Algal forest habitats
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Description
On South Australian reefs algal forests are habitats dominated by macro-algae. The forests can comprise of up to five different layers or strata as shown in Figure 1. The uppermost stratum is the giant kelp, found only in the South East(SE) of the State (see separate account of Macrocytis forests), and below this is the layer of canopy species up to 1 m high, comprising the kelp, Ecklonia, and the fucoids, with many species of Cystophora and Sargassum – all species that are widespread throughout the State.

![Diagram of algal forest layers](image)

Figure 1. The five layers or strata of a macro-algal assemblage (after Turner & Collings 2008).

The kelp Ecklonia tends to dominate exposed coasts, while the fucoids dominate moderately exposed to very sheltered reefs. The fucoids themselves (Order Fucales) are extremely rich in species, with some 67 species in southern Australia, the centre of their diversity globally. Their vertical distribution reaches 10–20 m in depth on coastal reefs, but distribution can be much deeper (to >50 m) on offshore reefs in the clear waters of the eastern Great Australian Bight (GAB).

Below the canopy is the algal understorey of (plants to ~40 cm high) which is extraordinarily rich in species, with ~1 000 or more species recorded within South Australia (SA) alone. Some species are widespread throughout southern Australia, whilst others are rare or with very restricted distributions. Below the lower depth limit of the canopy species red algae extend throughout the deeper photic (light) zone to a depth of 20–30 m on most coastal reefs, but can extend to depths of ~70 m in oceanic waters, such as the SE of SA or the eastern GAB.

Below the main understorey are algal turfs 1–2 cm high and encrusting algae comprising mainly calcified corallines. Algal turfs extend to 20 m depth or more with encrusting algae recorded to >100 m.

The high diversity of canopy and understorey species results in algal forest habitats being heterogeneous to the extreme, with change occurring continuously with shifts in temperature, exposure and other factors along the coast.
Distribution

Algal forest habitats occur on all rocky coasts except those in the upper Gulf's where algae are much less abundant. The SE coasts of South Australia are especially rich, with the large macroalgae, *Macrocystis*, *Phyllospora*, and *Durvillaea* being present.

Function

Productivity

The productivity of kelps is very high, as shown by the studies of Kirkman (1989) and Fairhead and Cheshire (2004a, b). For example, Kirkman calculated that an *Ecklonia* forest produced 22 times its own fresh weight a year, and this represents only ~11% of the carbon uptake of the kelp – the rest going back into the water as respired carbon, eroded tips of the blades, and in spore release. These in turn enter the food web and help support the innumerable plankton, herbivores and plankton feeders of coastal waters.

The productivity of fucoid algae is also very high. The crayweed, *Phyllospora comosa*, and the bull kelp, *Durvillaea potatorum*, that occurs in the SE of SA, produce 10 or more times their own weight a year (Sanderson 1992; Cheshire and Hallam 1989). The productivity of a mixed algal community at ~4 m depth, comprising mainly species of *Cystophora* and *Sargassum*, together with its understorey species was studied by Cheshire *et al.* (1996). The annual production of this community was estimated to be 19 times its own weight. Algal turfs only 1–2 cm high, which occur patchily in disturbed habitats, are also highly productive, and produce up to 10 times their weight a year (Copertino *et al.* 2005). In deeper water of 12–15 m red algal communities are also very productive, considering the reduction in light, and Shepherd (1979) and Sanderson (1992) found that they produced ~10 times their own weight a year.

Overall, it is evident that temperate reef algal systems are extremely productive in terms of carbon produced, and maintain a rich diversity of animal species, that are dependent on them for food.

Benefits

As described in the separate chapter on *Macrocystis*, kelps and fucoid algal habitats create an environment that supports a rich diversity of plant and animal species. These forests have both physical and biological functions as follows:

- the canopy dampens water movement, and provides a more sheltered habitat beneath it;
- the habitat favours a diverse flora and fauna under, and in patches between, the canopy;
- by its architecture provides micro-habitats in the upper and mid-canopy, and within holdfasts on the substratum;
- recycles nutrients taken up from the water;
- provides an abundant food supply for animals living in and around the forest;
- provides a nursery habitat for juveniles of many fish and other species.
In addition to the above general ecosystem services of the forest system, there are many mutualisms and other specific relationships between species. A good example is the obligate relationship between abalone larvae and crustose corallines. The coralline contains a settlement inducer that induces settlement of the abalone larva, and the coralline then provides habitat and food for the tiny abalone; the coralline in turn benefits from the grazing of the abalone on its surface.

Some algal habitats have features that provide refuge for unusual or rare species. For example, deep-water red algal communities provide habitat for some rare fish species (J.L. Baker pers. comm.). These include: the southern pygmy pipehorse, *Idiotropiscus australis*, the red pipefish, *Notioampus ruber*, rosy weedfish, *Heteroclimus roseus*, Forster’s weedfish, *Heteroclimus tristis*, Red Indianfish, *Pataecus fronto*, and red velvet fish, *Gnathanacanthus goetzeei*.

Deeper-water red algal habitats often have high species diversity and are comparatively rare on South Australian coasts. Representative beds of red algae are therefore worth conserving in their own right. Notable examples of such habitats recorded are:

- deeper reefs in the SE of SA, notably those 15–40 m off Cape Northumberland, where >200 species of red algae were recorded at a single site (Shepherd 1979);
- deep reefs off the Coorong at depths of 20–30 m (Haig et al. 2006).
- deeper reefs at 10–25 m in Backstairs Passage, on both the Fleurieu Peninsula and Kangaroo Island sides;
- reefs at 10–12 m depth ~10 km ESE of Troubridge I., lower Gulf St Vincent;
- deeper reefs in Thorny Passage, especially off Memory Cove at 20–40 m depth;
- reef habitats at 15–20 m depth in Anxious Bay, off Ward I., Hotspot, Nuyts Reef, and isles of Nuyts Archipelago in the eastern Great Australian Bight.

Some algae have very restricted distributions or are known from very few habitats. An outstanding example of this is the green alga *Palmocladathrus stipitatus*. This rare and remarkable alga has a stem that shows annular rings, out of which grows a delicate, cup-shaped, perforated membranous blade. Individual plants up to 8 years of age have been recorded (S.A. Shepherd

*Gnathanacanthus goetzeei* (Red Velvet Fish) amongst red algae, Stokes Bay, KI. (Photograph: David Muirhead).

*Palmocladathrus stipitatus*. (Photograph: Kevin L. Brandon)
unpublished data). The plant is known mainly from deeper water reef habitats in Anxious Bay at 15–20 m deep, and 3-4 km off Cape Northumberland at depths of 40–60 m, where the plant forms extensive mono-specific beds. The species also occurs in shallow water in caves at 10–15 m depth on the northern face of Waldegrave I., eastern GAB.

**Threats**

The major threats to algal forest habitats dominated by kelp or fucoid algae are excess nutrients and sedimentation. These tend to increase in densely populated coastal areas, where land use has intensified, and storm-water run-off and effluent discharges from industry and sewage treatment plants have increased. Offshore dredging and coastal construction also cause increased sedimentation.

The effects of excess nutrients are the decline and disappearance of algal forests and their replacement by algal turfing species 1–2 cm high (Connell 2008; Connell *et al.* 2008). The combination of nutrients and sedimentation are synergistic, and can dramatically increase low, algal turfs (by 77% in a study by Gorgula and Connell 2004).

Sedimentation alone is a stress on algal forests and can eliminate most species in an assemblage, to be replaced by low algal turfs, which themselves accumulate sediment, and prevent a return to the former forest habitat. Hence the final ‘alternative state’ becomes stabilised. In some cases in eastern Gulf St Vincent, the algal forest has been replaced by mussels, which are favoured by the increased nutrients, and again become stabilised. Examples of the above switch from algal forest to a degraded alternative state are the numerous reefs in eastern Gulf St Vincent from Port Noarlunga north to Outer Harbour (Turner *et al.* 2007; Connell 2008; Gorman and Connell 2009).

![Algal forest replaced by mussel bed, Gulf St Vincent.](image)

(Photograph: Alison Eaton)

Another threat to the integrity of algal communities is climate change, notably acidification of coastal waters. Little is as yet known about the effects, except that some algae e.g. calcified species, such as crustose corallines, will be deleteriously affected (Hall-Spencer *et al.* 2008), and that synergisms will occur, as in the accelerated expansion of turfing algae in the presence of nutrients (Russell *et al.* 2009). Other effects may be the disappearance of calcifying animals, such as grazing sea urchins or molluscs, with consequent cascading effects on algae.
Seawater temperature increases due to climate change are also likely to result in a suite of cold-adapted large brown algae retreating out of SA state waters over the next few years to decades. These include *Durvillaea* and *Phyllospora* mentioned above as well as the giant kelp *Macrocystis pyrifera* (var. *angustifolia*) that is covered by a separate chapter. All of these species are presently confined to the SE of the State, where they benefit from cold, nutrient-rich waters in summer from the Bonney Coast upwelling. If the intensity of upwelling increases then they may stay in State waters but it is also likely that the passage of high-pressure systems will move south of their present path and so miss SA. In that case then their climate-change driven retreat would be hastened.

**Considerations for Marine Protected Areas (MPA’s) in South Australia**

The very high productivity of algal forest systems, the diversity of canopy and understorey species implies that they are also places of high biodiversity, and should be well represented in all sanctuary zones and habitat-protection zones in the marine park system throughout the State. The threats to their integrity are mainly anthropogenic, from which it can be concluded that sanctuary zones containing them are best located adjacent to coastal terrestrial parks, from where nutrients and stormwater run-off are minimal.

### References:


