Kelp forests

Forests of a different kind

by **Gavin W. Maneveldt**, Department of Biodiversity and Conservation Biology, University of the Western Cape

ABOVE LEFT: *Ecklonia radiata*, a small species of kelp restricted to the warm temperate to subtropical shores of the south and southern east coasts.
ABOVE: At St James and Kalk Bay along the Cape Peninsula, kelp can be seen for several metres offshore and several hundred metres alongshore. Photos: Gavin Maneveldt.

The United Nations has proclaimed 2011 as the International Year of Forests to raise awareness about sustainable management, conservation and development of all types of forests for the benefit of current and future generations. Forests protect our watersheds, bind and conserve our soil, help combat climate change by absorbing and storing carbon dioxide, provide food, building materials and medicine, and are home to about 80% of the world's (terrestrial) biodiversity. When one reads these facts (see also text box alongside) you are drawn to the notion that what is really being referred to are terrestrial forests. But, what about that region of the planet that encompasses nearly three-quarters of its surface, namely the oceans? The oceans too have their equivalent of the terrestrial forests, namely kelp forests. In order to see this similarity, one has to understand what is meant by the term 'forest' in its purely technical sense.

The United Nations (UN) Food and Agriculture Organization (FAO) defines a forest as being 'more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10%, or trees able to reach these thresholds *in situ*', … and that this 'does not include land that is primarily under agricultural or urban land use'. According to this definition, a forest is 'determined by the presence of trees'. Critical to the interpretation of the term forest, is the capacity of the structural components (trees) to attain the minimum thresholds in their natural environment, unaided by direct human intervention. So, if we can argue that kelp communities meet these basic requirements, would we accept that they can be classified as forests, albeit of the marine kind?

Trees higher or longer than 5 m

A tree is defined as a perennial, woody plant that has many secondary branches supported clear of the ground on a single main stem or trunk with clear apical dominance, and a minimum height of 3 m at maturity. According to this definition, many plants among the monocots could not be considered trees. Palm (one of the most well-known and widely planted tree families in the world) and bamboo (the tallest members of the grass family) trees for example, possess unbranched stems. Along with palms and bamboos, other monocot trees from the genera *Pandanus*, *Dracaena* and *Cordyline* (to name but a few) have structural material that resemble ordinary 'wood' (and are even colloquially called wood), but their structure and composition is quite different from that of ordinary wood. Closer to home, the Quiver tree or Kokerboom (*Aloe dichotoma*) that is indigenous to southern Africa, although bearing secondary branches, does not have woody stems. Having said this, we can then surmise that the term 'tree' could be variably applied and even be re-defined. If we considered these examples, a tree could then be defined as a perennial plant that may, or may not, have secondary branches supported clear of the ground on a single main stem or trunk, with clear apical dominance, and that would achieve a minimum height of 3 m at maturity.

This latter definition allows us to consider kelp plants as trees. Compared to other seaweeds, kelp plants are comparatively long-lived, with individual plants of the Giant Kelp (*Macrocystis pyrifera)* living for over 10 years (and thus certainly perennial) and growing in excess of 6 m. Not only does this latter figure satisfy the height (length) requirement for a tree, but also the United Nations FAO definition of being 'higher than 5 m' when defining a forest. During optimal conditions, Giant Kelp can grow as much as 60 cm per day, quite easily attaining lengths (heights) prescribed as minimum for classification as trees. As a consequence of their rapid growth rates, kelp communities are among the most productive ecosystems on earth, supporting *in situ* primary production levels of as much as ten times greater than most terrestrial crops and intensive agriculture. Similar to terrestrial trees, individual kelp plants have a root-like holdfast, a stem-like stipe (that in most species is unbranched), and blades formed mostly at the distal ends of the stipes. Although not

Did you know?

- The livelihoods of 1.6 billion people depend on forests.
- More than 300 million people live in forests.
- Forests cover 31% of total land area of the world.
- 30% of forests are used for production of wood and non-wood products.
- Over 40% of the world's (terrestrially derived) oxygen is produced by rainforests.
- More than a quarter of modern medicines, worth an estimated US$ 108 billion a year, originate from tropical forest plants.

(From the International Union for Conservation of Nature (IUCN) – http://www.iucn.org/)

bearing an apical meristem, growth in kelp is controlled by an intercalary meristem that is located at the transition zone between the blades and the stipe. These meristems produce a kind of apical dominance that in most species of kelp results in only a single stipe.

Canopy cover of more than ten percent

While the UN speaks of a forest as a vegetation type possessing a canopy cover greater than only 10% of trees, most South African forest literature advocate a canopy cover more than 75% of trees that form a closed canopy. In addition, the South African literature makes reference to a community with definite and recognisable strata or layers, having at least three layers, namely a canopy, subcanopy or understorey (which includes epiphytes) and ground-dwellers. Even here, kelp communities quite readily satisfy the requirements.

In established kelp communities, kelp plants are most often the only marine algae that reach the surface (i.e. canopy cover equivalent to 100% of kelp plants) and, unless there are sandy gullies or barren areas, the kelp plants will form a closed canopy. Kelp can easily occur in densities of over 10 plants per square metre and the closed nature of the canopy is enhanced by the fact that over 50% of kelp biomass is blade material located apically at the distal ends. Similar to terrestrial forests, kelp communities are three dimensional (stratified) in their structure. Firstly, the kelp plants comprise the canopy-forming organisms and quite often more than 60% of the total kelp biomass in a typical kelp community is made up of the surface-reaching plants. These canopy-forming plants are the ones that utilize much of the available sunlight that strikes the water's surface. The remaining percentage of kelp, as well as a huge diversity of other macroscopic algae, comprises the subcanopy or understorey and the ground-dwellers. These latter algae survive in a dim world overshadowed by the canopy, very much like that which exists in a typical terrestrial forest. In addition, a host of epiphytic algae also exist in the kelp community. Depending on where these epiphytes are found (in the canopy, along the stipes of canopy- or subcanopy-forming plants, in the understorey), they in turn receive as much light as that which reaches their particular locations.

More than 0.5 hectares

0.5 ha is equivalent to 0.005 km^2, or 5000 m^2. In its most practical sense, this would equate to an area 50 m in width by 100 m in length. This really is not large at all. Among other factors, kelp plants are limited by available rocky substrate to which they can attach. This means that should the environment be conducive and enough rocky shore environments exist, kelp beds can stretch for several kilometres alongshore, and several hundreds of metres out to sea.

South African kelp species

Due to its unique geographic location (both longitudinal and latitudinal), and the presence of two interacting ocean currents (the cold Benguela Current on the west and the warm Agulhas Current to the east), South Africa is the only country that is home to all three (*Ecklonia*, *Laminaria* and *Macrocystis*) of the major kelp genera (of which 30 are currently recognized). Within these genera, four species of kelp are represented in South Africa.

Sea Bamboo or Seebamboes (*Ecklonia maxima*) is the most abundant of the four species and occurs along the cold temperate west and southern west coasts, dominating the inshore waters of the west coast. The species is the largest of the local kelps attaining lengths up to 15 m. This kelp plant possesses a massive holdfast that extends into a long, hollow, gas-filled stipe that ends in a gas-filled bulb (float) at its apex. The bulb further extends into a single flat, solid primary blade from which secondary blades emerge. In juvenile kelp, the primary blade is very elongated and bears only short secondary blades. As the plants mature, the primary blade becomes very much reduced, secondary blades elongate and these then form the bulk of the apical mass.

While *Ecklonia maxima* is the dominant kelp along inshore waters of the West Coast, this species becomes progressively replaced by the Split-fan Kelp (*Laminaria pallida*) in deeper waters and also further north up the West Coast and into Namibia. The species has a similar distribution to *E. maxima* and is similarly large, attaining lengths to 10 m. In *L. pallida* the stipe can be solid or hollow, but without a bulb at its distal end. Due to the absence of a gas-filled bulb and mostly solid-stiped plants around the Cape Peninsula, this species is generally a subtidal (subcanopy) species and so is seldom observed along the low shore intertidal zone. This kelp has a single broad, fan-shaped blade that becomes dissected into many regular longitudinal tears (or splits) giving the false impression

LEFT: *Ecklonia maxima* occurs abundantly along the cold temperate west and southern west coasts.
BELOW: *Macrocystis pyrifera* generally occurs in sheltered, shallower water, inshore of *E. maxima* and *L. pallida* beds.
BELOW LEFT: *Laminaria pallida* dominates in deeper waters and also further north up the west coast and into Namibia.
Photos: Gavin Maneveldt.

ABOVE: A clump of juvenile kelp plants showing their typical root-like holdfasts, stem-like stipes and blades formed at the distal ends of the stipes. Photo: Gavin Maneveldt.

of being multiple-bladed; hence its common name. Adult plants of *L. pallida* also differ from those of *E. maxima* in that they have warty stipes as opposed to the smooth stipes of *E. maxima*.

Generally found in shallow, somewhat sheltered water inshore of *E. maxima* and *L. pallida* is the Bladder Kelp (*Macrocystis pyrifera*), the least common of the cold-water West Coast kelps. This kelp was previous called *M. angustifolia* in South Africa, but molecular research has shown that globally only one species of *Macrocystis* exists. The species is relatively delicate, vine-like, and bears numerous blades at regular intervals along its slender stipe. At the plant's apex, the new blades are fused, gradually separating as they grow. The blades possess numerous marginal spines and a single gas-filled bladder at their bases, which allows this kelp to remain afloat and erect in the water column. In addition, the blades are rippled, a feature that is important for increasing absorption of nutrients in relatively low flow environments characteristic of sheltered lagoons and bays. Unlike the previous two species of kelp, an individual holdfast in this species can bear multiple stipes. Large populations of *M. pyrifera* are only found at two locations near Cape Town; one at Kommetjie, the other at Robben Island.

Related to *Ecklonia maxima* is a much smaller species of kelp known as the Spiny Kelp (*Ecklonia radiata*). This species is restricted to the warm temperate to subtropical shores of the south and southern east coasts. Spiny Kelp is notably stunted, reaching an average length of only about 1 m although plants in excess of 2 m have been recorded in deep subtidal areas throughout the South Coast, and shallow subtidal areas along the Eastern Cape coast that are influenced by localized upwelling. Unlike *E. maxima*, this species has a comparatively small holdfast and short solid stipe that lacks a gas-filled bulb. In adult plants, the primary blade is generally short and gives rise to densely crowded secondary blades that may be smooth or variably rippled. Secondary blades in this species are characteristically spiny, alluding to the species' common name.

Similarities between kelp 'forests' and terrestrial forests

Despite their one obvious difference (terrestrial *vs* marine), terrestrial forests and kelp communities share a number of features. Both ecosystems are considered nutrient-advantaged systems. In terrestrial forest ecosystems, nutrients are replenished from leaf litter-fall and the accumulation of humus in the soil. In kelp forest ecosystems, nutrients are kept in constant supply due to wind-induced mixing of water layers and through upwelling. Both ecosystems are three-dimensional (stratified) comprising canopy, subcanopy or understorey, and ground-dwelling organisms. The dominant canopy-forming organisms (trees and kelp plants) utilize most, if not all, of the available sunlight and make efficient use of their nutrient-rich surroundings through their monopoly of the light regime and their efficient uptake of the plentiful available nutrients. The canopy-forming trees and kelp plants are relatively fast-growing organisms that are highly productive, attaining many metres in height (length). Canopy and Dissolved Organic Matter (COM/DOM, i.e. leaf/blade litter), respectively the main food source, are derived directly from the canopy-forming organisms, and form the base of most of the food webs in these ecosystems. Solar and wind energy drives the productivity cycles and the availability of nutrients.

With so much similarity between these ecosystems, surely we cannot be wrong by referring to the marine counterparts as kelp forests?

WHAT DOES THAT MEAN?

Apical Related to, or denoting the apex or tip.
Apical dominance In plant science, apical dominance is the phenomenon whereby the main central stem of the plant is dominant over (i.e. grows more strongly than) the other side stems. There is usually a bud at the terminal end of the shoot that inhibits the development of lateral buds that would give rise to lateral growth.
Blade Synonymous with leaves in green plants.
Holdfast The root-like organ of attachment in kelp.
In situ A Latin phrase which translated literally means 'In position', i.e. in its original place or position.
Intercalary Somewhere in between.
Macroscopic Large enough to be perceived or examined by the unaided eye.
Meristem A region of plant tissue consisting of actively dividing cells forming new tissue, i.e. areas where growth takes place.
Monocot Abbreviated from Monocotyledon (mono = one; cotyledon = embryonic leaf), one of two major groups of flowering plants (the other being Dicotyledon; di = two) in which the germinating seed gives rise to only a single leaf. In dicots, the germination seed gives rise to two leaves.
Perennial When referring to plants, it means living for more than two years.
Primary production The production of organic compounds from atmospheric or aquatic carbon dioxide through the process of photosynthesis.
Stipe The flexible 'stem' in seaweeds.
Upwelling An oceanographic term that refers to a situation in which wind-driven dense, cooler, nutrient-rich, sub-surface water ascends towards the ocean surface.

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READING

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