Rhodolith habitats
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Description
Rhodoliths are mobile, free-living forms, as opposed to encrusting forms, of coralline algae, that roll about on shelly bottom or on sediment, sometimes among seagrass beds of Amphibolis or Posidonia, and form a unique habitat that has features of both hard and soft bottoms. Areas of seabed dominated by them are called rhodolith beds. Some 26 genera of crustose corallines are recognised, and at least 8 of them contain species that form rhodolith beds (Woelkerling 1996; Harvey & Woelkerling 2007; Harvey & Bird 2008). Rhodolith beds develop from crustose algal spores settling onto small grains of sand or gravel, or from broken pieces of coralline nodules.

In southern Australia five main rhodolith-forming genera have been recorded, Lithothamnion, Hydrolithon, Mesophyllum, Neogoniolithon, and Sporolithon, and they have a similar variety of forms as the encrusting corallines forms, i.e. warty, lumpy, fruticose etc. Rhodoliths often occur in high densities and form deposits of living and dead aggregations, comprising one to five or so species. Rhodoliths are rolled about by water currents and swell, and Foster (2001) has colourfully called them the “calcareous tumbleweeds of the sea”, forming “reefs which rock and roll”. Some commercial fishers call them ‘popcorn’.

Rhodoliths amongst mixed algae in shallow water, lower southeast.
(Photograph: Sarah Bignell)

After a bed is established, recruitment is probably mainly by breakage and overgrowth. Rhodoliths grow extremely slowly, according to the sparse data available, and growth rates in temperate waters are typically 0.2-0.6 mm yr$^{-1}$ in depths <20 m, and much lower (0.01-0.1 mm yr$^{-1}$) in deeper water (Foster 2001; Steller et al. 2007).

The longevity of rhodoliths is known for only two species in southern Australia. Shallow-water nodules of Sporolithon durum, 7-9 cm diameter and living at 1-3 m depth at Rottnest Island, Western Australia, were aged by radiocarbon dating at <60 years old (Goldberg & Heine 2008). Deep-water forms at 38 m depth, with a size range of 2-6 cm, from a rhodolith bed in Esperance Bay, Western Australia, were found to range widely in age from modern (<50 years old) to ~960 years. As rhodoliths can grow uninterrupted for more than 100 years, it is likely that the older ones became buried, died, and later exposed and recolonised (Goldberg 2006). The growth and
longevity information available suggest that established beds, especially in deeper water, are likely to be decades to many centuries old.

**Distribution**

Rhodoliths have strict habitat requirements. They are found mainly on sediments with a high calcareous content, and usually where shell, or gravel, or cobbles also occur. Carbonate production is high on the southern Australian shelf (see James *et al.* 1992, 1994, 1999), and favours rhodolith development, as shown in Esperance Bay, where calcium carbonate comprises 83% of the sediment (Ryan *et al.* 2007), and rhodolith beds cover 14% of >1000 km² of mapped bottom habitats (Baxter *et al.* 2005). Rhodoliths also require moderate water movement. If water movement is too low, they become buried by sediment, and if too high, they are rolled or carried away. The degree of water movement also affects the shape and branching patterns of rhodoliths, with spherical shapes favoured by moderate water movement, and irregular shapes by lower water movement (Foster 2001).

*Rhodoliths taken at 77 m in the eastern Great Australian Bight.* (Photograph: Shirley Sorokin)

Rhodolith beds are found sparsely throughout southern Australia, but this sparsity may partly be an artefact of the patchiness of bottom surveying, and the depths of offshore beds. They have been recorded down the west Australian coast, notably on the Rottnest Shelf at 35-60 m depth (Collins 1988; James *et al.* 1999). In the western Great Australian Bight (GAB), they were recorded in Esperance Bay, at depths of 27-65 m (Goldberg 2006). Beds are extensive among islands of the Recherche Archipelago, where they are found mainly at depths of 27-65 m in waters open to the swell (Harvey *et al.* 2004) and at 30 m depth off Twilight Cove, 430 km NE of Esperance Bay, (H. Kirkman pers.comm.). East of Israelite Bay in the NW GAB, the Roe Shelf extends for 100 km offshore from the Baxter Cliffs, and supports beds of small to cobblesized rhodoliths to ~5 cm size at depths of 35-60 m; they were described as ‘compact to rounded, branching or dendritic’ (James *et al.* 2001). In the NE GAB they are found at 60-135 m depth (James *et al.* 1994, 2001; S. Sorokin pers. comm.). On the Lacepede Shelf, SE of KI, they were recorded at 60-80 m depths (James *et al.* 1994), and also in near-shore waters off Port MacDonnell, South Australia (Harvey & Bird 2008), off Ocean Grove, western Bass Strait at depths of 30-35 m (S. Chidgey pers.comm.), and in deeper shelf waters of eastern Australia (Marshall & Davies 1978).

The exposed southern Australian coasts are subject to prevailing swells of 10-16 s period and wave lengths of up to 200 m. These swells penetrate to >100 m depth (rarely to 160 m depth),
and produce bottom orbital velocities of 50 cm s\(^{-1}\) (see Goldberg 2006)-an oscillatory motion more than enough to rework and sort the sediments. The depth range of 60-80 m on much of the southern exposed coast, and slightly shallower depths where swell is attenuated by coastal topography, are apparently optimal for rhodolith beds; however fragments of living rhodoliths are likely to be found in depths down to 240 m, as on the Lacepede Shelf, SE of Kangaroo Island (KI) (James et al. 1992).

In Gulf waters, rhodoliths also seem very patchy. In bays and gulfs the distribution of rhodoliths seems to be controlled by tidal movement or by wind-driven waves. Short-period waves of \(~1\) m high are able to move rhodoliths at 5 m depth, and tidal currents of 30 cm s\(^{-1}\) can roll or rock them, depending on the complexity of their shape (Marrack 1999; unpublished observations). Hence rhodolith beds in Spencer Gulf are located in places of moderate tidal current. Periodic rotation of nodules appears necessary for light to reach all sides of the nodule, as well as to prevent burial or fouling.

Svane et al. (2009) recorded rhodoliths as present in Spencer Gulf at depths of 20-25 m in places of moderate to strong tidal current, as shown in (Figure ); other records further south in Spencer Gulf are NE of Corny Point at 20 m depth (K. Rowling pers. comm.), and in beds off Pt Bolingbroke, near Port Lincoln, SW Spencer Gulf at 19 m (S.Fraser pers. comm.). In Investigator Strait rhodoliths are abundant at 20 m depth south of Troubridge Pt.

In shallow bays rhodoliths have been recorded in Proper Bay, Port Lincoln at depths of 3-4 m on a rubbly, limestone bottom (Shepherd 1975) and (as Lithothamnion erubescens) by Womersley (1956) in Pelican Lagoon, Kangaroo Island at <1 m depth. Harvey & Bird (2008) recorded an extensive rhodolith bed over 1 km\(^2\) in size at the entrance to Western Port, Victoria at a site with moderate tidal currents. The bed comprised five common species, and averaged \(~500\) rhodoliths m\(^{-2}\), of which up to two thirds were dead. Rhodoliths have also been recorded from numerous bays in eastern Australia, from Gabo Island north to Byron Bay (Harvey et al. 2002), but no further details are known.

![Figure 8. Rhodolith (Sporolithon durum) recorded from Spencer Gulf, with distribution map of records (extracted from Currie et al. 2009).](image)

**Function**

The production rates of rhodolith beds in temperate waters have been shown to be surprisingly similar to those for coral reefs. Typical rates are in the range 200 – 1200 g CaCO\(_3\) m\(^{-2}\) yr\(^{-1}\) (review of Bosence & Wilson 2003). Such rates can cause beds to accumulate at a rate of \(~1\) mm yr\(^{-1}\), though thick beds (to 1 m) have so far only been recorded in the western Great Australian Bight.

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Rhodoliths have been called foundation species or "bio-engineers", because they modify benthic habitats by providing hard surfaces for some species and shelter in their interstices and between nodules for others (Steller et al. 2003). Larger nodules, and those with higher branch density, support greater faunal densities than smaller or simpler ones (Steller et al. 2007). The Western Port rhodolith beds are dense, with an average of ~500 nodules m\(^{-2}\), and Harvey & Bird (2008) measured the cryptic fauna living within the branches of the rhodoliths. The rhodolith habitat contained an average density of 400 individuals L\(^{-1}\) (of rhodolith volume) living in their interstices, comprising 89% polychaete worms, 8% bivalves and the remainder echinoderms and crustaceans.

*Rhodolith bed at site with strong tidal current at 19 m depth off Point Bolingbroke, SW Spencer Gulf. (Photograph: S. Fraser)*

In another study by Mathis et al. (2005) of the fauna in the Esperance rhodolith beds, the average density of fauna living on the rhodoliths (the epifauna), and those nestling in the interstices between the warts or lumps of nodules, as well as those living in tubes or galleries within the nodules (the endofauna) averaged 1250 individuals L\(^{-1}\) (of rhodolith volume) excluding protists. About 62% of these lived in the interstices between nodules, and the rest lived on the surface (the epifauna). Polychaetes, with 59% of the total, were the most common group, followed by bryozoans (16%), arthropods (9%), sponges (6%), and ascidians (5%), with small numbers of hydroids, echiurans, sipunculans and bivalve molluscs.

These and other studies show that faunal species’ richness is almost twice as high, and density a thousand times higher in rhodolith beds compared with sandy bottom. The reason for such a huge difference is that the fauna of rhodolith beds includes many species requiring a hard substrate e.g. sponges and ascidians, as well as (a) species that live in the spaces between rhodoliths, (b) those that are interstitial in branching rhodoliths and (c) predators.

**Threats**
Rhodolith beds have very low resilience to bottom trawling, due to their slow growth rates, and the negative and fatal impact of burial. Trawling is the severest form of human disturbance that initially reduces rhodolith density and size, and ultimately degrades them structurally to a gravel bottom (Kamenos et al. 2003; Steller et al. 2003). Other threats to rhodolith beds are: turbidity and sedimentation from terrestrial run-off, as in Western Port (Harvey & Bird 2008); organic enrichment from fish farms; and storm-water or effluent outfalls.
Disturbance effects on the fauna living in the beds are as severe as those on the corallines themselves. Besides direct effects resulting from loss of habitat structure, indirect effects, such as declines in fragile and omnivorous species, increase in soft-sediment species and scavengers, and declines in predatory species, also take place. The outcome can be a high loss of species, functional diversity and resource monopolization by a few dominant species (Grall & Glémarec 1997). Another study on the specific effects of fish farms on the fauna of rhodolith beds found serious loss of faunal biodiversity, and particularly abundances of small crustaceans (ostracods, isopods, tanaids and cumaceans) (Hall-Spencer et al. 2006).

**Vulnerability and recommendations for MPAs in South Australia**

Rhodoliths are slow-growing and very long-lived, and their beds form a highly specialised habitat in places subject to appropriate water movement and absence of sedimentation. They can also be highly productive in that they may harbour a species-rich interstitial fauna. A consequence of the increasing threats to rhodolith beds globally, and the recognition of their high scientific and conservation value, is that many of them are protected in European waters (Council of European Communities 1992), and also New Zealand.

So far as is known they are comparatively rare in South Australia. They would be best protected within the MPA framework in Sanctuary or Habitat Protection Zones, to protect them from trawling, and harmful inputs from terrestrial sources. Beds deeper than 50 m are mainly under Commonwealth jurisdiction, but where they might occur in State waters e.g. in lower Gulf waters or around islands in the eastern Great Australian Bight, they should be protected as above.
References


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