



Marine
Conservation
Society

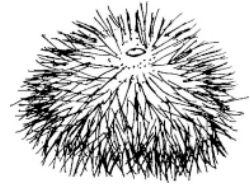
Kelp Forest

Name:

Per:

Date:

<http://www.marine-conservation.org.uk/kelpforest.html>



1. Explain why kelp forests are an extremely important ecosystem.
2. Explain the basic relationship between sea otters, purple sea urchins, and kelp within the kelp forest ecosystem.
3. What is a 'keystone species'?

Why is the presence of a keystone species so crucial in an ecosystem?

4. What is happening to the kelp forest as a result of the declining sea otter population?
5. Briefly summarize the effects of the 19th Century Sea Otter Fur Trade on the balance of the kelp forest ecosystem. How did the trade affect:
 - a) Purple Sea Urchins
 - b) Kelp?
 - c) Other kelp-forest inhabitants

6. Predict the effects of removing Purple Sea Urchins from a kelp forest.

7. Describe at least 3 threats to kelp forests.

a)

b)

c)

8. Explain how climate change can affect a kelp forest ecosystem.

9. What is a Non-native species?

What impact could they have on an established ecosystem?

10. Imagine that a non-native species (who eats primarily kelp) was introduced into a kelp forest ecosystem. Predict the effects on:

Sea Otter population

Purple Sea Urchin population

Kelp population





The Importance of the Keystone

In nature, all living things are in some way connected. Within each community each species depends on one or more of the others for survival. And at the core of individual ecosystems is a creature, or in some cases a plant, known as a keystone species.

This species operates much like a true keystone, which is the stone at the top of an arch that supports the other stones and keeps the whole arch from falling down. When a keystone species is taken out of its environment, the whole system could collapse.

In California's Monterey Bay National Marine Sanctuary the sea otter is a keystone species in the kelp forest ecosystem. Kelp forests provide food and shelter for large numbers of fish and shellfish. Kelp also protect coastlines from damaging wave action. One of the sea otter's favorite delicacies is the sea urchin who in turn loves kelp.

Kelp Forest

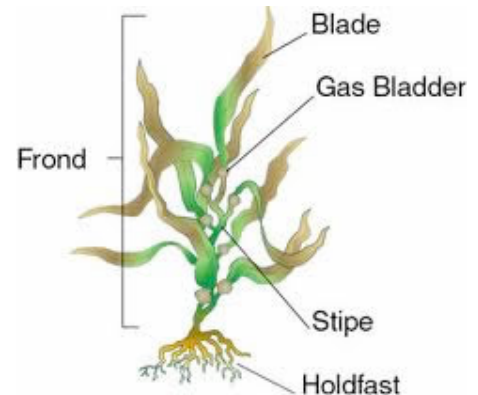
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Kelp Forest

Kelp forests are underwater areas with a high density of kelp. They are recognized as one of the most productive and dynamic ecosystems on Earth. Smaller areas of anchored kelp are called kelp beds. Kelp forests occur worldwide throughout temperate and polar coastal oceans. In 2007, kelp forests were also discovered in tropical waters near Ecuador.

Physically formed by brown macroalgae of the order Laminariales, kelp forests provide a unique three-dimensional habitat for marine organisms and are a source for understanding many ecological processes. Over the last century, they have been the focus of extensive research, particularly in trophic ecology, and continue to provoke important ideas that are relevant beyond this unique ecosystem. For example, kelp forests can influence coastal oceanographic patterns and provide many ecosystem services.

The plants that comprise a kelp forest have to be strong but flexible to survive extreme wave activity. Due to storms kelp can only form forests on rocky surfaces. To attach themselves they have evolved a holdfast. These structures appear to be roots however they are for anchorage only and do not take up nutrients.



Holdfasts have a strong grip, storms will snap the stipes but the stipes mostly hold, instead if the storm is severe enough the plants are uprooted as a whole with their holdfast still connected to their anchorage rock.

The kelp species making up a kelp forest depends on the exposure of the coast. On very exposed coasts, occur murlin *Alaria esculenta*; while on less exposed coasts furbelow *Saccorhiza polyschides*, tangle weed *Laminaria digitata* and Cuvie *Laminaria hyperborean*, while on sheltered coasts sugar kelp *Laminaria saccharina*.



When present in healthy numbers, sea otters keep sea urchin populations in check. But when sea otters decline, urchin numbers explode and grab onto kelp like flies on honey. The urchins chew off the anchors that keep the kelp in place, causing them to die and float away, setting off a chain reaction that depletes the food supply for other marine animals causing their numbers to decline.

By the early 20th century when sea otters were nearly hunted out of existence for their fur, kelp beds disappeared and so did the marine life that depended on kelp. Years later, conservationists moved some remaining otters from Big Sur to Central California. Gradually, their numbers grew, sea urchin numbers declined, and the kelp began to grow again. As the underwater forests grew, other species reappeared.

Protecting keystone species, like sea otters, is a priority for conservationists. Often, the extent of the keystone functions of a species aren't known until the species has been removed from its environment and the ecosystem changes. Rather than wait until it may be too late for the system's health and survival, scientists make every effort to keep an ecosystem working as nature had intended.

As for all plants, seaweed requires light to be able to carry out photosynthesis. Before the light reaches the kelp it has to travel through water reducing its “energy”. As with greater depth less light reaches the seabed, this determines the depth as which a kelp forest can exist.

The depth of course will vary depending on the turbidity of the water, the clearer the water the greater the penetration of light. Light levels not only affect the depth of the forest but the species it is comprised of, as different kelp species have differing minimum light requirements. This leads to a zonation of the kelps, which is nowhere as distinct as with the wracks. The shallowest zone is that of Tangle *Laminaria digitata*, followed by Cuvie *Laminaria hyperborean*, and in deeper water Sugar Kelp *Laminaria saccharina*. On very exposed coasts, Murlin *Alaria esculenta* will replace Tangle *Laminaria digitata*.

The kelps forest is an extremely important ecosystem. They are tremendously rich in marine life. The forest is outside the harsh environment of the intertidal zone. The conditions in the kelp forest are conducive to a much larger number of marine species. Kelp forests form convenient nurseries for fish fry as they offer shelter and food. This provides time for them to reach a larger size before they have to enter the more dangerous open sea, so improving their survival rates. The fry in turn attract predators, larger fish.

The kelps themselves provide shelter. Their holdfasts form an invaluable network of nooks and crannies between their “roots” perfect for small creatures. Freshly washed ashore hollow holdfasts of the furbelow or other kelp species still with their anchorage stone, are worth pulling apart, it is surprising the creatures you can find within.



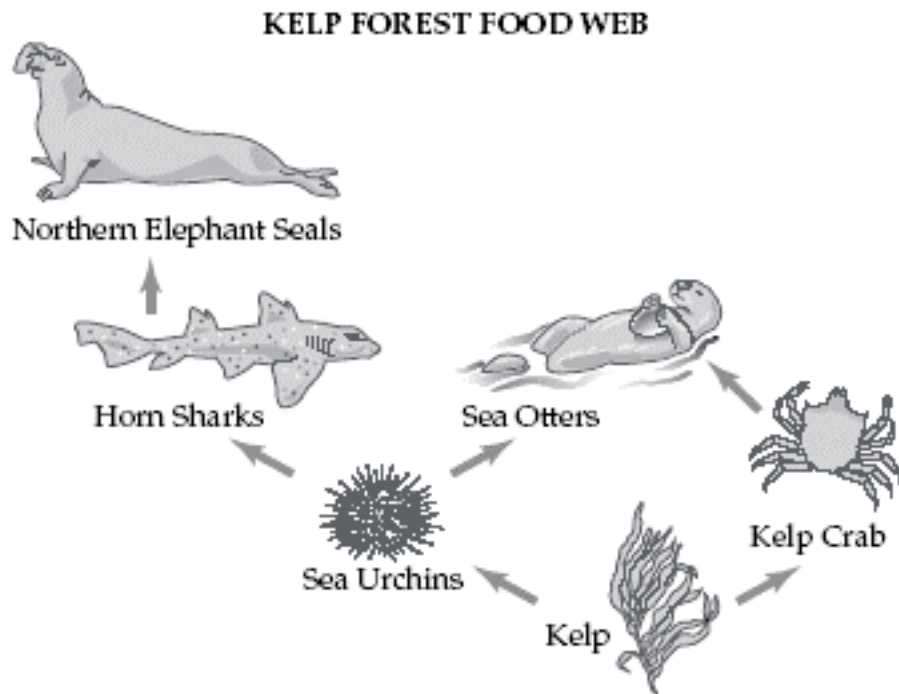
Kelp forest being grazed by sea urchins

The kelp plants act as platforms for plants and animals to live on particularly the stipes. The stipes in a forest together create a huge surface area. The stipes provide a good living environment, raising life to better light conditions, are good vantage points for those who depend on food brought in by the currents and are high enough to prevent the life on them from being smothered by silt.

The kelps are food themselves and are grazed by mollusks. Of particular note is the blue-rayed limpet *Helcion pellucidum*; this small mollusk eats its way into the stipe eventually weakening the plant sufficiently, for it to break off during a storm.

More importantly kelps are the “power house” of an important food chain. Not only do they provide food directly, but as they die they decay and provide nutrients for plankton and filter feeders, which in turn are eaten by higher animals, which again are eaten by other predators and so on.

Without the kelp forests these areas would be rock with relatively barren open sea above, rather than a rich environment with diverse range of species.



Kelp Forest Ecosystems

The architecture of a kelp forest ecosystem is based on its physical structure, which influences the associated species that define its community structure. Structurally, the ecosystem includes three guilds of kelp and two guilds occupied by other algae:

1. Canopy kelps include the largest species and often constitute floating canopies that extend to the ocean surface (e.g., *Macrocystis* and *Alaria*);
2. Stipitate kelps generally extend a few meters above the sea floor and can grow in dense aggregations (e.g., *Eisenia* and *Ecklonia*);
3. Prostrate kelps lie near and along the sea floor (e.g., *Laminaria*);
4. The benthic assemblage is composed of other algal species (e.g., filamentous and foliose functional groups, articulated corallines) and sessile organisms along the ocean bottom;
5. Encrusting coralline algae directly and often extensively cover geologic substrate.

Multiple kelp species often co-exist within a forest; the term understory canopy refers to the stipitate and prostrate kelps. For example, a *Macrocystis* canopy may extend many meters above the seafloor towards the ocean surface, while an understory of the kelps *Eisenia* and *Pterygophora* reaches upward only a few meters. Beneath these kelps there may be a benthic assemblage of foliose red algae. The dense vertical infrastructure with overlying canopy forms a system of microenvironments similar to those observed in a terrestrial forest, with a sunny canopy region, a partially shaded middle, and darkened seafloor.

Each guild has associated organisms, which vary in their levels of dependence on the habitat, and the assemblage of these organisms can vary with kelp morphologies. For example, in California *Macrocystis pyrifera* forests, the nudibranch *Melibe leonina* and skeleton shrimp *Caprella californica* are closely associated with surface canopies; the kelp perch *Brachyistius frenatus*, rockfish *Sebastes spp.* and many other fishes are found within the stipitate understory. Brittle stars and turban snails *Tegula spp.* are closely associated with the kelp holdfast, while various herbivores such as sea urchins and abalone live under the prostrate canopy; many sea stars, hydroids and benthic fishes live among the benthic assemblages; solitary corals, various gastropods and echinoderms live over the encrusting coralline algae. In addition, pelagic fishes and marine mammals are loosely associated with kelp forests, usually interacting near the edges as they visit to feed on resident organisms.

Kelp Forests and Climate Change

Climate change may influence kelp forests through the direct effects of temperature, moving the boundaries of the areas where they have the potential to survive. In addition, nutrient inputs necessary for the kelp to thrive may be altered due to changes in the geographical or seasonal distributions of rainfall and upwelling. In kelp forests off southern California, the proportion of cold water fish such as the greenspotted rockfish, have fallen and warm water species like the Garibaldi have increased since the 1970s.

Since the 1940s in Tasmania an increase of 1.5 – 2.0°C in minimum water temperature associated with a southward shift in the boundary between the warm East Australian current and the cold, nutrient-rich sub-Antarctic waters has contributed to a decline in the extent of what was once the largest kelp forest in Australia. An increase in the numbers of sea urchins has also contributed to the decline.

These are normally passive grazers of algae but graze the kelp when the waters become warmer, as in El Niño events. In the Northern Hemisphere former kelp forests have become 'sea urchin barrens' due to overfishing, removing the predators that would normally control the urchins. Disruption of ecosystems due to climate change may reinforce the imbalances that have resulted in the overgrazing of the kelps.