowly south along the coast, eating sea urchins, and restoring the natural balance of nature.

Kelp forests were also disrupted some 50 years ago when huge amounts of untreated raw sewage were dumped off the coast of Palos Verdes. Sea urchins are not only grazers of benthic algae but they are also excellent scavengers of particulate material in the water, which they capture on their spines and with their tube feet. The sewage was food to the urchins, and their populations exploded until the entire bottom was carpeted almost solidly with sea urchins. But occasionally the ocean currents would shift, sewage would become temporarily unavailable, and the urchins would feed instead on kelp holdfasts. The result was that the Palos Verdes kelp beds disappeared. Today treatment plants in the Los Angeles basin have nearly eliminated the release of raw sewage into coastal waters, reducing the threat to kelp forests from overgrazing by urchin

Literature Cited

Castro, Peter and Michael E. Huber, *Marine Biology*, McGraw Hill Higher Education, 1997.

KELP FORESTS
Concepts related to the California State Science Standards

Grade Four - Life Sciences

2. All organisms need energy and matter to live and grow. As a basis for understanding this concept:
a. *Students know* plants are the primary source of matter and energy entering most food chains.

3. Living organisms depend on one another and on their environment for survival. As a basis for understanding this concept:
a. *Students know* ecosystems can be characterized by their living and nonliving components.
b. *Students know* that in any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.

Grade Five - Ecology (Life Science)

5. Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept:
a. *Students know* energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs.
b. *Students know* matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.
c. *Students know* populations of organisms can be categorized by the functions they serve in an ecosystem.
d. *Students know* different kinds of organisms may play similar ecological roles in similar biomes.
e. *Students know* the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

Grades Nine through Twelve - Life Sciences - Ecology

6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:
a. *Students know* biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
b. *Students know* how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
c. *Students know* how fluctuations in population size in an ecosystem are deter-mined by the relative rates of birth, immigration, emigration, and death.
d. *Students know* how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.
e. *Students know* a vital part of an ecosystem is the stability of its producers and decomposers.
f. *Students know* at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.

KELP FORESTS
Concepts related to the California State Science Standards (continued)

All Grades - Investigation and Experimentation

7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

b. Use a variety of print and electronic resources (including the World Wide Web) to collect information and evidence as part of a research project.

c. Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.

d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e. g., motion of Earth's plates and cell structure).

e. Communicate the steps and results from an investigation in written reports and oral presentations.

KELP FORESTS

Concepts Related to the National Science Standards

1. **All plants need light to photosynthesize and grow.**

2. **Many factors affect the location of kelp forests, e. g. water temperature, wave action, pollution, and available nutrients.**

3. **People use algae in foods and other products.**

4. **Terrestrial and marine plants are similar in their functions and requirements for growth.**

5. **All habitats contain different species of animals and plants, adapted to their locations, which function as consumers or producers, predators or prey, and are part of food chains and food webs**

Kelp Forests Vocabulary

adaptations	Characteristics that help plants and animals to survive in their environment.
algae	Non-seed bearing plants which vary in size from microscopic one celled diatoms to large multicellular seaweeds.
blade	The leaf-like part of a seaweed.
canopy	The top layer of the kelp forest where fronds float on the sea surface.
camouflage	A shape, color, or pattern, or behavior that helps a plant or animal blend into its habitat.
carnivore	A meat eating animal.
community	All the plants and animals living within a particular habitat.
decomposer	An organism that breaks down dead animals and plants into nutrients.
frond	A kelp stipe and all the blades.
herbivore	An animal that eats plants.
holdfast	The part of the seaweed that attaches to the rocky bottom like an anchor.
kelp	Any large brown seaweed, like *Macrocystis*.
photosynthesis	A process in which plants use energy from sunlight to produce food (sugar) and oxygen.
predator	An animal that eats other animals.
prey	An animal that is caught and eaten.
producers	Living forms that produce their own food through photosynthesis.
stipe	The stem-like part of a kelp plant that connects the blades to the holdfast.
zonation	The distribution of plants and animals in a community into specific zones.

Activity #1 -Growing Algae

Objective:

Students will investigate the effects of light on algal growth.

Materials:

- · 4 glass pint jars with lids and small nail holes
- · algae culture
- · cheesecloth
- · gallon jar
- · black tempura paint
- · brush
- · rubber bands
- · paper
- · funnel
- · coffee filters
- · balance
- · hyponex
- · data sheet

Procedures:

In groups of 3-5 students prepare 4 pint jars as follows:

1. Wrap a piece of paper 10 cm wide around the sides of each jar and secure with a rubber band.
2. Paint the rest of the jar surface with black tempura paint. When paint is dry do the following:

- ➢ Wrap a second piece of paper around one jar on top of the first piece.
- ➢ Remove paper from jar 2 and replace with 2 layers of cheesecloth secured with a rubber band.
- ➢ Remove paper from jar 3 and replace with 4 layers of cheesecloth secured with a rubber band.
- ➢ Remove paper from jar 4 and leave glass exposed.

3. Mix 600 ml of water with 3 grams of hyponex mix and 1 liter of algae culture in a gallon container and shake.
4. Pour 100 ml of the mix into each jar and seal with lid that has a hole in it to release gas buildup.
5. Place in a well lit place, but not in direct sunlight.
6. Observe jar 4 in 2 weeks. Do you see any growth or change?
7. Label 4 dry coffee filters 1-4. Weigh each filter, record weights on the data sheet.
7. Open the other jars. Pour algae water from each jar through a funnel lined with the correspondingly numbered coffee filter. Let the algae dry and then weigh each filter and its algae. Record your results on the data sheet.

Evaluation:

- ➢ Each jar had a different amount of light available for plant growth. Is there a difference in the amount of growth that occurred in each jar?
- ➢ Can algae receive too much light? What could the result be?
- ➢ Why was hyponex added to the jars?

Activity #1 -Growing Algae

Student Data Chart

	FULL LIGHT	2 LAYERS CLOTH	4 LAYERS CLOTH	NO LIGHT
WEIGHT of FILTER & ALGAE				
WEIGHT of FILTER				
WEIGHT of ALGAE				

Activity #2 - Kelp Forests vs. Terrestrial Forests

Objective:

Students will compare terrestrial plants and forests to the kelp plant and forest and the communities surrounding them.

Materials:

- kelp plant or picture
- worksheet
- books about kelp community for research
- plants

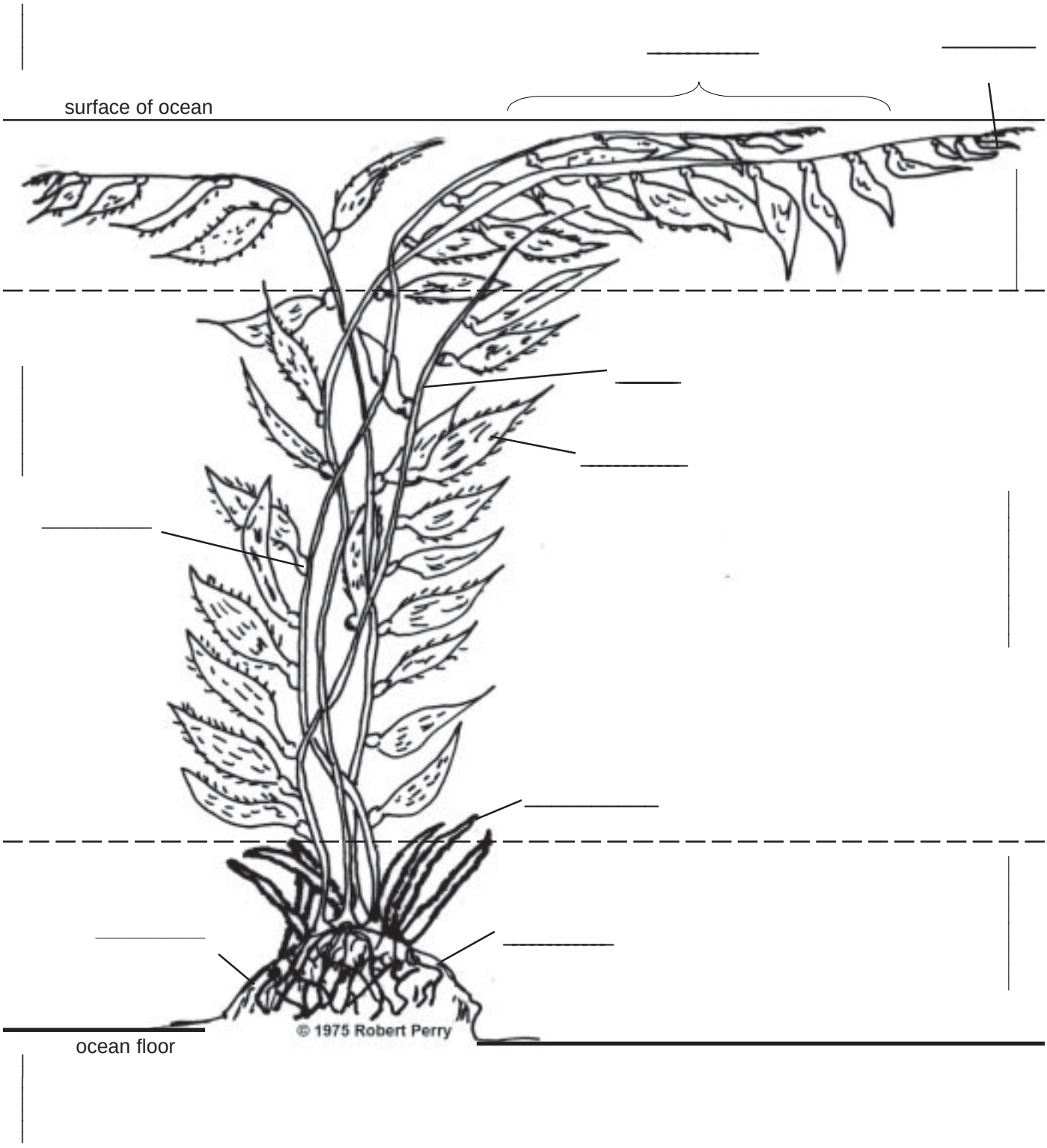
Procedures:

1. Discuss with students what terrestrial plants need to grow (sun, fertilizer, water, protection from bad weather). Ask which plant parts help meet these needs? What requirements does a marine plant like a kelp need to grow? How do you think their needs are met?
2. On the kelp worksheet label each part of the kelp and speculate on its function.. Teacher discusses possible answers and explains functions of parts apical fronds (terminal blades), holdfast, fronds, stipes, sporophylls, and the pneumatocysts (gas bladders).
3. Different animals live in different zones of the kelp forest. Divide the zones by drawing lines across your worksheet. Label the zones: "canopy", "stipes" and "holdfast." Research what lives in each zone. Make drawings of the animals and glue them on at the proper zone.
   Canopy: sea otters, plankton, sea birds
   Stipe: turban snail, blue rockfish, kelp bass, senorita, crabs, sea lions, barnacles, garabaldi, sheephead, surfperch, hydroids, bryozoans, isopods
   Holdfast: brittle star, horn shark, sea cucumber, abalone, sea urchins, bat star, tube worms, amphipods, crabs, sponges, clams, octopus, eel, young fish
4. Have students list a kelp forest producers, herbivores, carnivores, decomposers, filter-feeders and scavengers. In groups construct a kelp forest food web.
5. Have students describe adaptations of kelp forest animals for capturing their food and avoiding predators (speed, stinging cells, shell cover, pincers, camouflage, ability to burrow into holdfast, etc.)
6. Generate a list of differences and similarities between a kelp forest and a terrestrial forest. Discuss the actual communities of plants and animals that live in each.

Evaluation:

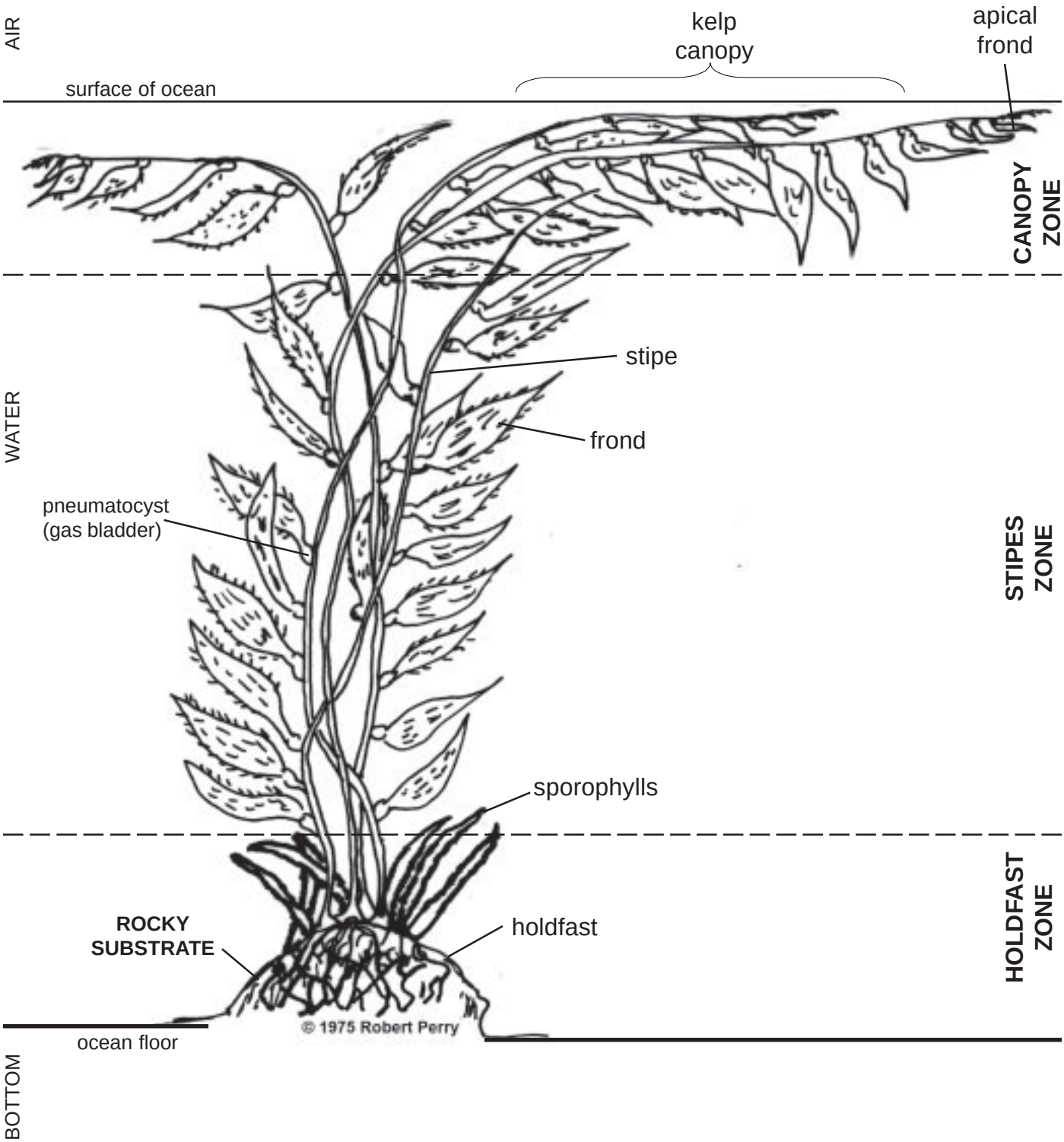
- Check the students' worksheets and journals for correctness of ideas.
- What does ecology mean?
- Explain the functions of the kelp plant parts.
- How can humans affect kelp forests?

Activity #2 - Kelp Forests vs. Terrestrial Forests



Giant Kelp - *Macrocystis pyrifera* -
Showing life zones and the anatomy of a plant.
(Student worksheet)

Activity #2 - Kelp Forests vs. Terrestrial Forests



Giant Kelp - *Macrocystis pyrifera* -
Showing life zones and the anatomy of a plant.
(Key to student worksheet)

Activity #3 - Kelp Forest Locations

Objective:

Students will identify the locations of kelp forests and why they grow there.

Materials:

- Map of kelp forest locations
- temperature map
- ocean circulation map
- colored pencils

Procedures:

1. Have students look at a map showing locations of kelp forests (Map 1).
2. Ask students to write a hypothesis about the location of kelp forests.
3. Given more information they can adjust their hypotheses.

A. Temperature of water (color in map 2): Kelp grows in colder waters (21° C or less).

B. Ocean circulation/upwelling: Ocean currents circulate in circular paths, bringing colder waters to the west coast of continents and upwelling nutrient rich water (Map 3).

C. Pollution: During heavy rains sewage and silt runoff into the ocean causes kelp to die off due to reduced penetration of sunlight.

D. Heavy wave action: During stormy weather holdfasts are ripped from the bottom and kelp forests are thinned.

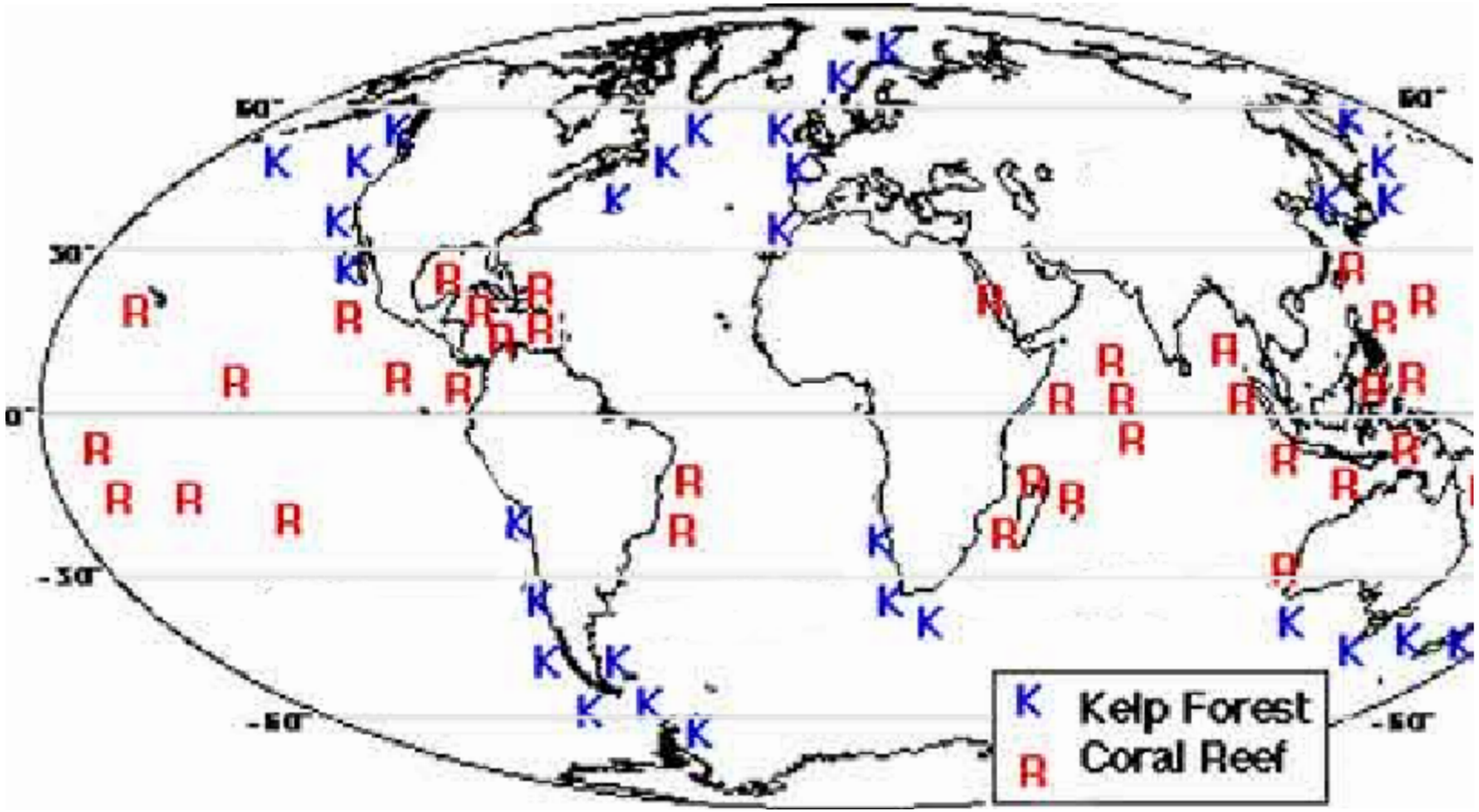
Why do kelp forests exist in the locations shown on Map 1? Adjust your hypothesis as needed.

Evaluation:

- Are kelp forests where you expected them to be?
- What factors cause kelp forests to be located where they are?
- What effect, if any, would El Niño have on kelp forests?

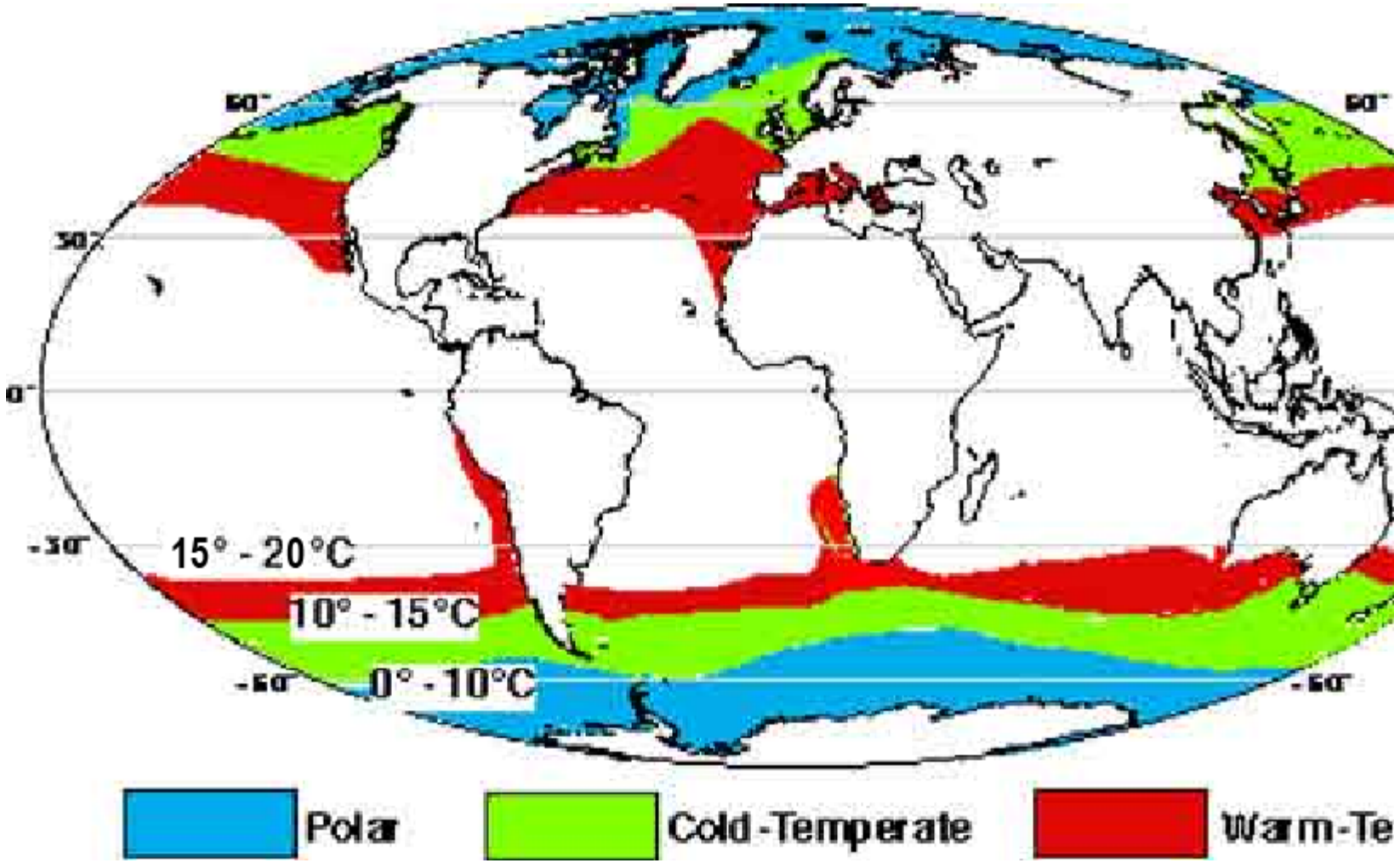
Why are kelp forests important to humans?

Activity #3 - Kelp Forest Locations
Global Distribution of Kelp Beds



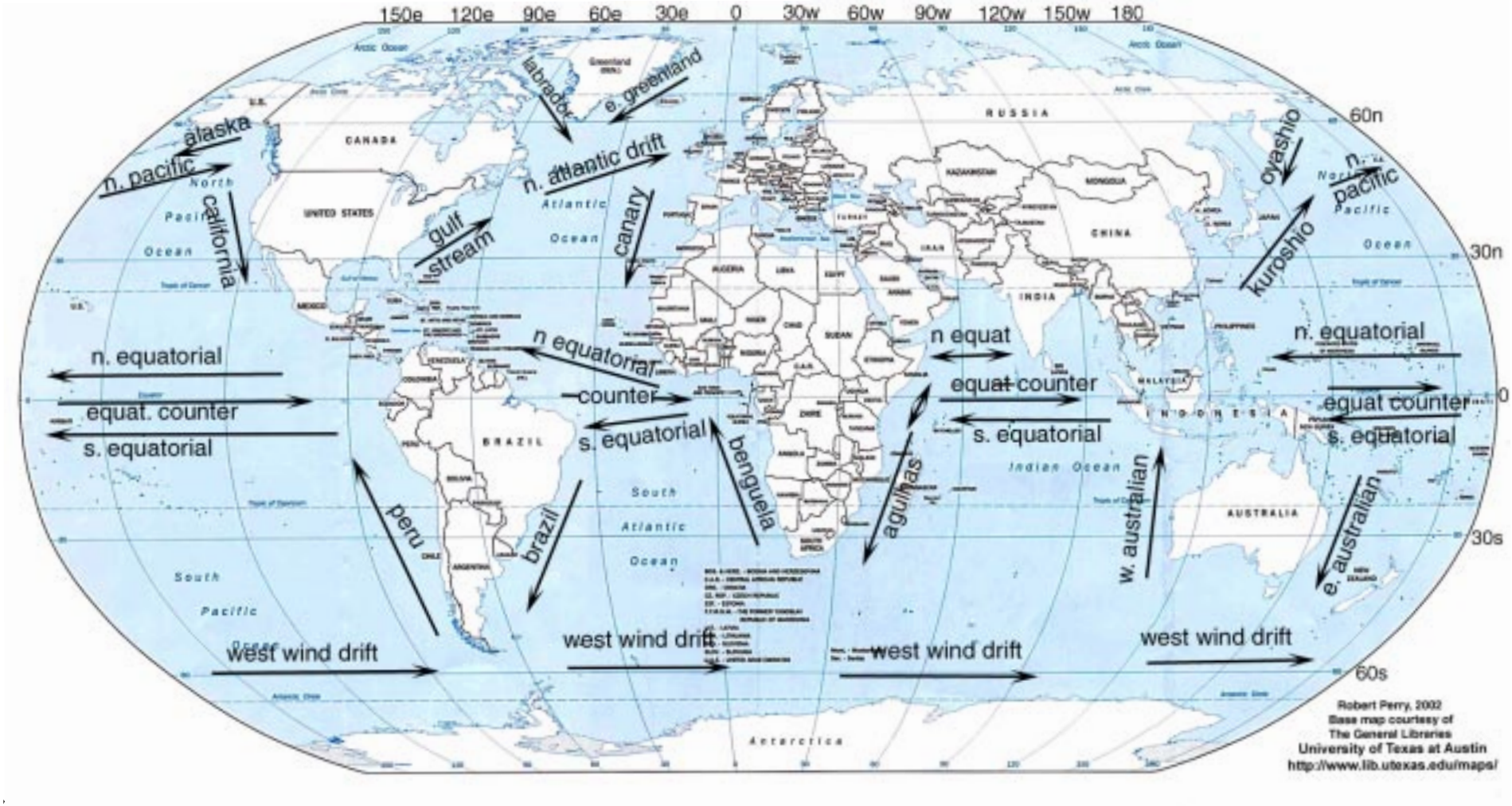
Map courtesy of Dr. André Freiwald
Friedrich-Alexander University Erlangen-Nürnberg
http://www.pal.uni-erlangen.de/exp/cwc/

Activity #3 - Kelp Forest Locations
Global Surface Water Temperatures



Map courtesy of Dr. André Freiwald
Friedrich-Alexander University Erlangen-Nürnberg
http://www.pal.uni-erlangen.de/exp/cwc/

Activity #3 - Kelp Forest Locations
Global Surface Currents



Activity #4 – Kelp Products

Objective:

Students bring in household products and packages.

Materials:

- Japanese rice crackers
- seaweed product
- questionnaire
- packages and products from home

Procedures:

1. Have students scavenge their homes for food and household products with algal derivatives listed in the contents (agar, algin, carrageenan, mannitol).
2. Have students check off on the questionnaire what they use or eat. Tell them if they reply "yes" to any of the questions they have eaten or used seaweed.
3. When students have brought in enough products, have them divide the packages into groups containing the same algal derivatives.
4. Have students try seaweed and rice crackers, if they like.

Evaluation:

- Is seaweed an important part of our economy? Why?
- Do you know of other groups of people or cultures that eat seaweed in their daily diets? Explain.
- Is it important to protect kelp forests from pollution?

Activity #4 – Kelp Products

Questionnaire

Answer each question yes or no.

1. *Did you brush your teeth today?*
2. *Did you drink chocolate milk this week?*
3. *Have you eaten ice cream this week?*
4. *Do you eat cottage cheese, cream cheese, yogurts or puddings?*
5. *Do you drink soft drinks or fruit juices?*
6. *Do you eat caramels, marshmallows or gummi candy?*
7. *Have you eaten mayonnaise, mustard, ketchup, French dressing or syrups?*
8. *Have you ever eaten seaweed?*
9. *Do you eat bread, cake, doughnuts, cookies or pies?*
10. *Do you like to chew gum?*
11. *Do you polish your shoes?*
12. *Do you use lotion on your hands?*
13. *Have you ever painted?*

Have you ever used gum adhesives?