HABITAT-FORMING BRYOZOANS IN SOUTH-EASTERN NEW ZEALAND

A SCIENCE SUMMARY FOR THE SOUTH-EAST MARINE PROTECTION FORUM

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ROOPU MANAAKI KI TE TOKA

BRYOZOANS – AN OVERVIEW

Bryozoans are colonial animals that live on the seafloor and feed by collecting single-celled algae from the seawater (suspension feeding). They encrust surfaces – rocks, seaweeds, other animals – and can also grow away from these substrates, forming three-dimensional structures. Bryozoans are fragile animals and easily damaged by disturbance of the seafloor (e.g. trawling and dredging) (Fig. 1).

There are about 6000 species of bryozoans in the world today and New Zealand is home to about 950 of these[1, 2]. More than half of New Zealand's bryozoans are endemic (i.e. they only live in New Zealand)[2]. Nowhere else on earth do so many species of bryozoan grow so large or form habitat used by so many other types of animal[3].

Figure 1. Colonies of different species have different shapes and sizes. These specimens are all from the Otago shelf thickets (top left, *Cinctipora elegans*, top right, *Hippomenella vellicata*, bottom, *Celleporaria agglutinans*. Photos: A. Wood.

Throughout this report, "bryozoans" refers to habitat-forming bryozoans unless otherwise specified. Bryozoans in this context, then, means colonies that grow to 5 cm or more in three dimensions, that dominate areas of seafloor, and that create small, reef-like structures known as patch reefs or thickets. Research that relates directly to habitat-forming bryozoans in the south-eastern area is related wherever possible, but where data are insufficient, research on bryozoans in general (all growth forms) or on habitat-forming bryozoans from outside the south-eastern area will be included. These differences will be clearly noted.

THE GROWTH & REPRODUCTION OF HABITAT-FORMING BRYOZOANS

Bryozoans around southern New Zealand are slow growing. Research in Fiordland on species that also live in the south-eastern area indicate minimum growth rates of 0.8–5 mm per year[4]. This means bryozoans take 6–30 years to reach 5 cm, the size considered by ecologists as likely to be useful as habitat to other animals[3]. Under the right conditions and in the absence of disturbance, however, bryozoans can grow much larger, and together, such structures can grow very large indeed. One bryozoan patch reef present in Foveaux Strait in 1978/79 was 500 m wide and over 10 km long[5].

Bryozoans are also slow to recolonise after disturbance events. Larvae are mobile (they can swim) for a short time, from a few minutes to a few hours, meaning they have very limited dispersal abilities compared to many other marine invertebrates. Bryozoans in Foveaux Strait have recolonised areas in as little as 12 years when there were colonies less than 1 km upstream, but when this distance extended to 13–21 km, there was no colonisation after as long as 50 years[6].

BRYOZOAN HABITAT REQUIREMENTS & DISTRIBUTION

Bryozoans live from shallow subtidal areas to the Territorial Sea boundary (12 nm), and beyond. The conditions that allow bryozoans to dominate the seafloor and so form habitat are not well understood but are believed to include a stable seafloor and high levels of water movement[3, 7]. Stable seafloors can include rocky reefs and biologically generated (biogenic) reefs, such as once existed in Foveaux Strait and its approaches[see 6 for details]. Elsewhere, bryozoans are restricted to sand and gravel sediments at water depths in which wave action is unlikely to disturb them (beyond the "wave base"). On the continental shelf off south-eastern New Zealand, such conditions generally occur at depths greater than 60 metres.

In the south-eastern area, bryozoans are known to live:

- in waters greater than 65 m off Otago Peninsula[8-12] (Fig. 2);
- along the northern edge of Karitane Canyon[13]. Only part of this canyon lies within the Territorial Sea; and
- off Oamaru, in association with sponges and coralline algae[13]. Again, only some of this habitat lies within the Territorial Sea.

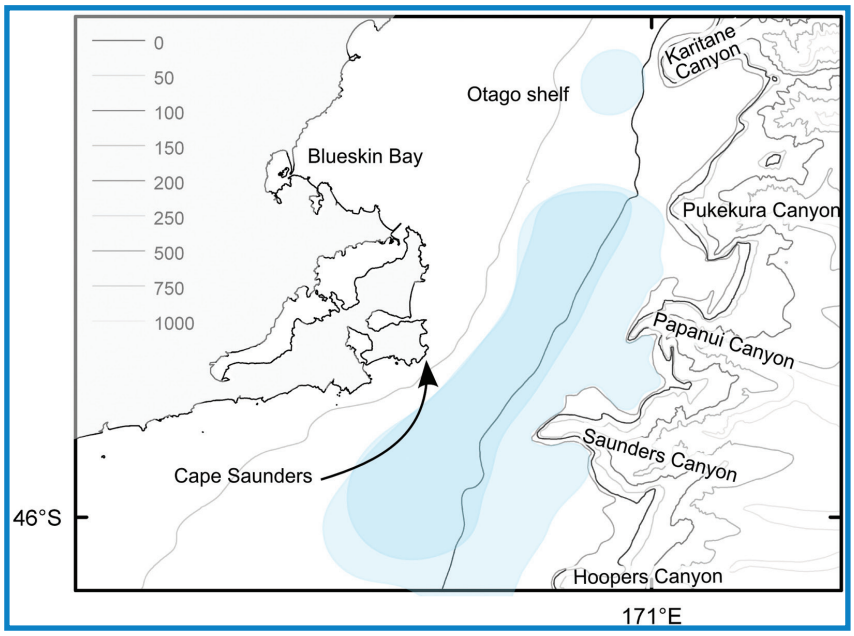

Figure 2. The present-day distribution of the main bryozoan thickets off Otago Peninsula – where bryozoans are most abundant – are reasonably well understood (darker blue) but the edges of this habitat have not been identified. Bryozoans are known to occur in reasonable quantities within the areas shown in light blue and are predicted to occur beyond this (see notes on SeaSketch, next page[A], or details in[12]). Depth contours are metres water depth.

Bryozoans also occurred in the eastern approaches of Foveaux Strait in recent history (e.g. immediately south of Waipapa Point in the last 100 years), but their present-day distribution is unknown. Computer-generated predictions[7, refined for SeaSketch] confirm that suitable bryozoan habitat is likely to be found throughout this area and indicate that bryozoan thickets could have extended around the coast to Tahakopa Bay (The Catlins). The same models indicate that bryozoans could find suitable habitat in a narrow band south of the existing Otago Peninsula thickets, along the shelf in depths of >70 m, as far as Molyneux Bay (see the layer "Predicted Bryozoa Distributions" in SeaSketch[A]). In support of this latter prediction, bryozoans have been recorded in considerable quantities off Nugget Point[14, 15].

THE PENINSULA THICKETS

Along-shelf (latitudinally), bryozoan thickets are located roughly parallel with Otago Peninsula (Fig. 2). Bryozoans extend to the north side of Blueskin Bay[8, 16], though not in quite the same abundance as further south. To the south, bryozoans occur at 70–120 m water depth on the south side of Saunders Canyon[9, 11], although both the number of species and their abundance is lower in this area. No studies have sampled sufficiently far south to conclusively identify the southern limit of the peninsula thickets[7].

Across the shelf (longitudinally), the bryozoan species that create the thickets vary with depth and sediment type[8, 17] and, likewise, the associated faunal communities (diverse groups of worms, crabs, sea stars, sea squirts, snails, and other molluscs) also change across the shelf[8, 11, 12, 17]. The species and distributions of habitat-forming bryozoans and the fauna that use them for habitat have been relatively stable for at least 30 years,[12] although more recent studies[9, 11] found fewer bryozoans in deeper water (>95 m) than had previously been recorded[8, 18].

Since 1984, queen scallops (*Zygochlamys delicatula*) have been fished in deeper waters, particularly on the flat areas between Pukekura (formerly Taiaroa) and Papanui Canyons[19]. In the early 2000s areas further south were more productive [R. Belton, pers. comm, in 14] and most catch in recent years has come from south of Otago Peninsula (Ministry for Primary Industries data). Bryozoans were reported as the dominant bycatch in the early days of the fishery[15] and a 2004 bycatch survey[14] found bryozoans were caught in significant quantities in both "exploratory" tows and in areas where scallops were commercially abundant. A recent survey of parts of the queen scallop ground (128–220 m water depth between Papanui and Saunders Canyons)[13] found that the bryozoan species that occurred there differed from elsewhere on the shelf.

KARITANE CANYON

Large colonies of *Hippomenella vellicata* have recently been observed along the north side of Karitane Canyon at about 200 m water depth[13]. Large rock lobsters were observed in association with these bryozoans, and various sponges, other bryozoans, and anemones covered the rock surfaces. On the adjacent continental shelf, the seafloor was sand, shell, and gravel, with many bryozoans and tubeworms. These canyon bryozoans are essentially an extension of the main peninsula thickets, and, like the bryozoans off Nugget Point, highlight the need for further research to determine the full extent of this habitat.

OFF OAMARU, INSHORE OF THE HAY PADDOCK

A recent survey[13] confirmed the continued existence of the Hay Paddock, a biogenic habitat recorded from the continental shelf off Oamaru in the 1970s[20]. The more recent survey identified two separate communities in this area[13], but bryozoans were only noted at the "Inshore of the Hay Paddock site". Abundant sponges were observed in association with the rocky reefs, and together with bryozoans and coralline algae, provided habitats for blue cod, leatherjacket, orange wrasse, southern pigfish, brittle stars, and sea cucumbers. The full extent of this biogenic habitat and the role of bryozoans in creating habitat structure at this site requires further research.

A *SeaSketch is an online collaborative mapping tool and can be accessed at http://southeastmarine.seasketch.org*

THE ECOLOGICAL FUNCTIONS & VALUES OF BRYOZOANS

Biogenic structures are widely accepted to create habitat for diverse invertebrate communities (e.g. sponges, anemones, worms, crabs, snails, sea stars, and sea squirts) and such habitats can significantly and positively influence survival of these invertebrates[21-25]. Biogenic habitats can also provide "essential fish habitats", areas where adult fish spawn[26], and "nursery habitats" which provide shelter and feeding grounds for juvenile fish[27]. At a larger scale, biogenic habitats may provide rich feeding grounds for vertebrates including marine mammals[28] and birds[29].

HABITAT FOR INVERTEBRATES

Invertebrate larvae are often mobile and can actively choose where they settle. Biogenic habitats interact with the existing environment (e.g. light, temperature, current, and wave conditions), affect the transport of food and oxygen across the seafloor[30], and alter sediment composition[31-34]. These changes combine to create an array of niches that can be inhabited by many different species. The three-dimensional space that biogenic habitats create can reduce competition for food and space[35] and alter the balance of predator/prey interactions[36-40]. In combination, these functions lead to a diversity of species at all food web (trophic) levels[41], which often results in a robust, efficient ecosystem. An important but sometimes overlooked function of biogenic habitats is that they support evolutionary processes; species living in these habitats can adapt and evolve at a faster rate than do those in other habitats[42-45].

NURSERY GROUNDS FOR FISH

Bryozoans (listed as "corals" in some older reports) and sponges once functioned as nurseries (i.e. habitats in which food and shelter are abundant) for tarakihi, red gurnard, leatherjacket, and snapper in the outer parts of Golden and Tasman Bays[20]. Inshore, off Separation Point (part of the land mass that separates Golden and Tasman Bays), bryozoans functioned as nurseries for tarakihi, snapper, blue cod, red mullet, and sea perch[46]. At near-by Torrent Bay, bryozoans provided habitat for juvenile fish and for "good quantities" of John dory and blue cod[46].

In Foveaux Strait, blue cod are associated with areas of "rough ground" – patch reefs of bryozoans and other animals that have regenerated where oyster fishing has temporarily ceased. Blue cod occur in high numbers on these patch reefs, eat a more varied diet, and grow more quickly than blue cod living on disturbed habitat nearby[47, 48].

Detailed surveys of habitat use by fish, juvenile or otherwise, have not been reported for the Otago Peninsula thickets; however, juvenile tarakihi were regularly observed off Otago Peninsula during the Catch Sampling Programme of 1967-71[20], and juvenile (0+) blue cod were recently observed in association with bryozoans at this site[13] (Fig. 3).

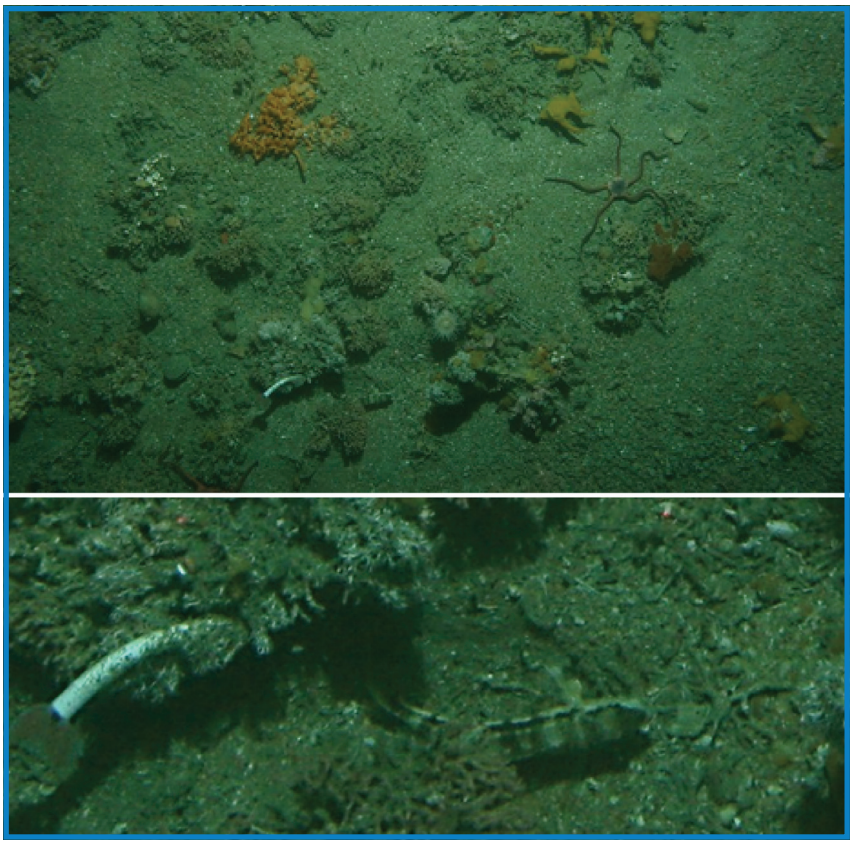

Figure 3. (top) Otago shelf at the metre scale; (bottom, close-up) juvenile (0+) blue cod using the biogenic habitat. Photo: M. Morrison (NIWA).

FEEDING GROUNDS FOR LARGE VERTEBRATES

The narrowing of the continental shelf off Otago Peninsula and the abundance of organisms that use the bryozoans as habitat (including non-commercial species) create feeding grounds for some larger vertebrates. There is considerable evidence that sea lions and yellow-eyed penguins target the waters over the bryozoans[29] and sea lions may even dive down to the thickets themselves[28].

THE ECONOMIC & CULTURAL VALUE OF BRYOZOANS

The economic, recreational, social, and cultural values of bryozoans in the south-eastern area are probably best considered in terms of the fisheries they support, since most habitat-forming bryozoans live below depths regularly experienced by the public.

ECONOMY

Two of the top 20 most valuable species[B] (blue cod and tarakihi) are commonly associated with bryozoan-generated habitat in the south-eastern area. Many other species such as queen scallop, red cod, leather jacket, sea perch, rough skate, blue cod, dark ghost shark, ling, and stargazer are fished on the continental shelf of the south-eastern area and may well use the bryozoans as habitat at some stage in their life cycles.

B *Based on the Asset Value of Species Managed under the Quota Management System for 2008, the last year for which data could be obtained from stats.govt.nz*

Information on the commercial catch and biology of fish stocks for these species can be found in the Fisheries Assessment Plenary 2015, available online from the Ministry for Primary Industries.

CULTURE

Recreational and customary fishers value many of the same species as do commercial fishers, including tarakihi and blue cod. Rod and line are used most commonly, set nets are also used for tarakihi, and blue cod may be taken by longlining, set netting, potting, and spearfishing[49]. Non commercial fishers often travel considerable distances (+15 km) offshore to fish for blue cod on the outer-shelf in the south-eastern area. Access to reliable recreational and customary fishing is very important to many New Zealanders from both social and cultural perspectives. Such fishing opportunities may often depend, directly or indirectly, on biogenic habitats including those generated by bryozoans.

THREATS & PRESSURES, TODAY & TOMORROW

Globally, sewage, industrial pollution, climate change, and large-scale disturbances caused by trawling and dredging are the main threats to habitat-forming bryozoans. In New Zealand, run-off of fine sediments caused by changing land use may have negatively affected bryozoans living close to shore, but the most serious disturbance has been from trawling and dredging.

FISHING IMPACTS

Trawling and dredging have caused extensive damage to bryozoans New Zealand-wide. Areas estimated to total >2000 km^2 of live habitat-forming bryozoans have been described in recent history from the New Zealand shelf, but much of this has been damaged or destroyed by trawling and dredging[50]. Today, there is an estimated 225 km^2 of bryozoan-generated habitat at Spirits Bay (Piwhane Bay)–Tom Bowling Bay (in the Far North)[est. from 51], about 55km^2 remaining at Separation Point[52] (down from 213 km^2 [est. from 46]), and about 450 km^2 total and >200 km^2 core area on the Otago shelf (see Fig. 2, [est. from 9, 11]).

Bryozoan-generated habitat is now considered almost non-existent in Foveaux Strait (down from >800 km^2 [est. from 5] and at Torrent Bay (down from 313 km^2 [est. from 46]).

Bryozoans are sufficiently delicate and slow growing that even a single pass by a trawl or dredge can cause damage that may take decades to recover and intensive trawling and dredging of some areas has already caused damage that may take centuries to recover.

Areas fully closed to bottom trawling, Danish seine and dredging (amateur and commercial), are the only way to avoid both the repeated (intensive) and the more subtle (exploratory) impacts of trawling and dredging, and so to enable seafloor communities to develop naturally and to function as fully as possible.

SEDIMENTATION

Sedimentation resulting from changing land use (e.g. forestry and dairy conversion) affects estuarine and marine systems around New Zealand and in general, sedimentation on the continental shelf has increased considerably in about the last 200 years[54, 55]. Sedimentation can have both chronic (e.g. inefficient feeding) and acute effects (e.g. smothering) on marine organisms – particularly those that suspension feed. Fine sediments may also prevent bryozoans from recolonising after disturbance[52].

In the south-eastern area, rivers (e.g. the Clutha/Mata-Au, the Waitaki) transfer massive quantities of sediment from the land to the sea throughout the year, but particularly during flood events. Present day conditions (ocean currents, tidal, and weather patterns) around Otago Peninsula mean that most sandy sediment is retained along the coast and is not thought to affect the peninsula thickets. Riverine muds are transported across the shelf and over the shelf break and, under normal conditions, are not expected to impact the bryozoans[18, 56]. Increased sediment loads, however, would be cause for concern, since mud accumulates within the bryozoan thickets in significant quantities (A. Wood, pers. obs).

Further north (off Oamaru), sand and mud readily accumulate on the mid-shelf and these accumulations may slow growth rates and reduce the ability of bryozoans to deal with additional disturbance[52].

SEWAGE

Bryozoans in the Mediterranean are more sensitive to sewage and industrial pollution than other, functionally similar animals[57], but we have no data for New Zealand species. In the south-eastern area, sewage processing varies greatly.

Waste arrives in the marine environment both near shore and up to 1.1 km from shore (at Tahuna, Dunedin). Particulate levels are low most of the time but when flood events occur and raw sewage enters the marine environment, acute problems (smothering, poisoning) are possible, and future population growth may increase the potential for damaging impacts to occur.

OUR CHANGING OCEANS

Climate change means that some parts of the seas around New Zealand will warm as others cool; waters in the south-east have already warmed by about 0.67 °C over the last 61 years[58]. Sensitivity to particular temperatures probably underlies the restricted ranges displayed by many bryozoan species. The northerly limit of *Cinctipora elegans*, for example, coincides with a winter seawater temperature of 12°C (just north of Cook Strait)[7]. Other locally important species (e.g. *Hippomenella vellicata*, see Fig. 1) have much wider natural distributions (from the Far North to the Antipodes Islands, 860 km south of Stewart Island).

For many other invertebrates, the genetic variation that exists across a species' full distribution means that some populations already have the ability to cope with changing environmental conditions built in to their genetic code[59]. If this is the case for bryozoans, then maintaining healthy breeding populations of different species throughout their full, natural ranges, will give bryozoans the best chance of adapting to climate change.

Ocean acidification – an increase in the acidity of seawater – is caused by anthropogenic carbon dioxide in the atmosphere being absorbed by the oceans. For living bryozoans, this environmental change could make the process of building skeletons (the structures that create habitat) more difficult and make dead bryozoans dissolve more quickly[60]. By the end of the century, possibly as soon as 2030, ocean acidification may affect many animals' (including bryozoans) ability to flourish in southern oceans[61]. Similarly to ocean warming, any genetic variation that can be retained in living populations may help bryozoans adapt to these changing conditions.

EXISTING MANAGEMENT & FUTURE THREAT MITIGATION

Managing existing threats and reducing the damaging aspects of human activities in the future depends on the nature of the threats in question. This section considers appropriate management and mitigation of the effects of trawling and dredging, sedimentation, pollution, and climate change on bryozoan-generated habitats.

SPATIAL CLOSURES

Closing areas to activities that cause harm is the main, most effective management tool for protecting vulnerable seafloor communities, and spatial closures are used all over the world in all types of marine habitat. A comparison of the distribution of spatial closures to the locations of known areas of habitat-forming bryozoans within the New Zealand Extended Continental Shelf showed that only two closed areas protect any of the known bryozoan areas[7].

The 1981 fisheries closure at Separation Point (between Tasman and Golden bays) was intended to protect fish nurseries, and the 1999 fisheries closure off Spirits Bay (Piwhane Bay) and Tom Bowling Bay (in the Far North) was set up to protect a highly diverse seafloor assemblage of suspension feeders, which included bryozoans[51]. These two closures have a combined area of 364 km^2.

South of Separation Point, no spatial closures protect any known bryozoan areas. A voluntary closure of about 110 km^2 was established for the Otago Peninsula bryozoan thickets in about 2000 (R. Voller, MFish, pers. comm), but this closure is neither formally advertised nor monitored [12].

UNDERSTANDING AND CONTROLLING SEDIMENTATION AND POLLUTION

Existing management of sedimentation risk largely depends on regional councils, which operate under the Resource Management Act (1991). Enforcement of these regulations and further regulation of land use as it relates to the likelihood of slips and runoff (planting out steep areas, for example) will be essential if the negative aspects of changing land use are to be controlled and shelf-dwelling assemblages are to be protected from land-based anthropogenic activities.

Existing management of sewage disposal and pollution relates mainly to the removal of particulates, treatment of pathogens, and to the controlled release of noxious chemicals. We have no evidence that existing management is insufficient from the perspective of bryozoans; however, with increasing human populations and the increasing likelihood of extreme weather events, it may become necessary to understand where waste products go when their release is uncontrolled such as occurs during flood events or spills.

CHANGING OCEANS

The ability of bryozoans in the south-eastern area to deal with changing sea temperatures and ocean acidification may depend on their existing genetic coding, which is likely to vary from one population to another throughout the natural range of each species. Spatial closures can protect these populations from anthropogenic disturbance so that genetic variability is retained, and appropriate management of sedimentation and pollution will mean that bryozoans will be in the best possible condition to reproduce and adapt. To be effective, spatial closures will need to protect populations of each species at various points (different latitudes, depths, coasts) in their natural ranges.

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