9.6 Bryozoan thickets extent and quality

Author, affiliation: Mark Morrison (NIWA)

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State of knowledge of the "Bryozoan thicket extent and quality" attribute: Excellent / well established – comprehensive analysis/syntheses; multiple studies agree.

Part A—Attribute and method

A1. How does the attribute relate to ecological integrity or human health?

There is a strong record of evidence in New Zealand of bryozoan thickets providing ecological integrity to significant local areas of the coastal zone and continental shelf, including: a) increasing biodiversity (invertebrates, fish)[1]; b) providing important nursery habitats for the juveniles of valuable fisheries species (e.g., blue cod, tarakihi, leatherjackets, snapper and dredge oysters)[2-5]; c) increasing foraging (food) resources for adults of these and other fisheries species[4]; d) increasing bentho-pelagic coupling through the consumption of phytoplankton and the subsequent expelling of waste products[6]; and e)providing stability to coarser bottom sediments as a biogenic cover, increasing the resilience of such areas to physical forces (currents, waves, storms)[7].

Human health is supported through the production of fisheries catch that supports healthier diets and lifestyles, by providing economic activities for local communities (including in more remote areas) and supporting recreational fishing activities for mental wellness. The ecological integrity provided by bryozoan thickets is directly proportional to the human health benefits.

Here we are referring to frame-building bryozoans, defined as "*species that regularly grow to ≥ 50 mm in three dimensions*" [8], and of these, those that are 'habitat-formers'. The most relevant habitat-former scale are defined as being "*those cases where frame-building bryozoans dominate (at least) square metres of seafloor and thereby contribute significantly to the habitat complexity of the locality*" (at least 27 New Zealand species) [8]. Singularly and collectively, these form 'bryozoan thickets [11-12].

A2. What is the evidence of impact on (a) ecological integrity or (b) human health? What is the spatial extent and magnitude of degradation?

There is very strong evidence of negative impacts on ecological integrity, across a range of New Zealand locations. Spatial losses and/or habitat quality declines include the impacts of historical and ongoing commercial fishing activities (Foveaux [7-9], South Taranaki [13], Chetwode Banks Marlborough Coast, Tasman Bay [8,10,16], and from human-driven land-derived sedimentation (Separation Point) [14-16]. Losses are probably under-represented as some bryozoan thicket areas were almost certainly lost early on in human occupation of New Zealand (e.g., areas of the Hauraki Gulf, as suggested from 'death assemblages') [17]. Cascades of effect will have flowed out into far-field non-bryozoan thicket areas, such as a reduction in the production of juvenile fish and by association, the abundance of adults.

Specific examples include a) oyster dredging in western Foveaux Strait from 1977 to 1998, with the loss of extensive long linear *Cinctipora elegans* bryozoan reefs (up to 1 metre high, 4 to 40 metres long, 3 to 6 metres wide) that formed current aligned reef clusters, 300 to several kilometres wide [7]; b) historical trawling in Tasman and Golden bays, which eliminated circa 300 km^2 of *Hippomenella vellicata* ('paper coral') at Torrent Bay [8], and a similarly large area west of D'Urville Island (with the addition of scallop dredging). The Separation Point bryozoan field (*Celleporaria agglutinans*) was estimated to cover circa 200 km^2 in its original state; following fisher concerns on spatial losses of this juvenile fish habitat from trawling impacts, a central 156 km^2 was closed to bulk fishing methods in 1981 [18]. In 2002 about 55 km^2 remained [14], but by 2021 all of the bryozoan habitat was lost, attributed to sedimentation from Cyclone Gita in 2018 [19]. On the South Taranaki Bight, some 2000 km^2 of bryozoan habitat is thought to be reduced in quality and height from the ongoing effects of trawling [6].

Human health has been affected by likely reduced fisheries catches and economic activity, through direct estimates of this have not been quantified [5-6].

A3. What has been the pace and trajectory of change in this attribute, and what do we expect in the future 10 - 30 years under the status quo? Are impacts reversible or irreversible (within a generation)?

The pace of change has varied between the regions, but the trajectory of change has been overwhelming negative. The examples given in A2 all involve loss of habitat. For Foveaux Strait bryozoans, significant loss was quantified from 1977 to 1998 (21 years) [7], with earlier large historical losses likely to have occurred since the oyster dredge fishery started operating in the 1880s. For Tasman/Golden Bays, complete losses of two bryozoan areas from trawling impacts had occurred by the late 1960s (over 500 km^2) [8,15-16], while the Separation Point field continued to decline until a complete loss some time before 2021 [19] (likely in 2018 in association with Cyclone Gita), despite protection from bulk fishing. Similarly, Chetwode Bank (circa 100 km^2, coastal Marlborough Sounds) was reported to have been historically covered in bryozoan reefs along with other biogenic habitats, with trawling eliminating this cover somewhere around the 1960s or earlier. Conversely, some bryozoan thicket areas appear to have remained largely unchanged (e.g., 100 km^2 of high quality habitat on the Otago shelf) [8-9,20], through some historical loss from fishing is likely.

In the next 10 to 30 years, recovery is likely for those areas where fishing has been the main driver of loss, if fishing pressure is removed, and the environment remains suitable for bryozoan thickets re-establishing. For Foveaux Strait, some areas of high-quality bryozoan thickets remain [21], possibly from those areas never having been heavily fished. Recovery would be expected across wider Foveaux Strait if oyster dredging was more spatially restricted, but the rate of recovery would be likely to vary widely [22]. Conversely, the extensive bryozoan area losses from Tasman/Golden Bay are unlikely to recover, as increased sedimentation has made the seafloor unsuitable for bryozoans, and significant source populations for larvae may no longer exist within the region. Emerging threats including ocean warming and acidification may increase in their negative impacts over coming decades [23].

A4-(i) What monitoring is currently done and how is it reported? (e.g., is there a standard, and how consistently is it used, who is monitoring for what purpose)? Is there a consensus on the most appropriate measurement method?

Little ongoing temporal monitoring is currently done for any bryozoan area, with the exception of a) a high biodiversity area (sponges, bryozoans) off Spirits Bay, upper North Island, closed to scallop dredging following its discovery, assessed for change at decadal scales [24,25]; and b) broad-scale ongoing monitoring of significant biogenic habitat areas across the Marlborough Sound by the Marlborough District Council (MDC) [26,27]. One-off surveys have been carried out to quantify change over time for some bryozoan areas that have older historical data with which to compare, including camera drops at the Ulva Marine Reserve, Stewart Island, and on the Otago shelf [19,20]; as well as camera drops, towed video, and multibeam sonar mapping of the Separation Point field [19, 28].

Measurement methodologies are not standardised, through there has been a call to do so [19], with methods including visual assessment from diving, dropped and towed cameras, from dredging, and the use of sidescan and multibeam sonar mapping. An ideal standardised methodology would include sonar mapping the extent of bryozoan fields, stratification of that imagery/data into different putative bottom types and stratified random ground-truthing using drop or towed cameras, including quantifying metrics such as colony counts (density) and % cover. Such an approach has now been used for several potential marine farm applications (south Foveaux Strait [21], offshore Marlborough Sounds), as well as for Separation Point, Chetwode Bank, and outer Queen Charlotte Sound bryozoan fields [28,29].

A4-(ii) Are there any implementation issues such as accessing privately owned land to collect repeat samples for regulatory informing purposes?

A suitable vessel is needed for bryozoan thicket surveys, ranging from small run-abouts for more coastal locations, to large seagoing vessels for areas on the continental shelf. Boat size is also driven by the type of sampling equipment being deployed.

Logistical barriers are largely the need to deploy expensive survey vessels and equipment, along with staff, to remote areas.

A4-(iii) What are the costs associated with monitoring the attribute? This includes up-front costs to set up for monitoring (e.g., purchase of equipment) and on-going operational costs (e.g., analysis of samples).

Depending on the location and depth of the bryozoan thickets to be monitored, significant up-front costs may be incurred through the purchase of expensive equipment such as cameras, and the building of bespoke towed camera arrays. Costs vary from low-cost simple systems such as a Go-Pro camera set within a drop frame/on a stand (<$1000), through moderate cost towed cameras (circa $16,000) to expensive high-quality camera arrays ($150,000–$250,000). Other costs include the availability of suitable hardware and software for post-processing and video analysis, and the high cost of human labour needed to process video (through A.I. may help offset this in the future). The use of sidescan and/or multibeam sonar systems is also a significant cost, including the skilled operators needed. Full mapping/monitoring of larger areas (e.g., Separation Point) using sonar approaches is likely to cost several hundred thousand dollars for the mapping alone, although sub-sampling transects could be deployed as a cheaper intermediate approach.

The need for a survey vessel is a significant cost, depending on the size of vessel needed. Small runabouts are relatively cheap to operate, but larger vessels may cost several thousand dollars a day to charter and consume relatively large fuel volumes. The use of day vessels invokes further costs of providing onshore accommodation and meals for the survey team (up to $1000 day for a team of four), while live-aboard vessels require the purchase of stores, and in some cases the services of a cook.

Significant monitoring work requires multiple days of survey, which may include higher labour costs through the need to work through weekends. Direct labour costs vary widely, depending on whether the work is being done in-house by an agency, or contracted out to a research provider.

The simplest lowest cost approach for monitoring of individual sites is the use of a Gro-Pro on a frame/stand, deployed from a suitable sized vessel for the area being surveyed.

A5. Are there examples of this being monitored by Iwi/Māori? If so, by who and how?

Although of interest to Māori, I am not aware of any bryozoan thicket monitoring being carried out by representatives of iwi/hapū/rūnanga.

A6. Are there known correlations or relationships between this attribute and other attribute(s), and what are the nature of these relationships?

Bryozoan thickets and the individual bryozoan species that contribute to them have not been studied in detail in terms of the environmental bounds within which they can exist, aside from the observation that they are generally associated with coarser clean bottom sediments (notably pebbles) and higher current flows [8-10]. Suspended sediment is a known stressor of these and other filter feeders and is thought to be responsible for the loss of the Separation Point bryozoan field. Phytoplankton / chlorophyll *a* in water (trophic state) and dissolved oxygen are almost certainly also important associated attributes for bryozoan thicket extent and quality, but no quantitative work or qualitative observations are available. Horse mussels are found in low densities in association with some bryozoan thickets, but whether there are any direct inter-relationships is unknown. Dredge oysters are considered to have been historically strongly associated with bryozoan reefs [7], but there are strong contrasting views also.

Part B—Current state and allocation options

B1. What is the current state of the attribute?

The current state of bryozoan thickets is generally well known at the broad scale of regional areas, where such thickets have or once covered a significant spatial extent. That state varies by area, e.g., Tasman/Golden Bay thickets – lost; South Taranaki Bight field – reduced quality; Otago Shelf –

healthy and probably static; Foveaux Strait – extensive biogenic reefs lost but recovering in some areas.

The central issue for monitoring and the use of bryozoan thickets is spatial scale, which would need to be addressed by good spatial stratification and associated stratified random sampling. Remote sensing methods such as side-scan and/or multibeam sonar are ideal for large scale detection and mapping but become cost-prohibitive at increasing big scales. They may also not be able to provide bryozoan discrimination for some bryozoan/seafloor combinations, such as the pebbles, sand and low height patchy bryozoans of the Otago Shelf [30,31].

B2. Are there known natural reference states described for New Zealand that could inform management or allocation options?

No, but such natural reference states could be developed for some areas using past or present data sets. Currently there are no formal definitions of natural reference states for any bryozoan area; these would need to be species mix specific as bryozoan thickets vary in their species composition around New Zealand.

B3. Are there any existing numeric or narrative bands described for this attribute? Are there any levels used in other jurisdictions that could inform bands? (e.g., US EPA, Biodiversity Convention, ANZECC, Regional Council set limit)

No. Numeric or narrative bands could be developed through the use of habitat/environment classification schemes such as the Coastal and Marine Ecological Classification Standard (CMECS). Work by NIWA is looking at this, although it would need to be accepted and adopted by regulatory agencies.

B4. Are there any known thresholds or tipping points that relate to specific effects on ecological integrity or human health?

No there are not. Current work on Habitats of Particular Significance to Fisheries Management is looking at the relationships between bryozoan thickets/reefs (and other biogenic habitats) and the juveniles of commercially important finfish species (notably blue cod, and to a lesser extent tarakihi), for the Marlborough Sounds region [28]. Indications are that fish density increases with increasing habitat cover and complexity.

B5. Are there lag times and legacy effects? What are the nature of these and how do they impact state and trend assessment? Furthermore, are there any naturally occurring processes, including long-term cycles, that may influence the state and trend assessments?

Yes. Areas where the general environment has changed to the extent it will no longer support the growth and health of historically present bryozoan thickets, are very unlikely to ever recover. A model of recovery by succession has also been proposed for Foveaux Strait bryozoan reefs, where recovery require a succession of intermediate biogenic habitats [22]. Naturally occurring processes such as El Nina and La Nino are also likely to affect recovery through wind and current changes, that in turn may influence larval retention and supply.

B6. What tikanga Māori and mātauranga Māori could inform bands or allocation options? How? For example, by contributing to defining minimally disturbed conditions, or unacceptable degradation.

I know of no relevant tikanga Māori and mātauranga Māori approaches directly at bryozoan thickets, although these may exist outside of the public domain.

Part C—Management levers and context

C1. What is the relationship between the state of the environment and stresses on that state? Can this relationship be quantified?

Bulk mechanical fishing methods (e.g., trawling, dredging) are well established as being very detrimental to bryozoan thickets. Extensive bryozoan reef areas have been lost from Foveaux Strait though oyster dredging [7] and are likely to be being prevented from recovery in some areas by ongoing fishing (although other factors may be involved). Bryozoan patches do currently exist within the general area available for oyster dredging [21], including areas that are seldom if ever targeted for oyster harvesting.

High sedimentation and associated suspended sediment, and seafloor deposition, is a known negative stressor of bryozoan thickets in Tasman/Golden Bay [14,32], and almost certainly drove the complete loss of the Separation Point bryozoan field following its protection from bulk fishing in 1981. It is also likely to be one of/the key stressor preventing the recovery of bryozoan fields in Torrent Bay, with its legacy and ongoing effects probably having shifted the seafloor state to one where bryozoans cannot re-establish (muddy, with little harder substrate). The lack of recovery of the west D'Urville Island bryozoan area is less clear in terms of stressors; fishing removed the bryozoans but in the present day the seafloor still holds lots of clean shell cover, and suspended sediment levels are low [31].

C2. Are there interventions/mechanisms being used to affect this attribute? What evidence is there to show that they are/are not being implemented and being effective?

C2-(i). Local government driven

The Marlborough District Council (MDC) has an ongoing programme of identifying and listing significant marine ecological areas within its region [26,27]. This includes both bryozoan thickets, and mixed biogenic habitats that include bryozoan patches. This listing enables these areas to be excluded from potentially harmful activities such as the establishment of marine farms but does not prevent damage from activities such as anchoring. Land-based sedimentation issues are not addressed by this designation.

C2-(ii). Central government driven

Interventions/mechanisms that are being used to protect the extent and quality of bryozoan thickets are limited to the voluntary (Otago Shelf) [20] or regulatory (Separation Point) [18] closure of important bryozoan thicket areas. The Otago Shelf bryozoans have shown no change over decades, whereas the Separation Point bryozoans have been completely lost [19,28].

C2-(iii). Iwi/hapū driven

I am not aware of interventions/mechanisms being used by iwi/hapū/rūnanga to directly affect this attribute.

C2-(iv). NGO, community driven

I have no knowledge of initiatives to improve bryozoan thickets spatial extent and quality being carried out by representatives of NGOs.

C2-(v). Internationally driven

I have no knowledge of obligations to internationally initiatives that would require improvement of improve bryozoan thickets spatial extent and quality.

Part D—Impact analysis

D1. What would be the environmental/human health impacts of not managing this attribute?

The environmental cost of not managing bryozoan spatial extent and quality is the ongoing loss of coastal biodiversity [1,33], juvenile fish production, and general carrying capacity of the coastal region [5,6].

Human health impacts will include a reduction in the production of fisheries species that support economic activity [5,6] and the associated benefits of consuming fish, as well as a reduction in recreational fishing benefits, for both food gathering and mental wellbeing.

D2. Where and on who would the economic impacts likely be felt? (e.g., Horticulture in Hawke's Bay, Electricity generation, Housing availability and supply in Auckland)

The impacts are likely to be felt in inshore fisheries for species whose juveniles directly use bryozoan thickets as juvenile habitat, as well as for larger fish that forage within bryozoan thickets. The spatial scale of these impacts will vary by species and region, depending on the movement/migration ranges of the associated fish species [5]. For example, blue cod impacts are likely to be at the scale of hundreds of metres to a kilometre, snapper impacts at the scale of regional stocks, and tarakihi potentially at the national scale, due to a large scale ontogenetic migration of juveniles from the lower South Island up the entire east coast of New Zealand, and of juveniles from the Tasman/Golden Bay region to the entire west coast of New Zealand.

D3. How will this attribute be affected by climate change? What will that require in terms of management response to mitigate this?

The impact of climate change on bryozoan thickets spatial extent and quality is unknown, but probably likely to be negative as many key species are more dominant and widespread in colder southern waters [10,34]. Ocean acidification has been identified as another major likely threat [23]. There is little opportunity for bryozoan thickets to extent their range further south, as they already occupy suitable depths and areas there. Range and spatial extent retraction seems likely. Protecting and restoring bryozoan thicket areas in southern regions where climate change impacts may be less severe is an obvious key response.

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