Kelp Forests

Lesson Objectives: Students will be able to do the following:

- Identify the parts of a kelp and explain their function
- Compare and contrast the components of the kelp forest with a terrestrial forest
- Describe one monitoring technique used within the kelp forest

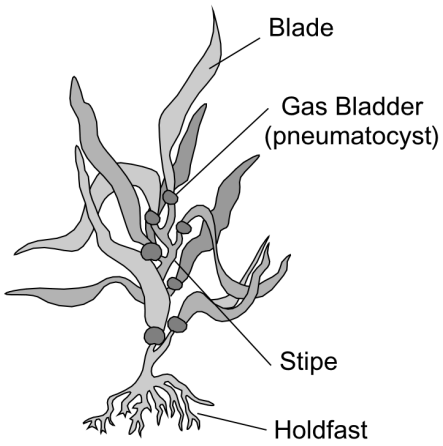
Key concepts: algae, blade, stipe, holdfast, alternation of generations, sporophyte, seasonality, ecological interdependence, monitoring

Kelp Overview

Kelps belong to a group of photosynthetic organisms known as **algae**. Algae range in size from microscopic single celled **diatoms** to large brown kelps. Kelps are characterized by three main parts: **blades**, **stipes**, and **holdfasts**. The blades are similar to the leaves of land plants. They are the photosynthetic factories of the kelp. It is here that energy from sunlight and nutrients from the water are combined to produce food. Stipes of kelps look like the stems of plants, but they do not perform nutrient transport functions like the stems of plants. Their main function is to provide support for the kelp blades. The holdfasts, similar in appearance to the roots of land plants, help to anchor the kelp on hard surfaces.

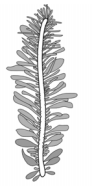
Although kelps resemble land plants, they are uniquely adapted to life in cool, clear, moving water. They depend on moving water to provide a steady supply of nutrients for **photosynthesis**. As water flows by the blades, their serrated edges help to increase water mixing. This drives more nutrients past the kelp plants. These nutrients are then absorbed by all parts of the kelp. Kelps also need sunlight for photosynthesis. Clear water allows various wavelengths of sunlight to penetrate to lower depths. Almost all of these wavelengths of light can be used for photosynthesis in the blades. The blades are kept near the surface by tiny floats. These hollow gas filled bladders are called pneumatocysts. Kelp blades also allow photosynthesis on both their top and bottom surfaces for maximum food production.

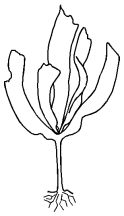
Kelp Characteristics




Giant kelp
Macrocystis pyrifera

Kelps are designed to reproduce in water through a complex process known as alternation of generations. In this process, the large kelp forms make spores or cells. These spores are released into the water where they are dispersed. Under the right conditions, these spores develop into microscopic male and female stages. When a male sperm fertilizes a female egg, it makes a plant that produces spores. This tiny plant, called a sporophyte, anchors itself to the bottom using its holdfast. As it grows, it begins to split. This growth center is called the apical meristem. When it splits each part of it becomes a blade or a stipe. This kelp continues to grow until it becomes a giant plant that produces spores. The cycle begins again. The kelp plants may grow for up to ten years, but the blades or fronds only last for a few months. As the blades are torn from the plants by wave action, they begin to decay. This decayed material helps recycle nutrients through the system. As the cycle of reproduction continues, the kelp plants form thick forest areas.

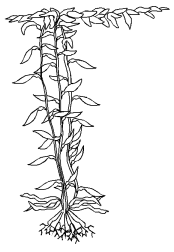

Feather Boa kelp
Egregia menziesii


Oarweed
Laminaria

These forests are found along the rocky shores of South America, South Africa, southern Australia, and the western coast of North America. There are many different kinds of kelps and over 20 different **species** are found in California alone. We will be taking a closer look at some of the more common kelps found along the California coast. These include the giant kelp (*Macrocystis pyrifera*), oarweed (*Laminaria setchellii*), bull kelp (*Nereocystis luetkeana*), and featherboa (*Egregia menziesii*).

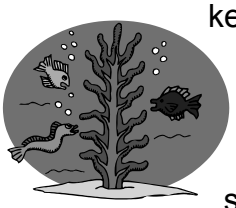
Characteristics of Kelp Forests

Kelp forests have some characteristics in common with forests found on land. They are complex **ecosystems** that support many interconnected food webs. They provide a variety of **habitats** for animals at all **trophic levels**. They can be divided into layers including the **canopy**, **understory**, and forest floor. They progress through seasonal cycles.



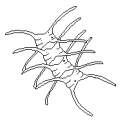
The forest layers help describe this complex ecosystem. The uppermost layer of the kelp forest is called the canopy. Along the California coast, the giant kelp is the main algae found in this layer. Among the fronds in the kelp canopy live bryozoans, hydroids, mysids, amphipods, isopods, crabs, snails, nudibranchs, and juvenile fish of all sorts. Some of these animals feed directly on the kelp and are capable of considerable damage if not kept in control. Controlling them are the predatory fish usually found in the mid-level of

the forest. Kelp surfperch, pipefish, clingfish, tubesnouts, and giant kelpfish are active **predators** here. Kelp bass and various rockfish often prey on the smaller fish. Kelp crabs and kelp snails feed among blades in the canopy and often fall prey to seabirds. The density of kelp fronds in the canopy affects the amount of light reaching the bottom and so determines the types and abundance of algae on the reef.



The understory lies below the canopy. This layer has algae of medium height much like the bushes and shrubs of the land forest. It also supports a variety of food webs. These food webs can be found in open water pathways, on reef tops, or in cracks and crevices. Shorter kelp varieties such as oarweed and featherboa are characteristic of this layer. The forest floor is the bottom layer. It includes the **substrate** and **benthic** creatures. In the kelp forest, this layer contains many animals. Here tunicates, sponges, and anemones are abundant.

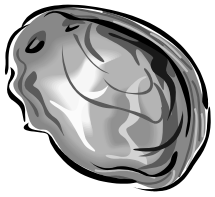
The kelp forests progress through seasons as the amounts of sunlight and nutrients change with natural cycles. The spring season begins as March winds blow surface waters offshore. This creates upwelling as nutrient-rich waters are brought up from the depths. At the same time, days are lengthening. More sunlight increases kelp growth. The kelps continue to grow rapidly until summer. In the top layers, long days and cool nutrient-rich water create the perfect environment for **phytoplankton**. These ocean producers become abundant and feed many animals living in this area. As the canopy thickens, light is cut off to the lower layers. Growth at these levels begins to slow. As fall approaches, wind directions change. This stops the upwelling of nutrients. The lack of nutrients and sunlight slow the growth of the forest. The kelp plants become weakened and begin to thin. The dead blades or kelp shed are torn apart by winter storms. Animals growing on the kelp drift are swept away with the dying fronds. Holdfasts also begin to weaken and loosen. They roll about driven by the moving water. The forest becomes sparse as winter progresses. This allows the sunlight to again penetrate to lower levels. As the months pass, days grow longer and winds become favorable. A new spring season begins.



Kelp Forest Monitoring

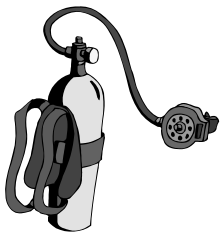
Long-term monitoring programs provide information about changes in ecosystem health over long periods of time. Through these studies, scientists are better able to understand the ecological impacts to long-lived species, the effects of natural cycles that take place

infrequently, and human impacts that change gradually over many years. One such monitoring program was designed and supported by the Channel Islands National Park, Channel Islands National Marine Sanctuary and the California Department of Fish and Game. This kelp forest monitoring program was conducted using a broad assortment of animals in a wide range of habitats. Scientists looked for sample organisms that represented a variety of trophic levels and life strategies. They included animals of various reproductive types such as those that bud or those that develop from fertilized eggs. They also included animals that live attached to the substrate and those that move freely. Researchers then chose sampling sites that represented various habitats. Once sampling species and sites were determined, management personnel designed a cost effective monitoring plan that could be carried out by trained volunteers supplied with appropriate technology. This monitoring plan included using quadrats, band transects, and roving fish counts.



Quadrats are used to collect density information on species that have relatively dense populations such as algae, sea urchins, and some sea stars. Band transects are designed to collect density information on species that are more widely dispersed such as abalone. A quadrat, in this case, is one square meter of space enclosed by PVC pipe. To identify the sample areas, quadrats are laid systematically (with a random starting point) along a transect. This transect is a line identified by a 100 meter tape measure. Band transects are larger sample areas created using a PVC pole and a shorter tape measure. These band transects are laid perpendicular to the main transect. As with the quadrats, selected species are counted along these band transects. Roving fish counts are used to monitor all the fish sited within ten meters of the transect line. These fish are identified, counted, and recorded. Additional monitoring techniques include larval recruitment platforms, videotapes, and water quality measurements.

Special technology is needed to conduct surveys underwater. These include self-contained underwater breathing apparatus (SCUBA), surface supplied air, wet suits, and dry suits. SCUBA gear allows the diver to move about freely underwater, but limits the amount of time that the diver can stay underwater without resurfacing. Surface supplied air reaches the diver through a breathing line. This line provides a continuous source of oxygen and



can lengthen the amount of time that a diver can spend underwater. Other lines allow direct communication with the crew on deck. Dry suits extend the time divers can remain in colder water. These suits get their name because they totally insulate the diver from the water.

By incorporating these and other techniques, the CINP and CINMS staff and many other **stakeholders** are able to collect information that will help us to better understand this dynamic ecosystem and ultimately ensure its continued protection into the future.

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Activity: Build a Forest

Forests occur on land and in water environments. Both forest types contain layers consisting of specific autotrophs and their accompanying heterotrophs. Generally the canopy contains the tallest photosynthetic members of the habitat. During certain seasons the canopy is also the thickest layer. Below the canopy is the understory containing medium sized autotrophs. These may be plants or algae. The deepest or bottom layer is the forest floor. Many important activities take place here at the sediment layer.

Objectives: Students will be able to do the following:
1. Describe the three main layers of a forest.
2. Make comparisons between kelp forests and land forests.
3. Create and explain a food web found in each type of forest.

Materials:
- Research materials containing information about kelp forests and land forests. (Students may use newspapers, journals, books, and the internet.) A good website is located at http://www.mbayaq.org/efc/hp.asp
- Drawing instruments
- Drawing Paper
- Lined paper or computer

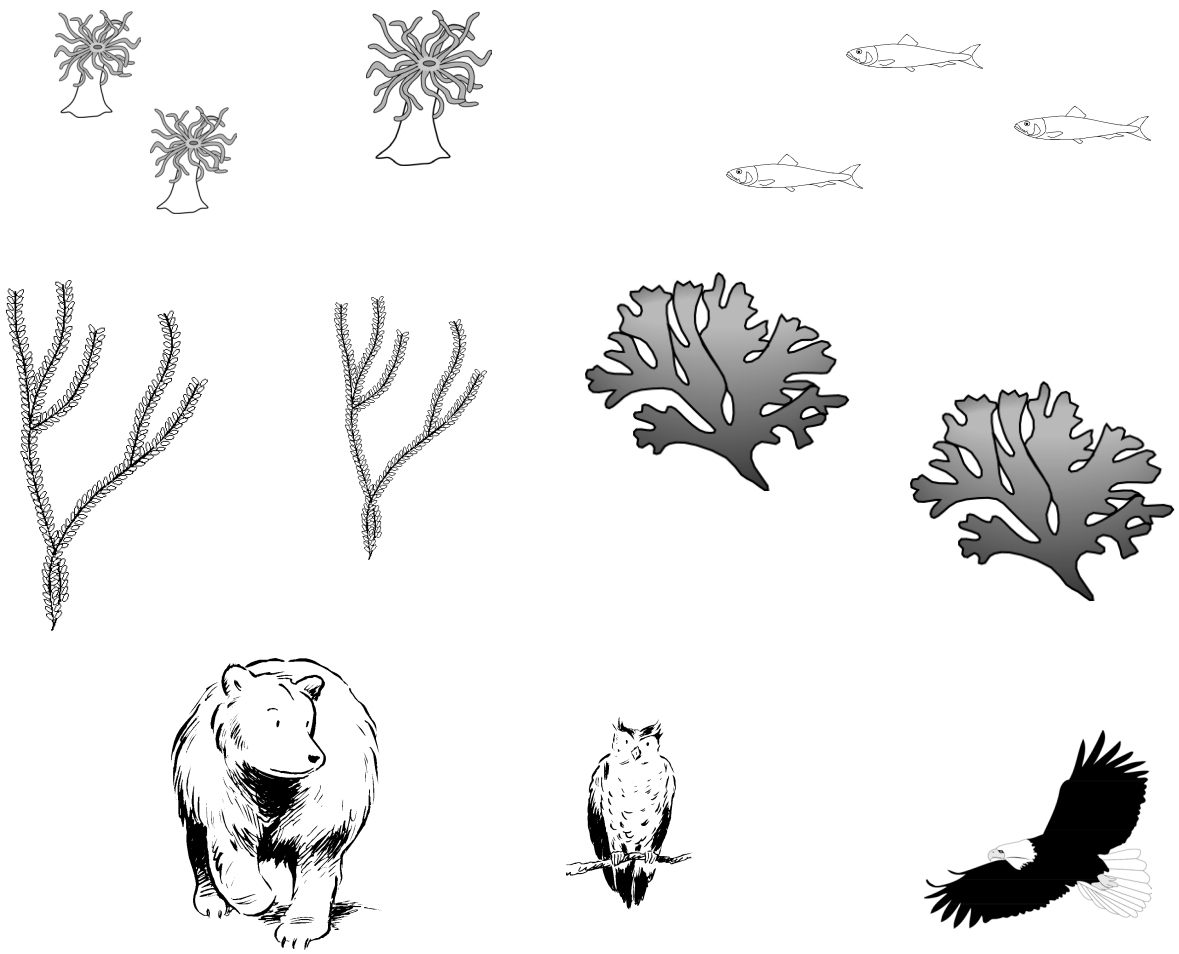
Procedure:
1. Discuss the three main layers found in a forest. Brainstorm with students about the different types of organisms that are found in each of these layers. (Be sure to include examples of both land forests and kelp forests.) Discuss the role of each organism in the forest environment. What ecological connections do the various organisms have with each other?
2. Have students research information about forest layers and their inhabitants (Be sure to include both types of forests.) Does information exist to support their original opinions? What new information did they learn?
3. Have students draw and label the layers of a land forest and a kelp forest. Have students include animals that would be found in each layer. (A picture sheet is attached that can be copied and distributed to younger students. They can cut and paste the appropriate members in each forest.) Older students can draw their own forests including unique organisms that they have researched.
4. Have students write about at least one food chain for each forest. (Students should use material that they gathered from their research.) Have students describe the individual members of their food chain and how each member is important within the whole ecosystem. Have students describe ways their food chain may be connected to other food chains in the forest.

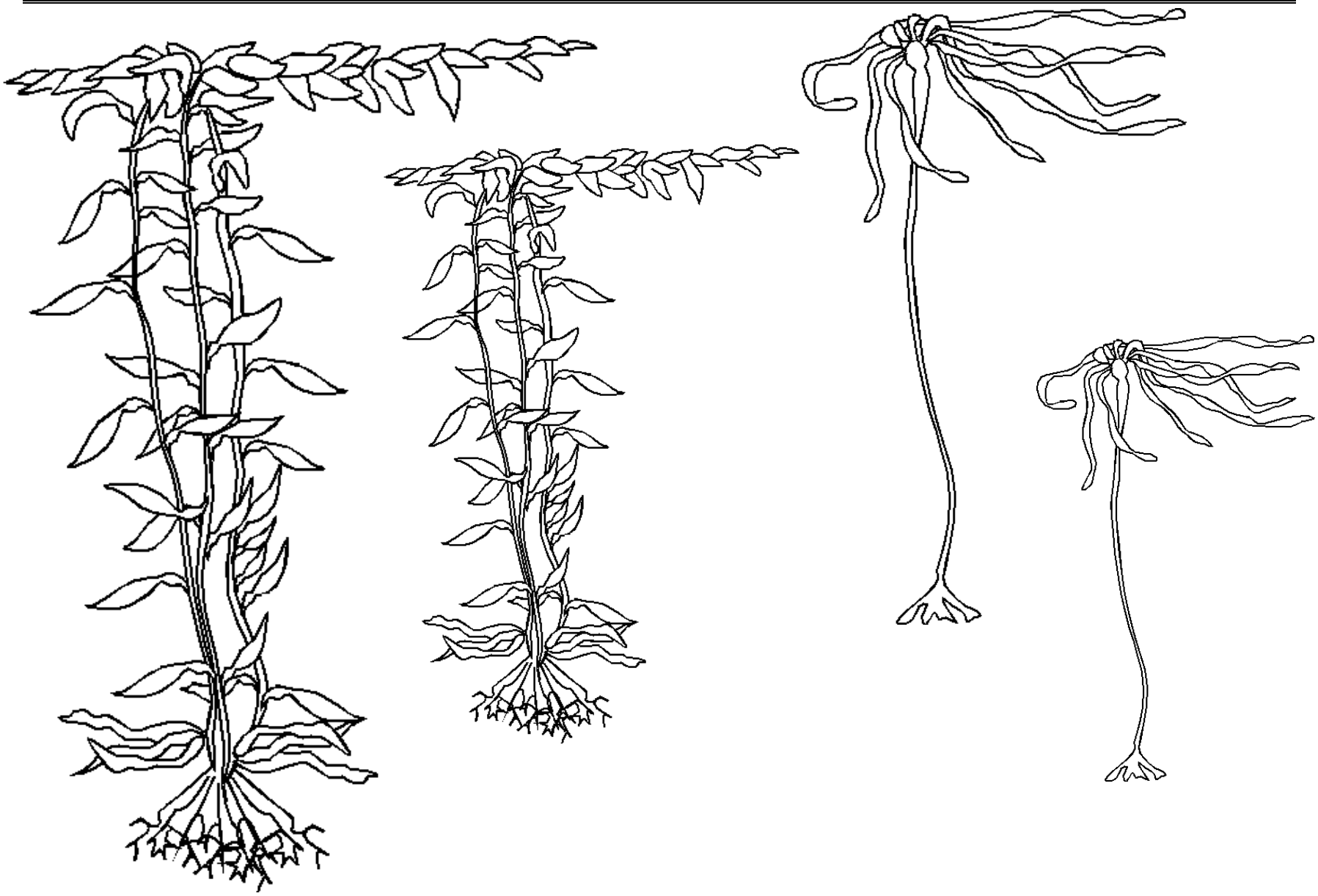
5. Have students compare and contrast the ecological niches of various members in each forest type.

Possible Extensions:

1. Have students draw a sequence of pictures depicting the seasons in a forest.
2. Have students describe one season in both the land forest and the kelp forest. (Students can describe their season pictorially, orally, in writing, or as a combination of the above forms.)
3. Have students work together to build an accurate model of the kelp forest. Individual students could choose organisms to research.

Forest Organisms





Student Information: Kelp Harvesting

Kelps are large brown

seaweeds that grow in underwater forests. These forests are found in cool, clear, moving waters along coastal areas. These underwater forests support complex food webs. They also provide essential **habitat** for many animals. Kelps are harvested from these forests. They are used in many products.

In the past, kelp was used as fertilizer. Native people used kelp for food. Today most kelp is harvested for its **algin**. Algin is used to thicken ice cream and other products. You can also find kelp in bread, paints, toothpaste, and hand lotion. The health industry uses iodine and potassium from kelp in dietary supplements. Recent research has also developed a way to make ultra pure algin. This refined algin may be used in the biomedical industry to keep organ transplants from being rejected.

Approximately 100,000 wet tons of kelp are harvested off the California coast each year. This makes kelp harvesting an important business in California. This industry provides jobs for many people and puts millions of dollars into the California economy. It is important to regulate such businesses in order to protect our natural resources. In California this industry is considered a commercial fishery. It is regulated by the California Department of Fish and Game.

Kelp harvesters use big ships equipped with machines that look like giant hedge clippers. These machines trim the top layer of the kelp **canopy**. The harvested kelp is taken back to port and sent to industrial plants. It is made into many products at these plants. The kelp forest easily recovers from this periodic pruning, because some kelp plants can grow up to 18 inches per day. After a harvesting trip, it takes the giant kelp about one month to regrow its lost portion.

By monitoring these areas, we will be able to continue to use the products from these forests for many years to come.