NIWA
Taihoro Nukurangi

Sensitive marine benthic habitats defined

Prepared for Ministry for the Environment

April 2013

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NIWA Client Report No: WLG2013-18
Report date: April 2013
NIWA Project: MFE13303

Cover image: Stony coral (*Solenosmilia variablis*) reef at a depth of 1000 m on the summit of Gothic Seamount, Chatham Rise (NIWA).

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Reviewed by Malcolm Clark

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Approved for release by Andrew Laing

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Executive summary

The Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (the Act) sets out a regime for managing the environmental effects of certain activities, such as petroleum exploration and production, mineral mining and marine scientific research, carried out in New Zealand's Exclusive Economic Zone (EEZ) and the continental shelf where it extends beyond the EEZ 200 nm boundary (ECS).

The Act classifies activities as prohibited, discretionary, or permitted. Regulations are being developed under the Act for permitted activities. The Ministry for the Environment is considering a set of conditions to manage the environmental effects of permitted activities in the EEZ if they occur in areas of sensitive marine benthic environments.

In consultation with NIWA, MfE has previously identified the following biogenic (biologically formed) and geological environments as sensitive:

- Beds of large bivalve molluscs
- Brachiopod beds
- Bryozoan beds
- Calcareous tube worm thickets
- Chaetopteridae worm fields
- Deep-sea hydrothermal vents
- Macro-algal beds
- Methane or cold seeps
- Rhodolith (maerl) beds
- Sea pen fields
- Sponge gardens
- Stony coral thickets or reefs
- Xenophyophores (sessile protozoan) beds

In this project definitions of these sensitive marine benthic environments are developed. Habitat definitions were derived from the scientific literature whenever available but in many cases, where definitions were lacking, definitions were drawn directly from the field experience of NIWA staff undertaking research in these areas. MfE will incorporate the key sensitive environment definitions into the draft regulations. The EPA will draw upon the report to develop guidance for operators planning to conduct permitted activities in the EEZ.

1 Introduction

The Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (the Act) received royal assent on 3 September 2012. It sets out a regime for managing the environmental effects of certain activities, such as petroleum exploration and production, mineral mining and marine scientific research, carried out in New Zealand's Exclusive Economic Zone (EEZ) and the continental shelf where it extends beyond the EEZ 200 nm boundary (ECS). The Act does not extend into the Territorial Sea; environmental effects in this region are regulated in accordance with the Resource Management Act 1991.

The Act sets out a default activity classification as discretionary – which requires marine consent. People or organisations seeking to conduct activities regulated under the Act in the EEZ and ECS are required to obtain marine consent, unless an activity is permitted or prohibited in the regulations. The regulations will fill out the detail of the EEZ management regime, specifying which activities are permitted or prohibited, and under what conditions. The Act will come into force when the regulations are promulgated. The Act allows activities to be permitted (with conditions) up to a threshold of significant environmental effects. Parliament has chosen to set the bar for permitted activities at those with up to minor environmental effects, or those that through specifying conditions, have minor or lesser effects.

The Ministry for the Environment is considering a set of conditions to manage the environmental effects of permitted activities in the EEZ if they occur in areas of sensitive marine benthic habitats. In this context "sensitivity" is defined by the United Kingdom's Marine Life Information Network (MarLIN)[1] as:

- the tolerance of a species or habitat to damage from an external factor, and
- the time taken for its subsequent recovery from damage sustained as a result of an external factor.

The rarity of a species or habitat is an element often included in sensitivity assessments in other jurisdictions. The MarLIN descriptions of tolerance MfE are using take rarity into account, as the more rare a habitat is, the more an external factor is likely to damage a significant proportion of the habitat, and therefore it has a lower tolerance rating.

In consultation with NIWA, MfE has identified the following biogenic (biologically formed) and geological environments as sensitive:

- Beds of large bivalve molluscs
- Brachiopod beds
- Bryozoan beds
- Calcareous tube worm thickets
- Chaetopteridae worm fields
- Deep-sea hydrothermal vents

[1] http://www.marlin.ac.uk/sensitivityrationale.php

- Macro-algal beds
- Methane or cold seeps
- Rhodolith (maerl) beds
- Sea pen fields
- Sponge gardens
- Stony coral thickets or reefs
- Xenophyophores (sessile protozoan) beds

In this project definitions of these sensitive marine benthic environments are developed. For example, this project addresses questions such as what density or percentage cover of sponges (as estimated using seafloor imaging equipment, or typical point and mobile seabed sampling gear as outlined in Appendix 1) defines a sponge garden? MfE will incorporate the key sensitive environment definitions into the draft regulations. The Environmental Protection Agency (EPA) will draw upon the report to develop guidance for operators planning to conduct permitted activities in the EEZ.

2 Methods

The scientific literature was searched for information relevant to the description, distribution, and definition of the thirteen sensitive marine benthic habitats. The literature search included published journal papers, published books and reports, as well as unpublished reports and student theses. Where the information from the literature was sparse or conflicting we drew upon our own field experience to define the minimum catch levels or percentage covers that indicate when a sensitive marine benthic habitat had been encountered. We also took into account the Ministry's need for definitions that provide operators a degree of certainty when they comply with the regulatory conditions for sensitive marine benthic environments.

3 Habitat definitions

3.1 Beds of large bivalves

3.1.1 Description

Bivalve molluscs commonly form patchy aggregations on the seabed, which are known as 'beds' (for infaunal species such as cockles) or 'reefs' (for emergent species such as mussels). These more or less discrete aggregations of bivalves can be considered as a type of 'biogenic reef' (definition below):

"Solid, sometimes massive structures which are created by accumulations of organisms….clearly forming a substantial, discrete community or habitat which is very different from the surrounding seabed. The structure of the bed (reef) may be composed almost entirely of the reef building organism and its tubes or shells, or it may to some degree be composed of sediments, stones and shells bound together by the organisms." (Modified from Holt et al. 1998)

Bivalve beds create biogenic structure in what may be an otherwise 'featureless' habitat. In addition, their shells (both live and dead) provide a substrate for settlement by organisms such as sponges and bryozoans, and shelter for mobile invertebrates and fishes. These aggregations modify the habitat considerably from that surrounding it, and consequently influence the composition of the associated community. For example, both emergent and infaunal beds can add complexity to soft sediment habitats by altering boundary flow conditions and providing hard surfaces on which other flora and fauna can grow. There is a considerable body of literature demonstrating the influence of mussel beds on seabed community composition (e.g., Commito and Boncavage 1989). In New Zealand, studies of the large horse mussel, *Atrina zealandica,* found clear differences between macrofaunal and meiofaunal assemblages inside and outside *Atrina* patches in the Hauraki Gulf (Cummings et al. 1998, Warwick et al. 1997). Similarly, Dewas and O'Shea (2012) found both seabed invertebrate mean taxon richness and abundance within infaunal beds of the large dog cockle, *Tucetona laticostata,* to be about 25% higher than in adjacent gravel beds. Figure 3-1 and Figure 3-2 show beds of horse mussels and dog cockles, respectively, and numerous fauna (e.g., small bryozoans, sponges, soft corals and coralline algae) growing on the shells.

Perhaps more important than their direct effects on seabed community composition is the habitat heterogeneity these bivalve beds create, and their important role in ecosystem functioning. Infaunal bivalves influence biogeochemical processes such as regeneration of sediment-associated nutrients, processing these nutrients and thus making them available for water column primary production (Hewitt et al. 2006). Sediment derived nutrients are considered a major contributor to continental shelf production (Pilskaln et al. 1998, Herman et al. 1999).

Figure 3-1: A bed of horse mussels with attached sponges and soft corals on soft sand sediments at 15 m water depth in Martins Bay, Hauraki Gulf (NIWA).

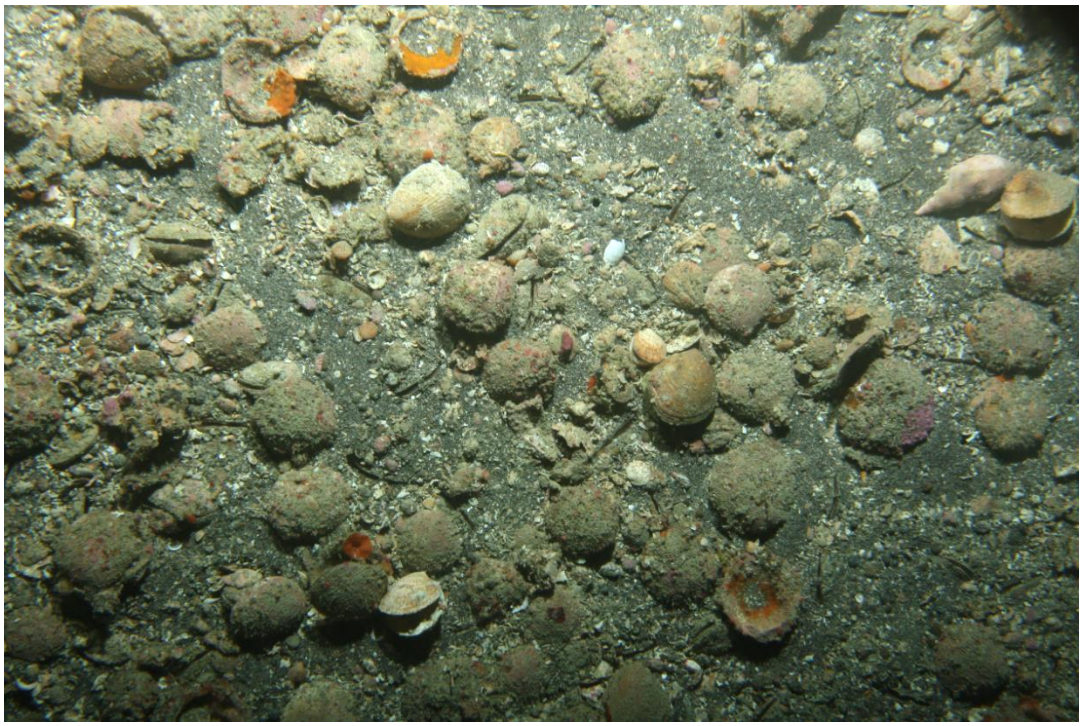

Figure 3-2: Dense bed of dead and living dog cockles in 55 m of water in the South Taranaki Bight. Each shell is approximately 70 mm across. (NIWA)

3.1.2 Distribution

In New Zealand, beds of large bivalves are confined mainly to the continental shelf (generally depths < 250 m) with the geographical distribution of suspension and deposit feeding species tending to reflect the pattern of sedimentation around New Zealand (Rowden et al. 2012). Suspension feeders are particularly well represented off Northland, off the west coast of the North Island to mid-shelf depths, and off south-eastern and southern-most New Zealand where surface sediments consist chiefly of modern terrigenous clean sands and coarser-grained relict terrigenous or biogenic sediment, or both (McKnight 1969, Rowden et al. 2012). Bivalve beds are more likely to occur on the continental shelf than on the continental slope or in abyssal depths (Rowden et al. 2012). The list of bed-forming species that may be encountered in the New Zealand EEZ is long, and too numerous to list exhaustively here. Common examples include suspension feeding species such as horse mussels, scallops (e.g*., Pecten novaezelandiae, Zygochlamys delicata*) and dredge oysters (*Ostrea chiliensis*). There are numerous other examples, such as *Dosinia anus* (venus shell/ringed *Dosinia*) and *D. subrosea* (silky *Dosinia*), *Spisula aequilatera* (triangle shell), *Mactra discors* and *M. murchisoni* (trough shells) and *Bassina yatei* (frilled venus shell), all of which generally occur at depths shallower than 20 m. Deeper bed-forming bivalves include geoducs (*Panopea zelandica* and *P. smithae*), *Tucetona laticostata* (large dog cockles), dredge oysters and queen scallops (*Z. delicatula).* For deep-sea mussels associated with hydrothermal vents or cold seeps, refer to sections 3.6 and 3.8.

3.1.3 Diagnostics

As noted above, the distinctive biogenic habitats created by bivalve beds are generated from the presence both of living and/or dead shells. The definition of a 'significant' bivalve bed may be based on percentage cover of the seabed, which, for emergent forms, can be easily determined from video footage. For example, Rees (2009) defined beds of mussels (*Modiolus modiolus*) in northern European seas as patches with >30% cover that occurred in one contiguous bed or as frequent smaller clumps of mussels. Cohen et al. (2007) defined a shellfish bed as covering "*at least 50% of the surface over at least several square meters and, in concentration, must provide a distinct three-dimensional substrate*." We have been unable to find any guidelines for estimating cover of infaunal bivalves by direct sampling methods (e.g., using proportions of individuals collected in a sediment core, grab or dredge. Given this general lack of information, we suggest that for now the definition for beds of large bivalves in the New Zealand EEZ should be: where living and dead specimens of bivalve species cover 30% or more of the seabed in imaging surveys covering 100 m^2 or more, contribute 30% or more by weight or volume to the catch in a single grab sample or dredge tow (Table 3-2).

3.1.4 References

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3.2 Brachiopod beds

3.2.1 Description

Brachiopods, commonly called lamp shells, belong to an ancient phylum dating back more than 500 M years to the early Cambrian. They are small (adult shells are typically 5-50 mm in length), bilaterally symmetrical, filter feeders, superficially resembling bivalve molluscs (Lee and Smith 2007). They are generally anchored to a hard substrate such as rock, gravel, or shell debris by a muscular stalk (Figure 3-3left) though in one genus the adults may be free living. New Zealand has 38 species distributed among 26 genera. Sixteen species are cosmopolitan, found around the world, 18 species are endemic to New Zealand, while four species are widely distributed in the southern hemisphere (MacFarlan et al. 2009). Some species are gregarious forming dense beds sometimes 2 or 3 layers deep and up to 1000 individuals per m^2 (Lee and Smith 2007). In some areas dead brachiopod shells contribute to habitat complexity and provide abundant interstices for small invertebrates and fish (Helen Neil, NIWA, unpublished data) (see Figure 3-3 right and bottom).

Figure 3-3: Left, a single specimen of *Neothyris lenticularis* at the Antipodes Islands (R. Singleton, NIWA). Right, close up dead brachiopod debris from the Antipodes Islands (NIWA). Bottom, deck shot of living and dead brachiopods from the Antipodes Island sampled using a bottom dredge (NIWA).

3.2.2 Distribution

Brachiopods occur throughout New Zealand at all depths from the intertidal to the abyss, predominantly attached to hard substrates of rock, gravel or shell debris in areas of significant water movement, free of fine sediment (Lee and Smith 2007, MacFarlan et al. 2009). The majority of species occur at depths less than 500 m, though at least half the cosmopolitan species are known from depths of over 1000 m (MacFarlan et al. 2009). Brachiopods from deeper habitats are probably under-sampled because of the difficulty of obtaining specimens from rock faces in deep water (Lee and Smith 2007).

Areas in the EEZ known to have diverse or numerically abundant brachiopod assemblages include deep-water sites off the Three Kings Islands; off Ranfurly Bank (East Cape); parts of the Chatham Rise where rare species are associated with coral thickets; and areas of the Campbell and Bounty Plateaux (Lee and Smith 2007). The Chatham Rise represents a biogeographic limit for many of the southern and sub-Antarctic species (Lee and Smith 2007).

Off the Antipodes Islands a biogenic habitat comprising live *Neothyris lenticularis* living on a substrate of dead brachiopod shells was encountered at a depth of 120 m. In one area the living biomass of *N. lenticularis* averaged 20.7 g m^{-2} (approx. 1 adult per m^2) and comprised 86% of the total biomass of organisms in the area. At another nearby area the living biomass of *N. lenticularis* averaged only 5.7 g m^{-2} but still comprised 81% of the total faunal biomass (Helen Neil, NIWA, unpublished data).

3.2.3 Diagnostics

Brachiopods occur in areas of hard substrates unlikely to be successfully sampled using box cores, multicores or grabs. However, a brachiopod bed can be considered to be present if one or more specimens of any species occur in successive samples obtained using point sampling gear.

In images of the seabed taken at the standard (NIWA towed camera protocol) survey height of 2.0-2.5 m, brachiopods may be difficult to distinguish because of their small size and overgrowth of other organisms. Only at very high densities might beds of brachiopods be readily identified. For this reason standard sea floor imaging should not be used to determine the occurrence of brachiopod beds, in particular their potential absence.

Rock dredges and epibenthic sleds deployed to obtain geological and biological samples from areas of hard bottom will generally retain brachiopods, if present, attached to the exposed rock or shell surfaces. If the catch rate equals or exceeds 1 or more live brachiopods per m^2 of seabed sampled by mobile sampling gear (see above) then a brachiopod bed can be considered to be present (Table 3-2).

Secondary indicators of localities where brachiopods might occur are areas of hard bottom, free of fine sediment, in locations of high water movement.

3.2.4 References

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3.3 Bryozoan beds or thickets

3.3.1 Description

Bryozoans are a phylum of suspension feeding organisms, most of which are colonial, benthic or epibiotic on algae, seagrass, and animals. The sub-millimetre sized individuals that comprise a colony are called zooids, and structural properties of the zooid exoskeleton enable colonies to attain various growth forms. Colony form varies between and within species, although growth forms characterize particular species. Growth forms range from encrusting uni- and multi-laminar colonies, to branches of radially arranged zooids, to erect uni and bi-laminate colonies. Zooid size does not vary greatly, but colony size varies enormously, depending on environmental conditions and species characteristics. Some species attain sizes of 50–500 mm in three dimensions. In exceptional circumstances, colonies can grow much larger, 700–1000 mm across. Large bryozoans are known as 'frame-builders', and have been defined as colonies greater than 50 mm in three dimensions. Frame-building bryozoans can provide habitat for numerous other sessile organisms, including sponges, ascidians, and bivalve molluscs, as well as motile organisms such as ophiuroids, annelids, and decapods. Bryozoan habitat is fragile and vulnerable to natural and anthropogenic disturbance particularly bottom trawling and scallop dredging which has caused significant loss of this habitat in some areas (see review by Wood et al. 2012).

Where bryozoans form habitat they contribute significantly to the complexity of a locality. Bryozoans generate habitat complexity at a range of scales, from those relevant to micro-organisms, to mega-fauna. Single or multiple bryozoan species can contribute to bryozoan-generated habitat complexity at any one site, sometimes in association with other frame-building taxa (molluscs, sponges, corals, etc.). These associated fauna are an important characteristic of bryozoan habitat, and may facilitate the growth of the bryozoans, by providing a stable substratum on which they can grow, or by 'welding' branches together, enhancing the integrity of the structure. The surfaces bryozoans provide can be very large in comparison to the area of sea floor occupied by colonies, so the surface area of habitat in a given area increases. Observation suggests bryozoan thickets alter local physical processes such as current speed. Bryozoans also trap sediments within their structures and this is often associated with more diverse biological assemblages (Wood et al. 2012). Thus the presence of habitat-forming bryozoans can allow more or different species to persist, and bryozoan habitat is thought to be important for generating and maintaining the biodiversity of an area (Wood 2005).

Habitat-forming bryozoans are defined as those frame-building species that dominate (at least) square metres of sea floor. There are a variety of descriptive names for the habitat formed by bryozoans (e.g. reef, meadow, forest, bed), including the term 'thicket' which originates from the description of the habitat on the Otago shelf. The term used reflects the

characteristics (size and density) of the habitat, although there is no consistent application of the terms (see Wood et al. 2012).

3.3.2 Distribution

Habitat-forming bryozoans occur from ~59°N to 77°S, but do not occur frequently in the tropics, being found most commonly in temperate continental shelf environments (< 200 m), on stable substrata in places where water movement is relatively fast and consistent. Areas where they are particularly rich and/or abundant include Antarctica (Weddell, Lazarev and Ross Seas), the North Pacific around Japan, the northern Mediterranean and Adriatic, and along the southern edge of the North Sea, through the English Channel and around the United Kingdom.

Habitat-forming bryozoans are particularly abundant and diverse in New Zealand, where 27 species provide habitat over hundreds of square kilometres of sea floor. Important habitat-forming bryozoan species in New Zealand waters include *Cinctipora elegans, Celleporaria agglutinans,* and *Hippomenella vellicata* (Wood et al. 2012).

Bryozoan reefs in Foveaux Strait have attained heights of 1 m, and ranged in size from 4–40 m long and 3–6 m wide, and have been estimated to have covered an area of >800 km^2 prior to damage from oyster dredging (Cranfield et al. 1999, Cranfield et al. 2003). At Separation Point (Tasman Bay) a bed of bryozoan colonies form isolated mounds up to 0.5 m high and can cover up to 50% of a 55 km^2 area (a remnant of a bed that covered an area of 300 km^2 prior to fishing damage) (Grange et al. 2003). On the Otago shelf bryozoan thickets of small groups of colonies reaching 15 cm height occur at a mean cover of 4% across an area of ~500 km^2 (Figure 3-4), with higher densities in the middle of the habitat (up to 56 % cover) at depths of 80-90 m (Batson 2000, Batson and Probert 2000, Jones 2006). While one frame-building species can dominate the reef, bed, or thicket, often multiple species of bryozoan contribute to habitat formation.

Figure 3-4: Bryozoan thicket (dominated by *Cinctipora elegans*) on the Otago Shelf (image; Emma Jones).

3.3.3 Diagnostics

Bryozoan thickets (here the term thicket is used synonymously with the terms bed, reef, meadow, etc.) can be deemed to exist when colonies of large frame-building bryozoan species (> 50 mm in three dimensions) are thinly scattered on the seabed (> 4% mean cover) over relatively large areas (10s – 100s km^2), or dominate the seabed (>50% cover at the scale of m^2) over smaller areas (10-100 m^2). Thickets can be identified by using direct sampling or, ideally, by imaging the seabed.

Obtaining video or photographs of the seabed allows bryozoan thickets to be detected without causing any damage to these sensitive habitats. Images taken using a drop-camera, towed-camera, Remotely Operated Vehicle (ROV) or an Autonomous Underwater Vehicle (AUV) within 3 m of the seabed can be used to identify live and intact colonies of large frame-building bryozoan species that occur at sufficient density to be deemed bryozoan-formed habitat (see definition below). Ideally a means to determine the size of the colonies should be visible in the image (e.g. scale bar, trigger weight, laser points). The presence of more than one habitat-forming bryozoan species can be expected to be imaged, as well as other large suspension-feeding organisms such as sponges and ascidians. Multiple imaging transects (of a km or more) across a study area can be used to determine the spatial extent of the habitat formed by the bryozoans.

Samples of bryozoans taken using direct sampling gear (e.g. box-corers, grabs, sleds, dredges, beam trawls) can be examined to determine if they contain frame-building bryozoan species that are known to occur in sufficient densities to form habitat. Samples taken by box-corers and grabs make it possible to determine the densities of the colonies. Towed gear such as dredges collect an integrated sample over larger (often unknown) areas from which it is difficult to obtain robust estimates of colony density, and which often destroy colony integrity making reliable size measurements problematic. The presence of more than one habitat-forming bryozoan species can be expected to be detected by sampling, as well as other large suspension-feeding organisms such as sponges and ascidians. Multiple samples by box core and grabs taken over the study area can be used to determine the spatial extent of the habitat formed by the bryozoans. Multiple samples using dredges, sledges and beam trawls should be avoided.

Using small box-corers or grabs will provide discrete samples that allow for the detection of bryozoan thickets while causing limited damage to the habitat. Towed sampling gear such as dredges and sleds, while also suitable for the initial detection of habitat-forming bryozoan species, will likely cause significant habitat damage if sampling is repeated in a limited spatial area or frequently across a wider extent. If towed gear sampling reveals the presence of one or more colonies of habitat-forming bryozoan species per m^2 of seabed sampled, this is sufficient to indicate the possible presence of a bryozoan thicket (Table 3-2). Thereafter the extent of a thicket should be determined either by multiple point sampling with a relatively small box-corer or grab, or ideally by seabed imaging techniques.

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3.4 Calcareous tube worm thickets or mounds

3.4.1 Description

New Zealand has a number of tube worm species in the family Serpulidae that secrete tubes of calcium carbonate. They occur from the intertidal to abyssal depths but are most common in coastal waters. Gregarious settlement in some species and subsequent growth of intertwined calcareous tubes allows mounds or patch reefs to develop. The best described mounds are built by *Galeolaria hystrix*, endemic to southern Australia and New Zealand (Day and Hutchings 1979), and this species will serve as an example for calcareous tube worm mounds generally (Figure 3-5).

G. hystrix can form three-dimensional mounds more than a metre high and several metres in diameter. As with most other biogenic species, densities range from scattered individuals, through to a dense mosaic of three-dimensional mounds over the seabed (Morrison et al. in revision).

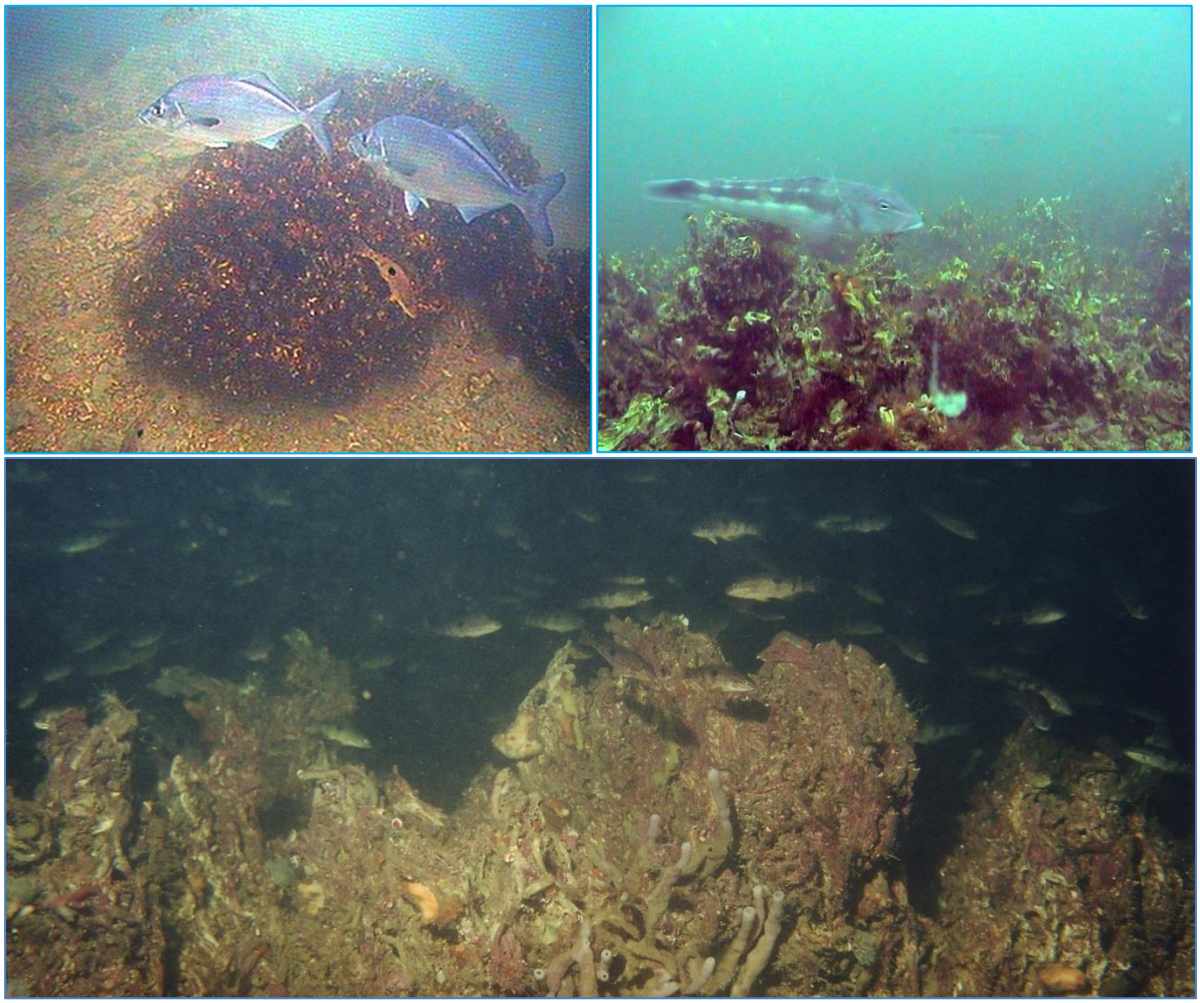

Figure 3-5: *Galeolaria hystrix* mounds. a) discrete mounds in Port Underwood, with associated blue moki (*Latridopsis ciliaris*) and spotties (*N. celidotus*), b) continuous *G. hystrix* mounds at Perano Shoal, Port Underwood, with adult blue cod (Source: R. Davidson, Davidson Consulting Ltd), c) top of *G. hystrix* mound at Big Glory Bay, Paterson Inlet, with sponges, ascidians, and a school of spotties, (Source: A. Smith, University of Otago).

3.4.2 Distribution

In New Zealand the range of *G. hystrix* extends from the Taranaki Coast down to Stewart Island (Morton and Miller 1973, Hare 1992, Smith et al. 2005, Davidson et al. 2010). Mounds have been found at two shallow water sheltered locations in New Zealand: at depths of 6-30 m in Port Underwood, Marlborough Sounds (Davidson et al. 2010); and at depths of 9-16 m in Big Glory Bay, Stewart Island (Smith et al. 2005) but it is possible mounds may also occur in deeper water in suitable conditions.

In the Marlborough Sounds, Davidson et al. (2010) described tubeworm mounds dominated by G. *hystrix* as being widespread in sheltered areas, but most often encountered in the form of individual tubes attached to hard substrates. The density of three-dimensional mounds was described as "*usually sparse or occasional*" at most locations where they occurred, but at some locations they became "*relatively common or abundant*", covering up to 100% of the seabed (Figure 3-5a, b). Mounds occurred on both soft and hard seabed, but appeared to need some hard structure on which to initially establish; including dead shell in the case of soft sediment systems. On-going gregarious settlement by larvae is enhanced by chemical

and physical cues provided by the presence of live adult worms (Brougham 1984; Kupriyanova et al. 2001). At three locations in Port Underwood high densities of mounds were found by Davidson et al. (2010). At Perano Shoal, mounds extended from 6 to 30 m depth, covering an area of 3.8 ha. Associated with these mounds were a range of other organisms, including “Christmas tree” polychaete worms (*Spirobranchus latiscapus*), burrowing anemones (*Cerianthus* sp.), octopus, blue cod and tarakihi. The other two Port Underwood tubeworm mound sites were both associated with headlands on the eastern shore-line, with greater current speeds than the adjacent bays. These sites were largely composed of cobbles and bedrock, along with some adjacent soft sediment areas. Mounds at the ‘Knobbies’ site were especially large in size, and occurred in water depths of 3–12 m depth, covering 34,000 m^2; while a smaller bed at Whataroa Point covered a further 9,000 m^2 in 3–14 m water depth (Davidson et al. 2010)

Further south, *G. hystrix* mounds have also found in Big Glory Bay, Paterson Inlet, Stewart Island (Figure 3-5c) (Smith et al. 2005). There they occurred in water depths of 9–16 m, and were detectable by side-scan sonar. Using side-scan records, Smith et al. (2005) surveyed selected sites within Big Glory Bay using visual diver transects, and found 114 *G. hystrix* reefs (mounds) within a survey extent of 28,000 m^2. Reefs were patchy or clumped in their distribution, with an overall average reef density of 40 reefs per ha. Most reefs were 1–5 m in diameter, up to 1.5 m high, with live worm ‘occupancy’ rates of tubes of up to 65%. Sixty-four per cent of reefs were in a whole state and alive, with the remaining 36% broken or dead. One large (but dead) reef was almost 100 m in diameter. The habitats surrounding the reefs were a mixture of mud and red algal meadows. Radiometric dating of a basal specimen of reef carbonate carried out by Smith et al. (2005) showed it to be less than 50 years old.

3.4.3 Diagnostics

Calcareous tube worm mounds are likely to be rare in New Zealand’s EEZ but if encountered characteristically comprise many individuals. A mound can be considered to be present if in a single point sample using a box core, multicore, or grab (at a spatial scale of cm to m), two or more intertwined specimens of a species occur (Table 3-2). Towed sampling methods using dredges or beam trawls are likely to break apart the individual tubes. In these cases if calcareous tube worm species comprise 10% of the catch it can be considered that a thicket has been encountered. In seabed imaging calcareous tube worm mounds will be readily apparent as raised reef-like structures up to 1.5 m high and 1-100 m in diameter. They are likely to be encountered at relatively low densities (e.g. 40 per ha) thus the occurrence of a single mound is sufficient to indicate the presence of a thicket of calcareous tube worms.

Large tube worm mounds, >1 m high and >5 m in diameter, may be detectable in deep water using multibeam acoustic survey equipment.

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3.5 Chaetopteridae worm fields

3.5.1 Description

A number of tubeworm species reach sufficient sizes and/or densities to provide biogenic habitat for other species. Thickets or mounds 1–5 m in diameter and up to 1.5 m high built by numerous individual calcareous tube worms are described in the previous section. Overseas workers have shown that even ‘low-relief’ tube-worm beds can be correlated with increases in fish densities (e.g. Stoner et al. 2005). In New Zealand, virtually nothing is known about potential role of tube-worms in forming biogenic habitat for other species, although low relief worm tube meadows similar to those described by Stoner et al. (2005) are widespread in many areas (Morrison et al. in revision). One species forming such meadows is *Phyllochaetopterus socialis;* known as ‘wire-weed’ or ‘tarakihi weed’ to east coast South Island commercial fishers. It lives in a thin wiry tube some 8–10 cm in length protruding from soft sediments on the seabed and ranges from isolated individuals within mixed epifaunal assemblages, through to extensive dense mono-specific meadows at the tens of kilometres scale.

3.5.2 Distribution

P. socialis is a cosmopolitan species occurring in coastal and shelf waters off Australia, Europe, and eastern North America, as well as New Zealand. To date fields or beds of this species are best known from the east coast of the South Island though they may also occur around the North Island.

On the continental shelf off Oamaru, Batham (1969) described "*a vast meadow of so-called tarakihi weed*" (55–88 m water depth), known locally as the Hay Paddock, consisting of *P. socialis*. This was associated with a muddy-sand and broken bryozoan bottom, with numerous other species noted to be present. The on-going existence of the Hay Paddock was confirmed through its identification by several independent fishers during local ecological knowledge (LEK) interviews, followed by targeted sampling in 2011 (Morrison et al. in revision). Underwater imagery showed a seabed with an extensive low relief cover of sponge species (mainly finger forms) and *P. socialis* (Figure 3-6a), along with associated species, including a number of sea slug species, starfish, large wandering anemones, and sea cucumbers. Samples collected by beam trawl suggested that the sponges may be growing over *P. socialis* tubes, which may act as surfaces on which sponge can recruit and grow. The Hay Paddock extends over a putative >140 km^2, with an approximately 7 km^2 block being multi-beamed and sampled by Morrison et al. (in revision)

Sampling by Morrison et al. (in revision) off North Canterbury revealed extensive fields of *P. socialis* in 70–110 m water depth (Figure 3-6b), with c. 90 km^2 of this habitat occurring within the multibeam sampling region (Figure 3-7). The edges of this habitat continued beyond the sampling extent to the north and west. Epifaunal species associated with *P. socialis* included at least 12 species of ascidians, as well as sea cumbers, starfish, spiny sea dragons and relatively large numbers of juvenile sea perch. To the south of this meadow, sampling revealed a landscape mosaic of smaller discrete *P. socialis* patches (metres scale), within a background of bare muddy sand seabed. These small patches appeared to be associated with pronounced epifaunal diversity, especially of ascidians and sponges (Figure 3-6c). Further inshore (50–70 m depth) only small areas of wire-weed were found, with the occasional patches encountered appearing to be of lower quality (shorter and smaller tubes), and to be associated with muddier sediments.

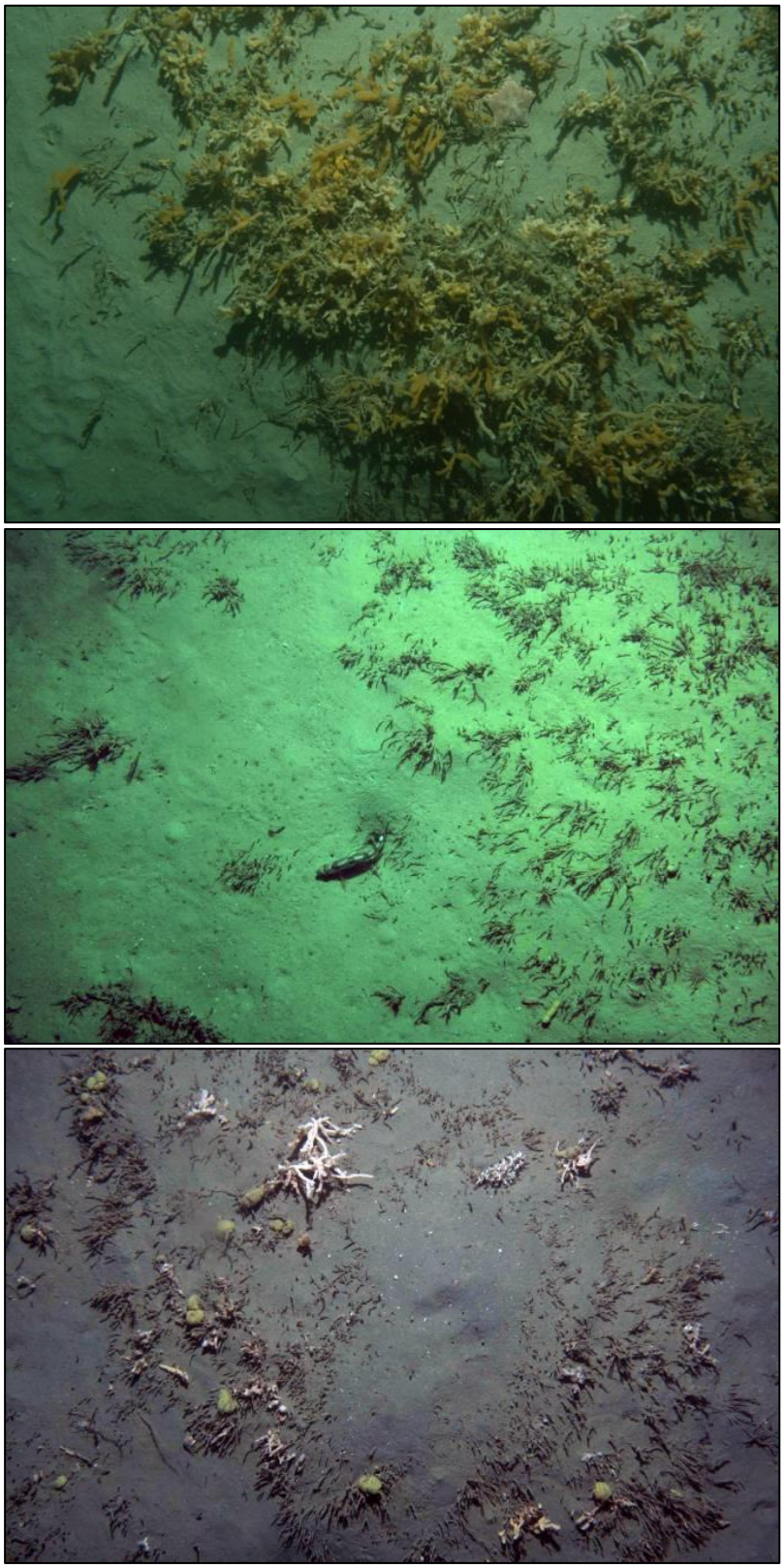

Figure 3-6: Chaetopteridae worm fields. a) the Hay Paddock, with *Phyllochaetopterus. socialis* and substantial sponge assemblage; b) *P. socialis* ('wireweed') meadow off North Canterbury, with sleeping tarakihi ; c) high epifaunal diversity associated with a small *P. socialis* patch. Images from Morrison et al. (in revision).

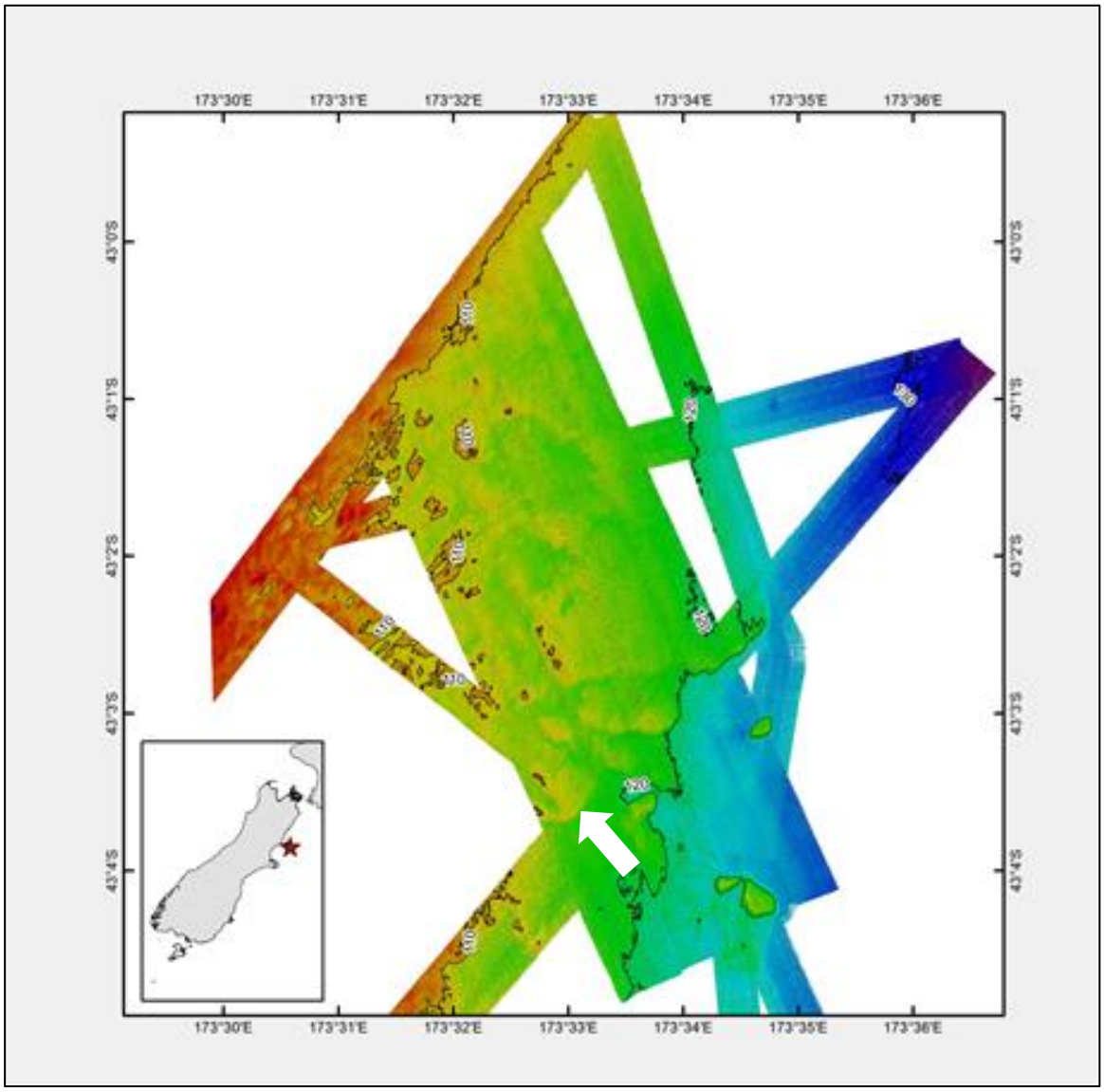

Figure 3-7: Multi-beam image of *P. socialis* field off North Canterbury. Seabed bed-forms, shown as variations in depth, are thought to be the result of *P. socialis* trapping sediment and forming mounds. The arrow indicates the edge of a worm field. (Image from Morrison et al. in revision).

3.5.3 Diagnostics

Fields of this species occur when the worm tubes and associated epifaunal species occupy 25% or more of the visual field in underwater imagery over areas of >500 m^2, or contribute 25% or more by weight or volume to the catch obtained by towed sample gear, or occur in two successive samples collected by point sampling gear (Table 3-2). Tube worm beds may form a contiguous cover or a mosaic of higher density patches interspersed with areas of bare sediment.

A secondary indicator of the presence of chaetopteridae worm fields is the characteristic seabed bed forms evident in multibeam surveys showing low relief mounding (<0.5m) with well-defined outer edges (see Figure 3-7). In contrast, calcareous tube worm mounds are more discrete, typically 1–5 m in diameter and up to 1.5 m high (see section 3.4).

3.5.4 References

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3.6 Deep-sea hydrothermal vents

3.6.1 Description

Hydrothermal vents occur where cold seawater percolates down through the seabed, is heated through geothermal energy, becomes buoyant and rises to the seabed, dissolving metals and sulfides from the surrounding rocks. The temperature of the venting fluid can vary a great deal, often related to water depth (i.e. pressure); high temperature vents are those emitting fluids at temperatures ~200 - 500 °C, low temperature vents are typified by temperatures of ~40-100 °C, but can be as low as a few degrees above the ambient temperature of seawater. Venting can occur from point sources, chimneys (made from precipitated minerals) or cracks and fissures in the seabed, or percolate in a diffuse fashion through sands or muds (Figure 3-8). The former venting is usually characterised by higher fluid temperatures than the latter form of venting.

Hydrothermal vents provide a habitat for unique communities of organisms dependent on the sulfide-rich vent fluids that support chemosynthetic bacteria at the base of the food web. These vent specialist communities include organisms that rely on a symbiotic relationship with the chemosynthetic bacteria and can only survive in close proximity to vent fluid emissions. For example, the tubeworm *Riftia pachyptila* has no mouth or gut and obtains its energy from the endosymbiotic bacteria housed within a specialised sack-like organ, the trophosome. Other vent specialist species do not rely exclusively on a relationship with endo or epi-symbionts, but are also able to obtain some sustenance independently by suspension or deposit feeding – for example, species of mussel, stalked-barnacles and shrimp. Some species found only at hydrothermal vents do not appear to have a symbiotic relationship with chemosynthetic bacteria, but instead are tied to the type and abundance of food available at the vent sites. For example, species of anemones may feed (like the mussels and barnacles sometime do) on aggregated particles of free-living chemosynthetic bacteria in the water, while species of predatory or scavenging seastars, snails and crabs may feed upon sessile fauna like vent mussels or mobile fauna such as vent shrimps. Vent specialists can only exist in close proximity to the active venting, and this vent community is surrounded by a distinct non-vent community at the periphery of vent site. This ‘background’ community is comprised of organisms found elsewhere in the region, but often at greater densities. This ‘halo’ effect is thought to occur through enhanced food supply, with tissue stable isotope values

indicating the contribution of a chemosynthetic food source to halo fauna diet (Erickson et al., 2009). Hydrothermal vent communities typically have high biomass and low diversity compared to the background communities (Van Dover 2000). Despite relatively low diversity, there have been more than 500 new species described from hydrothermal vents, with more expected to be described as more vent fields are discovered (Desbruyéres et al. 2006).

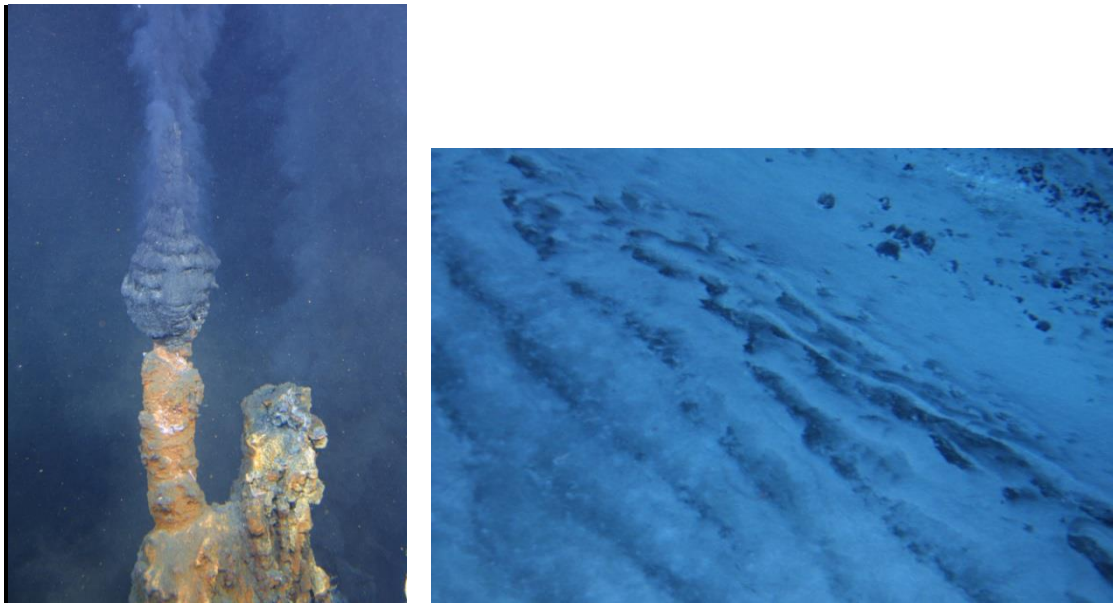

Figure 3-8: Brothers Seamount, Kermadec volcanic arc. (left panel) High temperature/point source (a "black smoker" at 1600 m), and (right panel) low temperature/diffuse hydrothermal vent habitats at 1300 m (images JAMSTEC/GNS/NIWA).

The fauna of hydrothermal vents in New Zealand waters were first discovered in 1987 on the shelf (Kamenev et al. 1993) and on deepwater seamounts in 1998 (Wright et al. 1999). There are as yet no formal descriptions of the dominant species found at shallow water vents (a small tubeworm, anemone, sponge and burrowing shrimp). The first formal descriptions of the dominant species at deepwater vents began in 2000, with the stalked-barnacle *Vulcanolepis osheai* (Buckeridge 2000). Other dominant or characteristic invertebrate species of deepwater vents include the mussels *Gigantidas gladius*, *Vulcanidas insolatus* (Cosel and Marshall 2003, Cosel and Marshall 2010), shrimp *Alvinocaris niwa, A. longirostris, A. alexander, Lebbeus wera, Nautilocaris saintlaurentae (*Webber 2004, Ahyong 2009), crabs *Gandalfus puia*, *Paralomis hirtella* (McLay 2006, Dawson 2008), and a large tubeworm *Lamellibrachia juni* (Muira and Kojima 2006). Two species of fish have also been recorded exclusively from hydrothermal vents in the region, *Pyrolycus moelleri* and *Symphurus thermophilus* (Anderson 2006, Munroe and Hashimoto 2008). Background fauna of New Zealand hydrothermal vents include species of coral, sponge, squat lobster, brittle-stars, sea-stars, and gastropods. While a number of the dominant vent and background species of hydrothermal vent sites in New Zealand waters have been identified, and it is possible to recognise broadly different vent communities (Figure 3-9), descriptions of whole communities are still poorly resolved (Clark and O'Shea 2001, Rowden et al. 2003, Beaumont et al. 2012).

Seabed communities found at hydrothermal vents are considered to be sensitive to physical disturbance by human activities such as fishing and mining, as well as scientific sampling.

Despite the recognition that vent species are adapted to periodic natural disturbance - hydrothermal vents are ephemeral habitats, with venting being periodically 'switched off' by changes in geological or geo-thermal processes or being buried by volcanic eruptions – levels of endemism exhibited by vent communities suggest impacts to these habitats may lead to significant effects, including species extinction (Van Dover 2011). Some vent species in New Zealand waters are recognised by the national Threat Classification System, including *Vulcanolepis osheai* which is considered among the top ten species at risk of extinction ('nationally critical') (Freeman 2010).

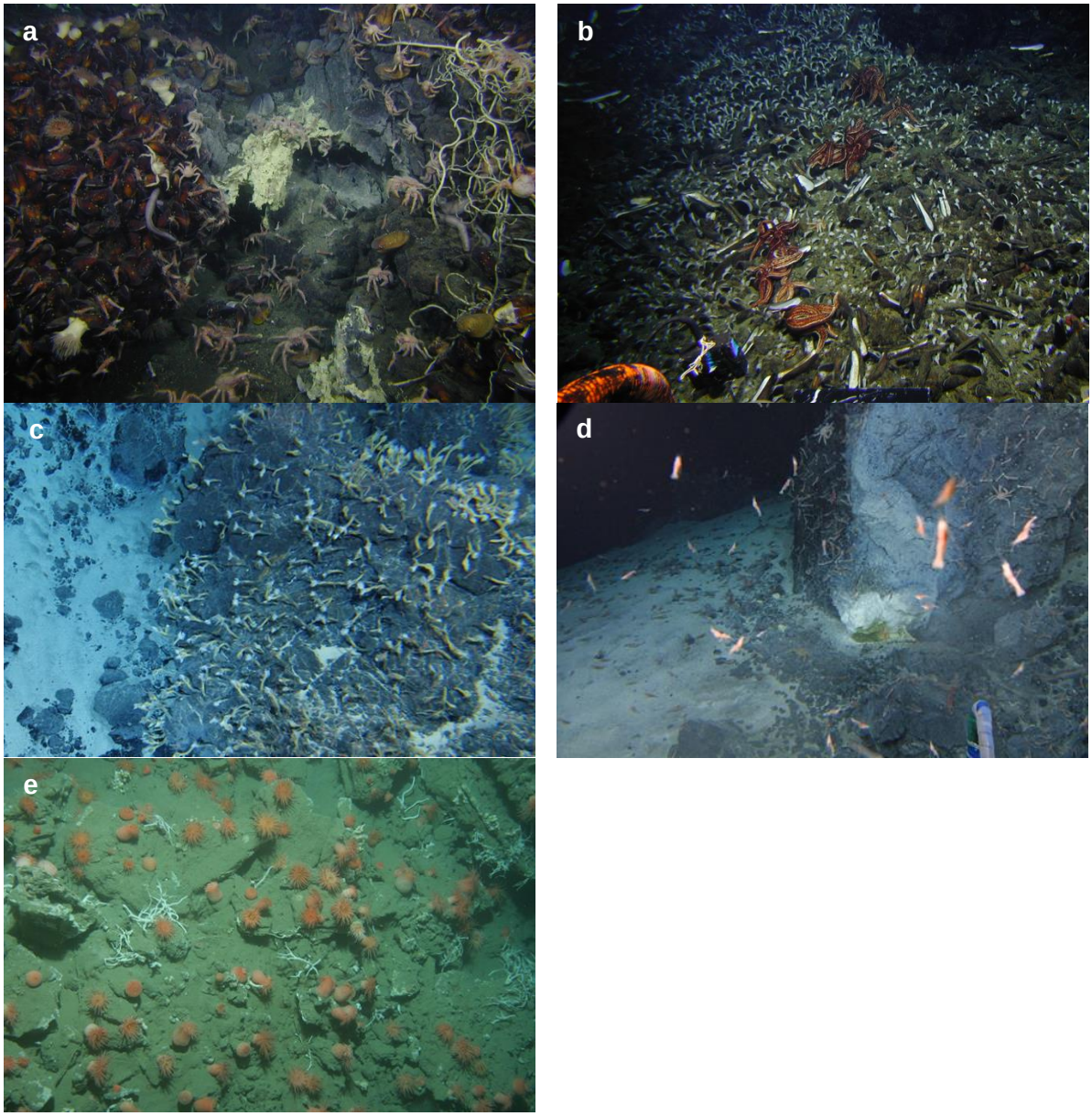

Figure 3-9: Hydrothermal vents communities in New Zealand waters. Vents dominated by (a) the mussel *Vulcanidas insolatus* and the tubeworm *Lamellibrachia juni* (Monowai Seamount, 1150 m), (b) the mussel *Gigantidas gladius* (Rumble V Seamount, 500 m), (c) the stalked barnacle *Vulcanolepis osheai* (Brothers Seamount, 1300 m), (d) unidentifiable vent shrimps (Brothers Seamount, 1300 m), (d) unidentified anemones and sponges (shallow water Calypso vent field, 200 m) (images from NIWA, GNS, JAMSTEC).

3.6.2 Distribution

The global distribution of hydrothermal vents is related to the distribution of the plate boundaries, and vents have been found to support chemosynthetic-based communities at depths ranging from 0 to ~5000 m (Tarasov et al. 2005, Connelly et al. 2011). In New Zealand waters, hydrothermal venting is associated with the subduction zone of the Pacific plate under the Australian plate to the north of New Zealand (Figure 3-10). The composition of the communities present at a hydrothermal vent site is influenced by the venting activity, with different species associated with high and low temperature venting, and distance away from the source of venting (see review by Van Dover et al. 2000). Species composition is also influenced by evolutionary and geographic factors, and at least 11 biogeographic hydrothermal vent faunal provinces have been identified. The vent fauna of New Zealand waters represent a single biogeographic province (Rogers et al. 2012).

Vents and chemosynthetic-based communities have been found in shallow shelf waters of the Bay of Plenty (8-200 m, Kamenev et al. 1993, Stoffers et al. 1999) and in deeper waters on the seamounts of the Kermadec Volcanic arc (to ~1800 m, Clark and O'Shea 2001, Rowden et al. 2003, Beaumont et al. 2012). More than one hydrothermal vent can occur on a seamount, and their characteristics vary depending upon the depth that they are located (Beaumont et al. 2013, Leybourne et al. 2013). Hydrothermal vent sites are typically small, the communities associated with source point venting can be constrained within areas of <20 m^2 (Beaumont et al. 2012). However, diffuse venting sites can support communities that extend over linear distances of 220 m (Rowden et al. 2003), and multiple single source point vents can constitute a 'vent field' over areas >1 km^2 (Kamenev et al. 1993, Stoffers et al. 1999). Even though considerable effort has been expended in detecting hydrothermal venting activity on the Kermadec volcanic arc (> 20 sites have been identified to date; de Ronde et al. 2001, de Ronde et al. 2007), given the relatively small size of individual hydrothermal vent sites, it is likely that there are more vent habitats and their communities to be discovered in New Zealand waters.

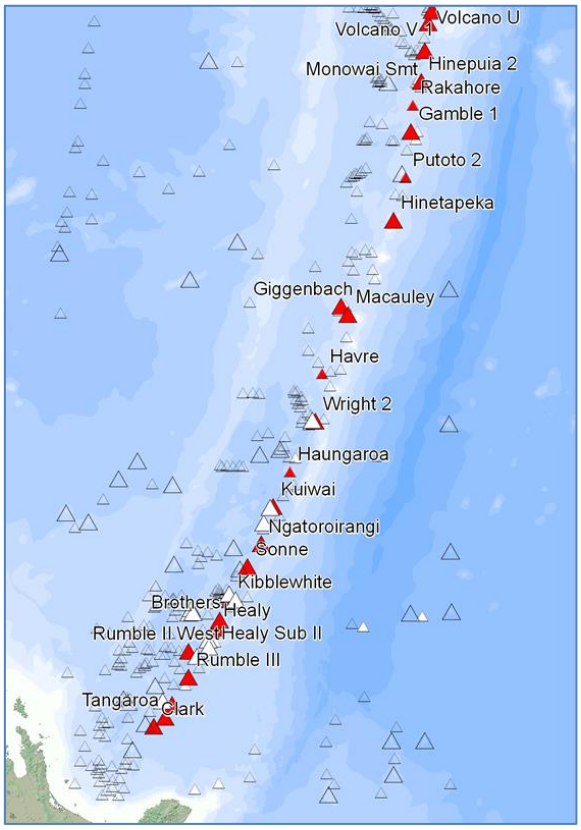

Figure 3-10: Map showing the distribution of seamounts (triangles) along the Kermadec Volcanic Arc known to have hydrothermal vents (red triangles with names) (NIWA).

3.6.3 Diagnostics

The general locality of hydrothermal vents can be detected by a systematic survey that collects hydrographic, optical, and chemical data using water profiling systems and discrete water sampling in areas suspected to be hydrothermally active (e.g., de Ronde et al. 2001). The results of such surveys can be used to guide further surveys using photographic and direct sampling techniques to identify the sites where chemosynthetic-based vent communities exist. Ideally, in order avoid damage to these communities, drop/towed cameras, crewed submersibles, Remotely Operated Vehicles (ROVs) or Autonomous Underwater Vehicles (AUVs) should be used to collect video or photographic samples rather than towed sleds or dredges (which should not be used further once a vent community has been detected by these sampling methods). Box-corers or grabs are unlikely to prove suitable techniques for sampling what is predominantly a hard substrate habitat.

Any occurrence of live specimens of known vent species is confirmation of an active hydrothermal vent site, whether these specimens are imaged or sampled directly (Table 3-2). Species currently known to be specific to hydrothermal vents in New Zealand waters include: *Vulcanolepis osheai, Ashinkailepas kermadecensis, Gigantidas gladius, Vulcanidas insolatus, Alvinocaris niwa, A. longirostris, A. alexander, Lebbeus wera, Nautilocaris saintlaurentae, Gandalfus puia, Xenograpsus ngatama, Paralomis hirtella, Bathyaustriella thionipta, Siboglinum* sp.*, Oasisia fujikurai, Lamellibrachia juni, Sclerasterias eructans, Parachnoidea rowdeni, Pyrolycus moelleri,* and *Symphurus thermophiles*. In seabed

photographs and video, other characteristic indicators of hydrothermal vents include: patches of white bacterial mats and yellow sulphide minerals on sediments or rocks, chimney structures and cracks and fissures emitting fluids.

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3.7 Macro-algal beds

3.7.1 Description

Beds of macro-algae occur on hard rocky substrates within the photic zone to depths of about 200 m. Macro-algae range from small foliose brown, red, and green algae (members of the Ochrophyta, Rhodophyta and Chlorophyta Phyla respectively, see Gordon 2012), to large brown algae or kelp. Kelp beds are recognised worldwide as key contributors to reef ecosystems through the energy captured via photosynthesis, the provision of highly structured three dimensional habitats critical for other species, and also through the fixed carbon retained within, and exported from, kelp forests (e.g., Graham 2004). Although the major biogenic habitat structure is provided by large brown algae, the under-storey vegetation of red and green algae may also provide a significant proportion of biomass production, food and shelter for a range of herbivorous fish and invertebrates, as well as for filter feeding species consuming particulate and dissolved organic compounds from macro-algae (Choat and Ayling 1987, Bracken and Stachowicz 2006, Eriksson et al. 2006, Schiel and Lilley 2011). In off shore locations beds of macro-algae are likely to harbour distinctive and poorly described invertebrate faunas.

The term ‘kelp’ is used for two different groups of large brown algae in New Zealand – the true kelps or members of the Laminariales, and bull kelp or species of the genus *Durvillaea*, belonging to the Fucales. These two orders of brown algae have fundamentally different life histories.

The member of the Laminariales known to occur on offshore rocky outcrops in New Zealand’s EEZ is *Ecklonia radiata* (Figure 3-11). The importance of *Ecklonia radiata* to marine communities is well documented. Jones (1984, 1988) showed that reef fishes such as wrasses and monocanthids recruit, some exclusively, among the fronds of *E. radiata* and there feed solely on small invertebrates. Choat and Ayling (1987) showed that the presence of *Ecklonia* beds affects the character of the fish fauna throughout northern New Zealand. Sea urchins do not recruit or survive well as juveniles in *Ecklonia* beds (Andrew and Choat 1985). The ecology and physiology of *Ecklonia* has been well studied in north eastern New Zealand and in Fiordland but equivalent work is not available for other regions or for offshore reefs in the EEZ.

Another member of the Laminariales, *Lessonia variegate*, is also likely to occur on offshore rocky outcrops in New Zealand’s EEZ , although it has not yet been reported from these areas. Beds of *Lessonia variegata* are found subtidally on very exposed rocky reefs (Figure 3-12).

Five species of bull kelp occur in New Zealand waters, the most commonly occurring species being *Durvillaea antarctica* and *D. willana*. They are restricted to very shallow waters, and are unlikely to occur on non-emergent reefs in the EEZ.

Other brown alga known to occur below 30 m water depth and likely to occur on reefs in the EEZ include *Carpomitra costata* and *Halopteris sp.*

Figure 3-11:The deep-water form of *Ecklonia radiata* showing a single large blade arising from the stipe. Photo courtesy of Mark Morrison.

Figure 3-12:Two views of *Lessonia variegata* showing the range in colour and stipe length. Photos courtesy of S. Schiaparelli.

Some red and green macroalgae have been sampled from reefs to 100 m in the EEZ but they are not all yet formally identified and described and to date this flora has been poorly sampled. Species of red algae and green algae that have been identified from the NZ region in water over 30 m and up to 200 m deep, and thus are likely candidates to occur on reefs to these depths in the EEZ, include those listed in Table 1.

Table 3-1: Species of red and green algae that have been identified from the NZ region in water over 30 m and up to 200 m deep (W Nelson, NIWA, unpublished data).

Red algae	Green algae
Acrosymphyton firmum	*Caulerpa flexilis*
Adamsiella melchiori	*Caulerpa geminata*
Anotrichium crinitum	*Caulerpa 'sertularioides'*
Arthrocardia sp.	*Codium gracile*
Ballia callitricha	*Codium sp.*
Callophyllis ?	*Palmophyllum umbracola*
Corallina sp. with non-geniculate coralline epiphyte	*Umbraulva spp*.
Cryptonemia ?	
Echinothamnion hystrix	
Euptilota sp.	
Gracilaria truncata ?	
Griffithsia crassiuscula	
Grifithsia sp.	
Hymenena sp	
Laingia hookeri	
Lembergia allanii	
Lophurella hookeriana	
new genus Rhodymeniales	
non-geniculate coralline algae	
Peyssonnelia sp.	
Phacelocarpus labillardieri	
Phycodrys adamsiae	
Phycodrys novae-zelandiae	
Plocamium cirrhosum	
Plocamium sp.	
Rhodophyllis membranacea	
Rhodymenia hancockii	
Rhodymenia sp.	
Sporoglossum lophurellae	
*Strebloclad*ia *glomerulata*	
Vidalia colensoi	

3.7.2 Distribution

In New Zealand waters *Ecklonia radiata* is the ubiquitous kelp, found from the Three King Islands in the north to Stewart Island in the south (Adams 1994). *Ecklonia radiata* grows subtidally on rocky shores from moderate shelter through to exposed coasts and from the low intertidal zone to depths greater than 25 m (Schiel and Nelson 1990). In clear oceanic

waters such as occurs at Ranfurly Bank off East Cape, it has been observed to depths of 70 m (Mark Morrison, NIWA unpublished data).

Lessonia variegata is reported from around the North, South and Stewart Islands, although recent work using molecular markers suggests that this species has a much more restricted distribution, and is found only in the lower North Island and northern South Island in the vicinity of Cook Strait with several other species occurring further north and south (Martin and Zuccarello 2012).

Beds of small foliose red and green macro-algae as well as kelps potentially may occur anywhere in the EEZ and ECS where rocky reefs extend into the photic zone (to depths of 200 m depending on water clarty) Within the EEZ rocky reefs in the critical depth zone are very rare and thus beds of macro-algae are likely to be equally rare. Macro-algae have been recorded in the EEZ from the crest of the Mernoo Bank east of Banks Peninsula, from Ranfurly Bank off East Cape and from the shallow summit of at least one seamount on the Kermadec Ridge (Wendy Nelson, Mark Morrison NIWA unpublished data).

3.7.3 Diagnostics

The presence of rocky reefs within the upper 200 m of offshore waters anywhere in the EEZ is an indicator of the potential for beds of macro-algae to occur.

Detection of a single occurrence of any species of red, green or brown macro-algae is sufficient to indicate that this rare habitat has been encountered (Table 3-2).

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3.8 Methane or cold seeps

3.8.1 Description

Cold seeps occur where methane-rich fluids escape into the water column from underlying sediments. Active seep sites are usually associated with areas where gas hydrates, a form of clathrate in which methane is frozen within a matrix of water ice, occur within the sediments. Gas hydrates form under specific pressure-temperature conditions, the gas hydrate stability zone, which typically occur within the upper 500 m of sediments beneath the seabed and in water depths of at least 500 m. Free gas and methane-rich pore fluids are trapped beneath the gas hydrate stability zone which acts as a "seal" (Pecher and Henrys 2003). Rupture of the gas hydrate stability zone, by for example geological faulting, uplift, or seabed slumps may result in fluids and free gas reaching the seabed. If this release is persistent, cold seeps develop and are colonised by distinctive communities of benthic fauna.

Cold seeps typically support communities dominated by chemoautotrophic benthic organisms which depend on symbioses with chemosynthetic bacteria that generate energy from reduced compounds, methane, and hydrogen sulphide, in the fluids emerging from the sediments (see also section 3.6). Seep fauna typically include large tube worms in the polychaete family Siboglinidae, vesicomyid clams, and bathymodiolin mussels (Baco et al. 2010). Other seep-associated taxa may include siboglinid pogonophorans, thyasirid, solemyid and lucinid bivalves, trochid and buccinid gastropods, cladorhizid and hymedesmid sponges, bresiliid shrimp, amphipods, galathaeoid crustaceans, and polynoid, dorvilleid, hesionid, and ampharetid polychaetes (Levin, 2005).

Initial characterization of the faunal communities at methane seep sites along the Hikurangi Margin by Baco et al. (2010) showed that the dominant, megafaunal, symbiont-bearing taxa are siboglinid (tube) worms, vesicomyid clams, and bathymodiolin mussels. Community structure varies with particular sub-habitats within the seeps and population densities vary between sites. High population densities and low taxonomic diversity are typical characteristics for megafaunal taxa of cold seep communities globally.

Most seep sites studied on the Hikurangi Margin have extensive cover of carbonate precipitates forming large boulders, pavements, and crusts with megafaunal communities

dominated by *Lamellibrachia* sp. siboglinid tubeworms (Figure 3-13A), *Calyptogena* sp. vesicomyid clams (Figure 3-13C), bathymodiolin mussels (*Bathymodiolus* sp. and *Gigantidas* sp.), and sponges (*Pseudosuberites* sp. and *Stelletta* sp.) (Figure 3-13 B). Carbonate rock structures at older or relict sites may be colonised by cold-water corals and have extensive areas (up to 7 ha in area) of disarticulated vesicomyid clam shells. Common mobile megafauna include buccinid gastropods, and pagurid, lithodid, and brachyuran crabs. Soft-sediment seep habitats surround the carbonates and include fields of pogonophoran worms (three species of *Siboglinum*), solemyid clams (*Acharax clarifcata*), thalassinid shrimps (*Vulcanocallix* sp.), and ampharetid polychaetes (two undescribed genera) (Sommer et al. 2010). Core and grab samples indicate numerous additional undescribed species of peracarid crustaceans and polychaete worms. White bacterial mats are often present on soft sediments in and around seep sites (Figure 3-13D).

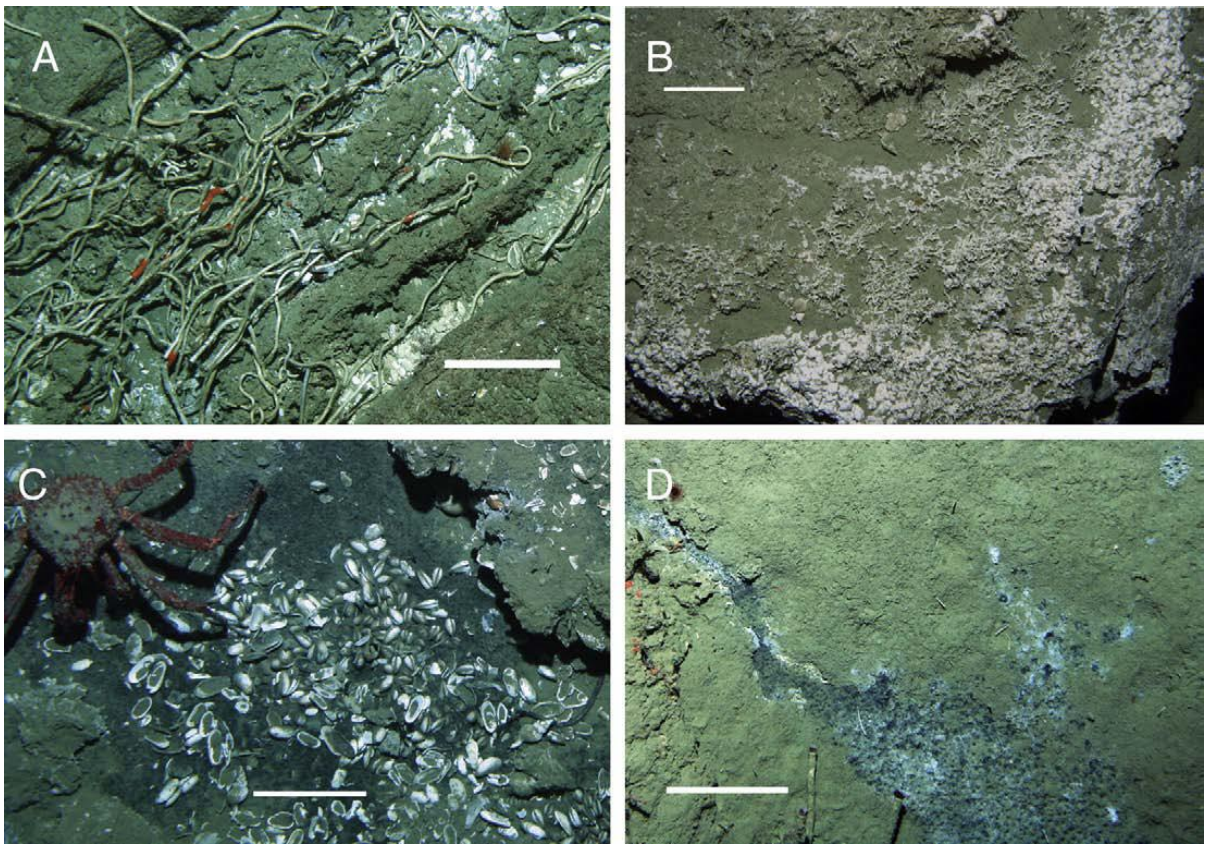

Figure 3-13:Representative cold-seep associated megafauna and microhabitats found at methane seeps on the New Zealand margin at depths of 770-1200 m. (A) *Lamellibrachia* sp. aggregation on carbonate platform, Hihi; (B) Sponge mat (*Pseudosuberites* sp.) covering carbonate rock, North Tower (C) Live vesicomyid (*Calyptogena* sp.) clams and dead shells in a seepage-darkened sediment patch, North Tower; (D) Bacterial mat on dark sulphide-rich sediment with pits made by ampharetid polychaetes, Hihi (from Baco et al. 2010). See Figure 3-14 for locations of named seep sites.

3.8.2 Distribution

Cold seep systems are now known to occur throughout the global ocean, including the Arctic and Antarctic (Sibuet and Olu 1998, German et al. 2011) and across a wide range of depths. In New Zealand, research cruises in 2006 and 2007 confirmed active and locally intense

methane seepage at many sites on the Hikurangi Margin along the east coast of the North Island, and that most of these sites support live communities of obligate seep-associated fauna. The widespread occurrence of relict seep sites, as indicated by accumulations of clam shells and extensive carbonate chemoherm structures, both offshore and on the adjacent land, indicate that seep activity has persisted over an extended period (Greinert et al. 2010) (see Figure 3-14). Clusters of active methane seeps have been confirmed within the five areas indicated in Figure 3-14 but it is highly likely that more such sites are yet to be discovered around New Zealand (Lewis and Marshall 1996).

At the species level, much of the seep-associated fauna from the Hikurangi Margin appears either to be new to science, or endemic to New Zealand seeps, suggesting the region may represent a new biogeographic province for cold-seep fauna (Baco et al. 2010). Some overlap at the species and genus level is indicated, however, between the sampled seep communities and the fauna of hydrothermal vents on the Kermadec Arc in the region.

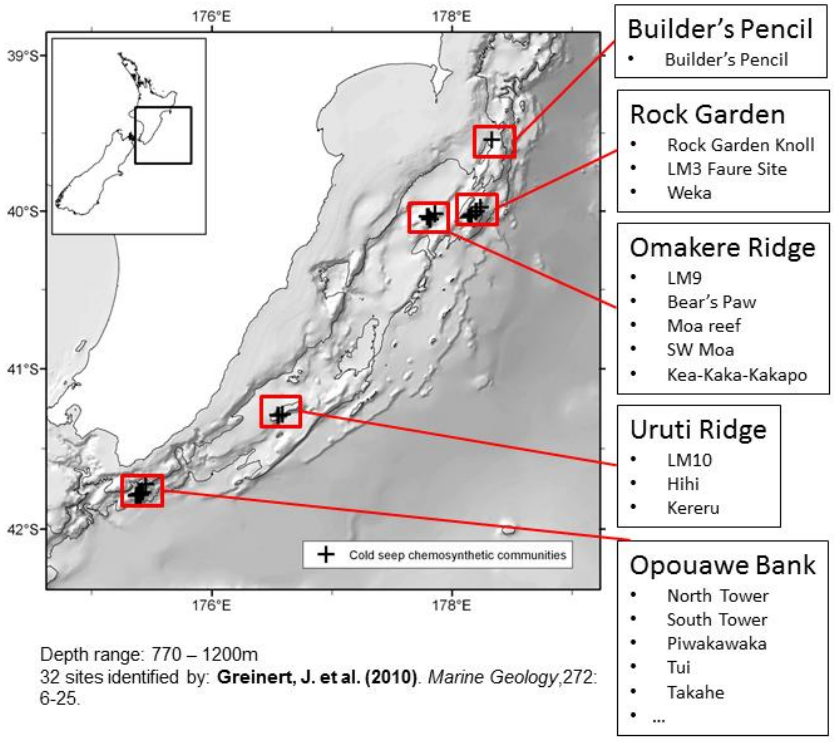

Figure 3-14:Cold seep sites on the Hikurangi Margin, North Island, New Zealand. At least 32 active seep sites have been located across five regions on the margin (labelled boxes), and live chemoautotrophic communities have been confirmed at 19 of these (principal sites names shown by region). For full details see Greinert et al. (2010) and references therein.

3.8.3 Diagnostics

Methane seeps can be identified by:

(1) Detection of characteristic water-column flares (e.g.,Figure 3-15) in single- or multi-beam echo-sounder traces caused by the phase difference between methane-rich fluids and sea-water (Greinert et al. 2010). Such flares are often the first indication of an active seep site but because fluid release at the seabed can be highly variable both temporally and spatially (Klaucke et al. 2010), their absence does not mean that seep sites are not present. Acoustic flares from active seeps can look very similar to marks generated by demersal fish aggregations and thus have frequently been targeted by deep sea trawl fishers. Indeed, many of the first discoveries of active seeps in New Zealand resulted from such activity (Lewis and Marshall 1996).

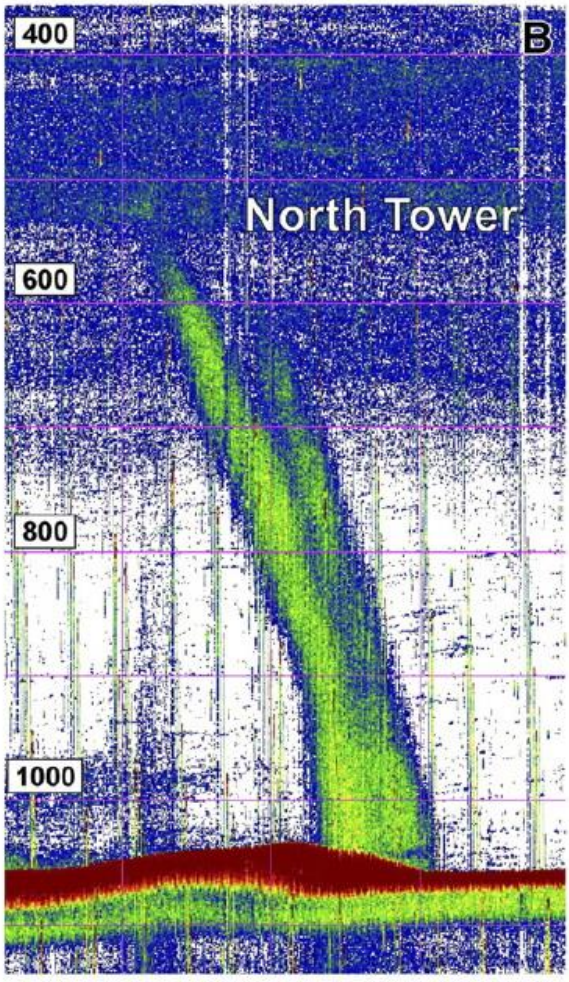

Figure 3-15:Single beam echo-sounder image of water-column flare above North Tower cold seep at Opouawe Bank (NIWA). The seabed is shown in red and the depth scale is in metres.

(2) Detection of distinctive chemoautotrophic fauna at the seabed. The large siboglinid tubeworm *Lamellibrachia* sp. and the vesicomyid clam *Calyptogena* sp. are known only from active seep sites in the New Zealand region. Any occurrence of live specimens of either of these species is confirmation of an active seep site (Table 3-2). Other commonly-occurring

seep-associated taxa include: mussels in the family Bathymodiolinae; solemyid clams (*Acharax clarificata*); *Stelletta* n. sp. and *Pseudosuberites* sp. sponges, and several smaller taxa, notably ampharetid, dorvilleid, and pogonophoran (*Siboglinum* sp.) polychaete worms. While all of these latter taxa are indicative of seep sites, some are also known to occur in other reducing habitats such as hydrothermal vents (bathymodiolin mussels), hypoxic sediments (solemyid clams), and whale falls (many polychaete taxa).

In seabed photographs and video (which are the preferred sampling methods through towed camera, ROVs or AUVs), other characteristic indicators of seep activity include: patches of dark, sulphide-rich, sediment; white bacterial mats on sediments or rocks, and patches of carbonate rock and *Calyptogena* sp. clam shells in otherwise soft-sediment areas.

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3.9 Rhodolith (maerl) beds

3.9.1 Description

Rhodoliths are free-living calcified red algae (Phylum Rhodophyta, see Gordon 2012) that occur in localised areas worldwide, forming structurally and functionally complex habitats (sometimes called maerl). The complex morphology of rhodoliths provides a very heterogeneous habitat. Rhodolith beds feature high benthic biodiversity supporting many rare and unusual species. The branching or rounded thalli collectively create a fragile, structured biogenic matrix over coarse or fine carbonate sediment (see Figure 3-16). Productive fisheries are often coincident with rhodolith beds and it is thought that the high level of functional diversity that they provide may be an important driver in maintaining productivity. The complex habitat structure also provides refugia for juvenile fish and settlement habitat for shellfish larvae (Steller et al. 2003, Nelson et al. 2012). Internationally rhodolith beds have been identified as critically important biodiversity hotspots, harbouring high diversity and abundance of marine animals and algae in comparison with surrounding habitats (Steller et al. 2003). Rhodolith beds have also been identified as important nursery areas for commercial species such as scallops, crabs, and fish, and are home to high densities of broodstock bivalves (Nelson 2009).

Figure 3-16:Examples of rhodoliths collected from the Kapiti region (NIWA).

Recent international studies show that these fragile and slow growing (0.05-2 mm/yr) algae are at risk from the impacts of a range of human activities including physical disruption

(trawling, dredging, anchoring) (Hall-Spencer and Moore 2000), reduction in water quality (offshore dumping) (e.g. Wilson et al. 2004, Riul et al. 2008), alterations to water movement (marine engineering), and aquaculture installations (shellfish rafts and lines, fish cages) (Hall-Spencer et al. 2003, 2006). The diversity and abundance of organisms supported by rhodolith beds significantly increase with complexity (branching density) and the space available (thallus volume) (Steller et al. 2003), and hence fragmentation will likely reduce these.

Like other calcified macroalgae, rhodoliths will be impacted by acidification of the oceans resulting from global climate change. Although the potential impacts are not yet fully understood, they are likely to be complex and variable between species (Doney et al. 2009, Hall-Spencer et al. 2008, Kuffner et al. 2008), and it is thought that sensitive reef-building species such as coralline algae may be pushed beyond their thresholds for growth and survival within the next few decades (Anthony et al. 2008). A recent study has shown that rhodoliths are profoundly adversely affected by acidification, and show a much greater impact than exhibited by other coralline algae or corals (Jokiel et al. 2008).

3.9.2 Distribution

Very little information exists about the location, extent or ecosystem functioning of rhodolith beds in New Zealand. They are known to occur in coastal localities at North Cape, Bay of Islands, Kapiti Island, Marlborough Sounds, and Foveaux Strait. It is likely they also occur in the EEZ at localities characterised by strong currents within the photic zone (to depths of 200 m depending on water clarity), particularly around the margins of reefs or elevated banks.

3.9.3 Diagnostics

Steller et al. (2003) indicated that if there was more than 10% cover of living coralline thalli in seabed images the area was considered to be inside a rhodolith bed. Detection of a single occurrence of any rhodolith species in a point or mobile sampling device is sufficient to indicate that this habitat has been encountered (Table 3-2).

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3.10 Sea pen field

3.10.1 Description

Sea pens are colonial marine cnidarians (the same phylum as corals, medusae, hydroids and myxozoans) in the order Pennatulacea. Sea pens occur on fine gravels, soft sand, mud or abyssal ooze, anchored in the sediment with a root-like bulbous peduncle and carrying the feeding polyps on a flexible erect stalk (Figure 3-17). This feature allows sea pens to inhabit extensive areas of the sea floor unlike many other erect filter feeding organism that need a hard substrate for settlement and attachment (Williams 2011).

To date 31 species of sea pens are known from New Zealand waters, although 19 remain to be formally described (Gordon 2009). Baillon et al. (2012) found fish larvae to be consistently associated with five species of sea pen on the Grand Banks off eastern Canada. Faunal associations with New Zealand sea pens remain to be described.

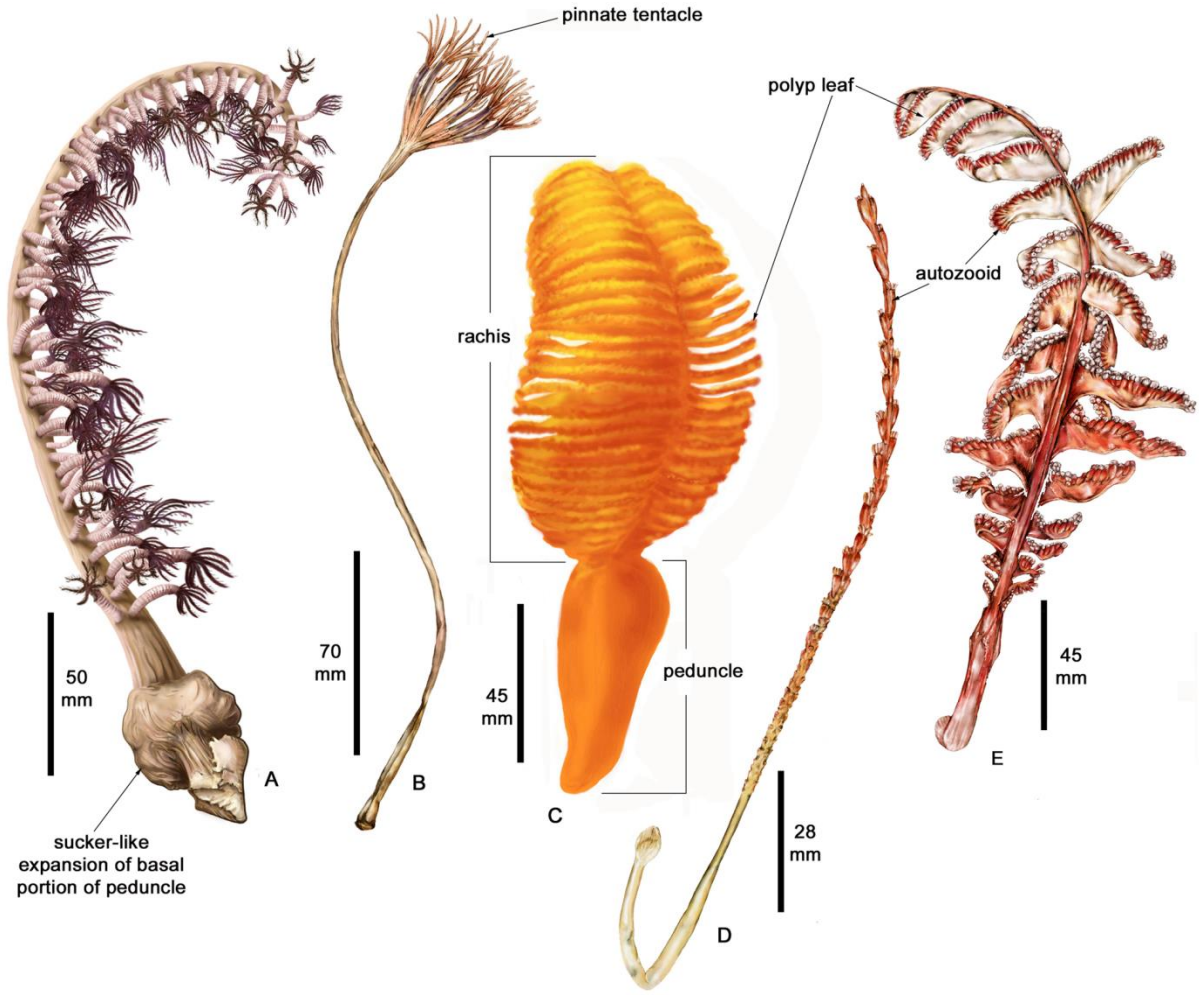

Figure 3-17: Diversity of morphological form in sea pens (From Williams 2011).

3.10.2 Distribution

Sea pens occur on soft sediments in deeper water of the continental shelf, slope, and abyssal plains where turbulence is unlikely to dislodge them and where there is a current to ensure a flow of plankton across their feeding polyps. A shallow water species *Pteroeides* sp. also occurs in Fiordland where Duncan (1998) found spatial variability in size frequency and density suggestive of spatially unpredictable and patchy recruitment. Mostly observed as isolated individuals, in a few places sea pens have been observed in densities up to 6 per m^2 (Figure 3-18) but this may reflect the small extent of exploration of New Zealand's EEZ. Langton et al. (1990) observed densities of *Pennatula aculeate* in the Gulf of Maine of up to 8 per m^2. Baker et al. (2012) found sea pen fields to cover large tracts of muddy sea floor over a 1000m depth range in canyons off Newfoundland, Canada.

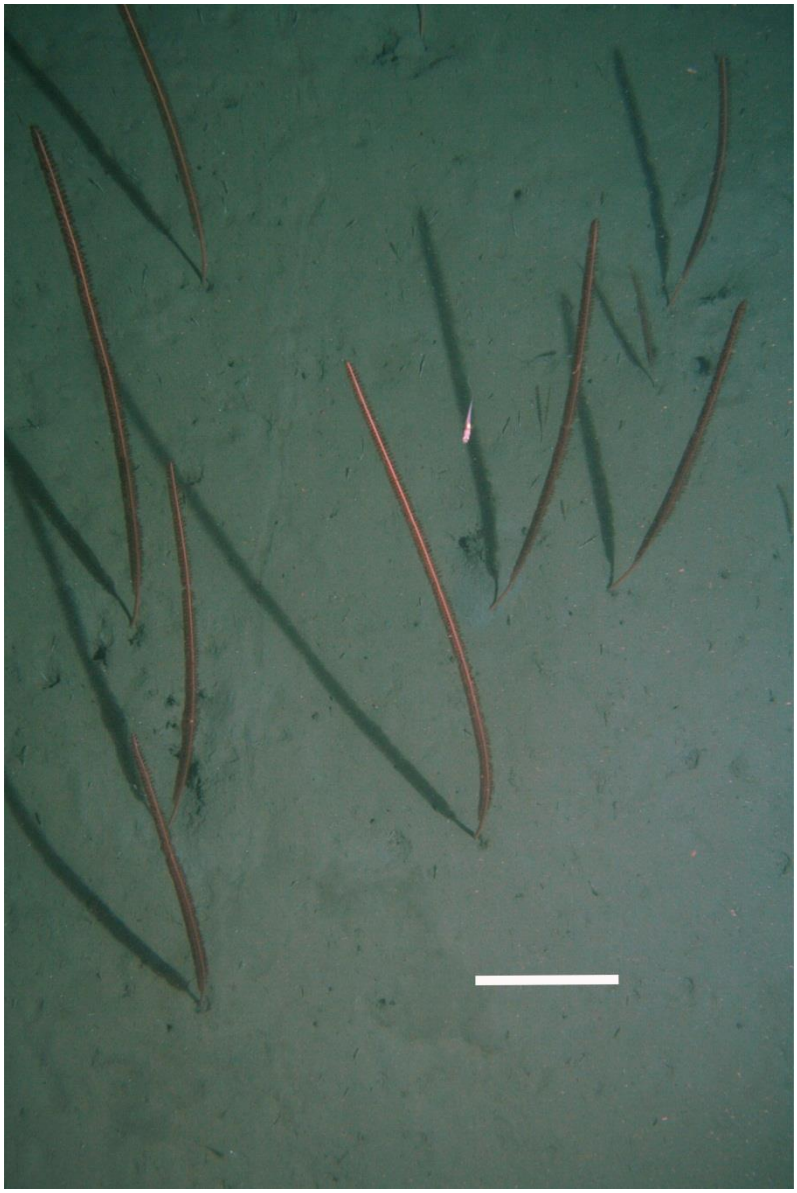

Figure 3-18:Field of sea pens (*Halipteris* sp.) at 560 m depth in Honeycomb Canyon off the Wairarapa coast. Note the flexing of the sea pens in the current and juvenile fish upper centre. Scale bar shows 20 cm. (NIWA, voyage TAN1004, station #56).

3.10.3 Diagnostics

Sea pens are usually encountered as sparse populations in video surveys and mobile gear sampling of the sea floor in New Zealand's EEZ. They are unlikely to be sampled using point sampling gear but if one or more specimens of any species of sea pen are found in two successive samples a sea pen field should be assumed to be present. The occurrence on average of 2 or more individuals per m^2 in seabed imaging surveys or surveys using towed gear is sufficient to indicate the presence of a sea pen field (Table 3-2).

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3.11 Sponge gardens

3.11.1 Description

Sponges are sedentary, filter-feeding metazoans that utilise a single layer of flagellated cells (choanocytes) to direct a water current through their bodies for the purposes of feeding and excretion (Bergquist 1978; Kelly et al. 2009) (Figure 3-19). Sponges are found predominantly in marine environments, but may also be found in freshwater rivers, lakes and ponds. On hard substrates sponges encrust the surface at the base of the body or by a restricted area, peduncle or stem. Those that occur in sand and gravel anchor themselves with fibrous root-like processes at the base of the sponge, a solid onion-like bulb, or attach directly to rubble in the soft sediment. Those that occur in abyssal muds frequently anchor themselves with tufts of very long simple or grapnel-like spicules (Kelly 2007a; Kelly et al. 2009).

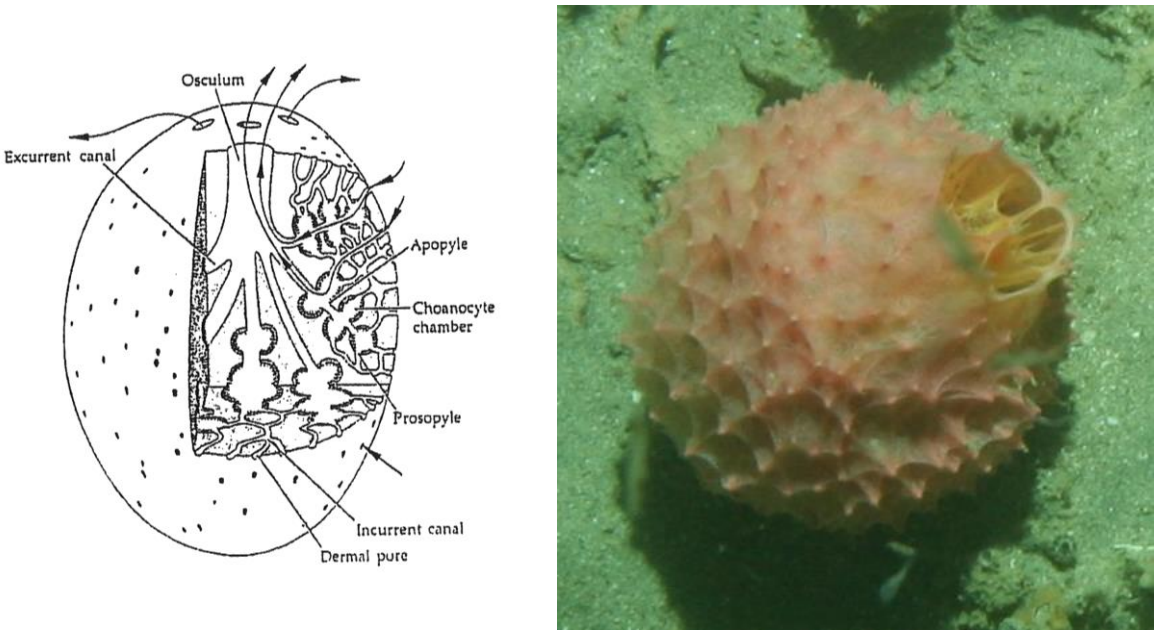

Figure 3-19:Sponge structure and functioning. Left: Model sponge showing aquiferous system with internal choanocyte cells and chambers, inhalant and exhalent canals (osculum) (after Bergquist 1978); Right: Spherical sponge *Tethya fastigata* Bergquist and Kelly-Borges, 1991 (right) showing general form and exhalent oscules at apex of body (Photo: NIWA).

There are four major types of sponges: the demosponges (Class Demospongiae), the glass sponges (Class Hexactinellida), the calcareous sponges (Class Calcarea), and the homoscleromorph sponges (Class Homoscleromorpha), the latter two classes being comparatively poorly represented in New Zealand. To date well over 500 sponge species have been formally described from New Zealand waters but there are many more known with new discoveries every year.

3.11.2 Distribution

Sponges are dominant marine invertebrates from the tropics to the poles in many subtidal environments including shallow coastal rocky reefs, seamounts, hydrothermal vent systems, and oceanic ridges. They are also common anchored in or detached as 'rollers' on shelf sediments, and down to abyssal and trench (hadal) depths of several kilometres. In New Zealand demosponges dominate the shelf and coastal faunas (1-250 m) whereas in deep-water environments glass sponges generally dominate. Some sponges in the Order Poecilosclerida, usually Family Cladorhizidae, have a carnivorous feeding regime. These tiny feather- or lollipop-like sponges lack the typical attributes of a poriferan aquiferous system (Vacelet and Boury-Esnault 1995; Kelly et al. 2009) and are found relatively commonly at trench (hadal) depths around New Zealand, and on seamounts (Kelly et al. 2009; Kelly and Vacelet 2011). Similarly, lithistid demosponges (rock sponges) are common on many seamounts and ocean ridges to the north and northeast of New Zealand (Kelly 2005; Kelly 2007b; Kelly et al. 2009).

At the regional level, certain areas in the New Zealand EEZ have been identified as 'hotspots', areas that are considered significant in terms of sponge biodiversity (species

diversity, richness, endemism, special phylogenetic groupings) (Kelly 2003; Kelly 2005). Kelly (2005) identified the northern New Zealand region that includes Three Kings, North Cape, Spirits Bay and offshore carbonate bryomol gravel banks (Pandora and Wanganella Banks) as the dominant New Zealand sponge biodiversity hotspot. Since 2005 numerous circum-New Zealand EEZ NIWA voyages have revealed much about the spatial distribution and biodiversity of sponges, particularly in areas that were previously poorly sampled such as the west coast of the North Island, the west and east coasts of the South Island, and Southern Ocean seamounts, plateaus and oceanic ridges.

Hotspot regions of high sponge biodiversity are often referred to in practise as 'sponge gardens', but sponge gardens are usually defined and recognised by their spatial characteristics. While a sponge garden is usually recognisable as it has high sponge density, it may also be characterised by morphological diversity (spatial 'biogenic' relief), the large size and abundance of sponge individuals, percentage cover, and the uniformity or mixed nature of the distribution of the species. Examples of known sponge gardens in the New Zealand EEZ include:

High species diversity, high morphological diversity, large individuals, high density, high percentage cover, mixed distribution, e.g. sites within:

- Spirits Bay rocky reef , 50–70 m (Figure 3-20A)
- Three Kings subtidal rocky reefs, 30–50 m

Medium species diversity, high morphological diversity, small individuals, medium density, medium percentage cover, mixed distribution, e.g. sites within:

- Outer Pearl and Anchorage, Port Pegasus, Stewart Island, 10–20 m (Figure 3-20B, C)
- Macquarie Ridge seamounts, 300-1600 m (Figure 3-20D)
- Thompson and Doubtful Sounds, Fiordland, 30–100 m
- Outer Bay of Islands, 50–150 m

Medium species diversity, medium to high morphological diversity, low to medium density, low percentage cover, non-uniform distribution, e.g. sites within:

- Leigh Marine Reserve, 20–50 m (Figure 3-20E)
- Chatham Rise Seamounts, 200–1200 m (Figure 3-20F)
- Cavalli Seamounts, 400–1000 m

Low species diversity, high morphological diversity, low to medium density, medium percentage cover, non-uniform, clumped distribution, e.g.

- Hay Paddock, North Canterbury biogenic wire-weed polychaete habitat, 80-120 m (Figure 3-20G)
- Thames Estuary, Hauraki Gulf biogenic horse mussel habitat, 20-35 m (Figure 3-20H)

- Otago Shelf biogenic bryozoan habitat, 30-300 m

Low species diversity, low morphological diversity, low to medium density, low percentage cover, uniform distribution, e.g.

- Glass sponge gardens off Great Barrier Island, 60–100 m; North Taranaki Bight, 160–330 m; and the Bay of Islands 90–150 m (Figure 3-20I)
- Turnip and onion soft sediment sponge gardens in Spirits Bay, 50–100 m

Low species diversity (one taxonomic group) with low morphological diversity (high numbers of immature specimens), high density, high percentage cover, uniform distribution, e.g. sites at

- Rungapapa Knoll and Volkner Rocks in the Bay of Plenty, 100–500 m (Figure 3-20J)
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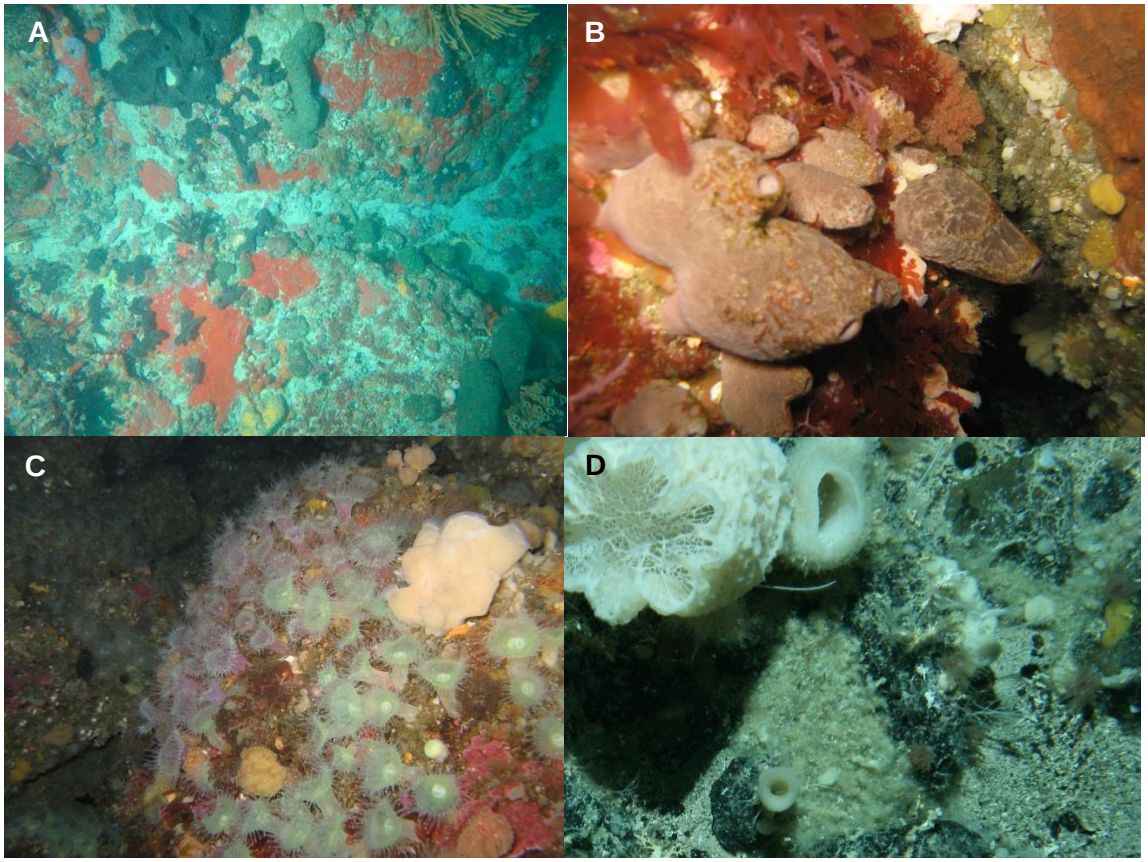

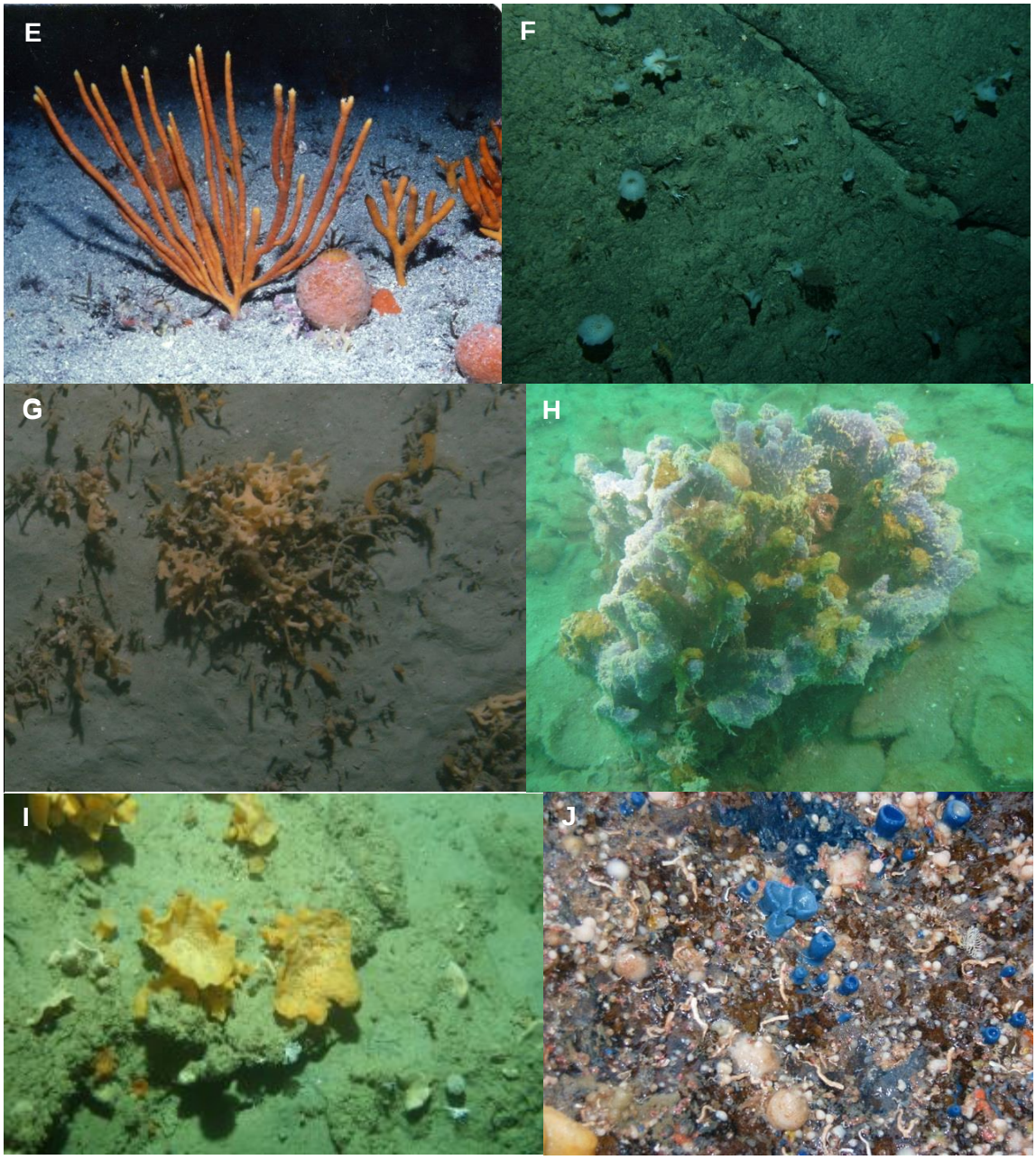

Figure 3-20:Examples of New Zealand sponge gardens. A, Spirits Bay rocky reef sponge garden (Photo: NIWA); B, *Thorecta reticulata* Cook and Bergquist, 1996 encrusting with other non-sponge species in Port Pegasus, Stewart Island (Photo: Debbie Freeman); C, *Leucosolenia rosea* Kirk, 1896 encrusting with other non-sponge species in Port Pegasus, Stewart Island (Photo: Debbie Freeman); D, deep-water sponge garden on Macquarie Ridge (Photo: NIWA); E, Leigh Marine Reserve sponge garden (Photo: Avril Ayling); F, glass sponge gardens on Chatham Rise seamounts; G, Hay Paddock, North Canterbury biogenic wireweed polychaete habitat (Photos: NIWA); H, bivalve sponge biogenic habitat, Tamaki Strait, Hauraki Gulf (Photos: NIWA); I, glass sponge garden (*Symplectella rowi* Dendy, 1924) in the outer Bay of Islands (Photo: NIWA); J, *Reidispongia coerulea* Lévi and Lévi, 1988 and other lithistid Demospongiae on hydrothermally active Rungapapa Knoll (Photo: Malcolm Clark, NIWA).

3.11.3 Diagnostics

Sponges are encountered as sparse, moderate and dense populations in video surveys, trawls, dredges and grabs of the seabed in New Zealand's EEZ.

In seabed photographs and video, characteristic indicators of sponge gardens include an average 25% or greater percentage cover of one or more sponge species in uniform or clumped distribution over an area of 100 m^2 or more. The occurrence of 25% or greater volume of mixed sponges or single sponge species in successive samples obtained using point sampling gear, or 20% or greater volume in a sample obtained using mobile sampling gear, is sufficient to indicate the presence of a sponge garden (Table 3-2). A trawl is considered to be less destructive than a dredge/grab for sponge gardens as the softer net will disturb only those species that are brittle, or attached loosely in soft sediment, or those that are already detached as rollers.

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3.12 Stony coral thickets or reefs

3.12.1 Description

Corals are a group of colonial organisms belonging to the phylum Cnidaria. Coldwater (or Deepwater) corals are those corals found most commonly between ~200 m and 2000 m water depth and at temperatures between 4°C and 12°C. More than 10,000 described species of coldwater corals are known worldwide, distributed among the Scleractinia (stony corals), Octocorallia (soft corals), Antipatharia (black corals), and Stylasteridae (hydrocorals). Several taxa within these groups can provide habitat for, or are known to be associated with, some species of fish and invertebrates. The most complex habitat is provided by the stony coral species which produce 3-dimensional matrix colonies that can coalesce to form 'reef', 'mound' or 'thicket' structures (Roberts et al. 2006). Some structures can be very large, forming reefs that extend over kilometres in length and up to 35 m in height (Fosså et al. 2005), while coral carbonate mounds and other patch-like structures such as thickets typically occupy areas of 1-10 km^2 and <1 km^2, respectively (Wheeler et al. 2007). The size of these structures depends upon the environmental conditions suitable for growth, and the length of time that conditions have been suitable for growth. Some structures have been growing continuously for 50,000 years (Roberts et al. 2006). Coldwater corals can not only be slow growing and long-lived, but are also fragile (Reed et al. 2007, Adkins et al. 2004, Roark et al. 2009), and the biodiversity associated with these coral structures can be high (Jensen and Frederiksen 1992, Henry and Roberts 2007). As such these habitats are considered to be "vulnerable marine ecosystems" that require protection (FAO, 2009) from the impacts of deep-water fishing, drilling, and mining (Fosså et al. 2000, Hall-Spencer et al. 2002, Van Dover 2011, White et al. 2012).

3.12.2 Distribution

Coldwater stony corals that form complex three-dimensional structures are found in many areas around the world (Hovland 2008, Roberts et al. 2009). Many of these corals are located on the north-east Atlantic margin, predominantly at shelf breaks and on the upper continental slope (Roberts et al. 2006). As well as a hard substrate required for attachment, the presence of deepwater coral dominated structural features is related to conditions particularly favourable for corals. These include high nutrient and food supply for growth, currents or mixing to deliver the food and nutrients, and low sedimentation rates to allow efficient feeding and to avoid physical burial (see relevant references in Roberts et al. 2009). The location of coldwater coral reefs and mounds is reasonably well known in the northern hemisphere, such large features have not been well documented in the southern hemisphere. The only indications that coral-dominated habitat in the southern hemisphere may occupy similar sized areas to reefs or mounds found in the North Atlantic Ocean are the coral mounds recently found on the Uruguayan shelf and slope (Carranza et al. 2012) and the single and early record provided by Squires (1965) from the Campbell Plateau off New Zealand. The existence of live coral associated with the latter structure, originally interpreted from acoustic signals, has yet to be visually confirmed by underwater photographs or video.

Smaller patch reefs or thickets have been directly observed by on many seamounts around New Zealand, Australia and Argentina (Althaus et al. 2009, Clark and Rowden 2009, Muñoz et al. 2012). These patches typically occupy only parts of the seamount, specifically the summits and ridges of the features where the corals benefit from increased current flow

around or along these rocky promontories (Figure 3-21). These patch reefs or thickets can be 600 m long, 20 m wide and 3 m high (Clark and Rowden 2009, Clark et al. 2010). Corals can also form more dispersed thickets where substrate for attachment is provided by isolated rocks or stones. For example, dispersed thickets are present in areas where hard substrate is provided by phosphorite nodules on or just beneath the surface of the soft sediment that dominates the crest of the Chatham Rise (Dawson 1984). Where nodules are relatively dense these thickets of stony corals are similarly dense and can extend over distances of 100s of metres, forming a distinct habitat (Kudrass and von Rad 1984) (Figure 3-22).

Four of the five most significant habitat-forming species of stony coral in New Zealand waters (*Madrepora oculata, Solenosmilia variabilis, Goniocorella dumosa, Enallopsammia rostrata*) are distributed throughout the region. The fifth species, *Oculina virgosa*, is found only in warmer waters off North Cape and along the Kermadec Ridge. This species is generally found at depths of 100 m on the shelf or seamounts, while *G. dumosa* is found primarily around 400 m on slopes and rises. The remaining species typically occur in deeper waters (800-1000 m) and are mostly associated with seamounts (Tracey et al. 2011).

Figure 3-21:Stony coral (*Solenosmilia variablis*) reef at 1000 m depth on the summit of Gothic Seamount, Chatham Rise (NIWA).

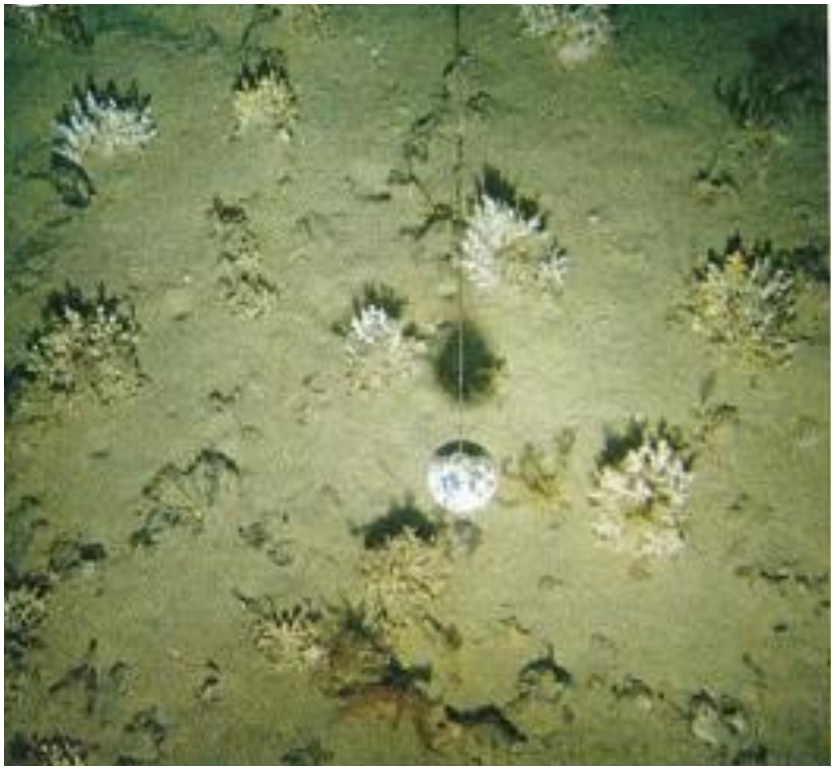

Figure 3-22:Stony coral (*Goniocorella dumosa*) thicket on phosphorite nodules on the Chatham Rise (image from Kudrass and von Rad 1984).

3.12.3 Diagnostics

Stony coral reefs or thickets can be deemed to exist when live or dead colonies of structure-forming species (*Madrepora oculata, Solenosmilia variabilis, Goniocorella dumosa, Enallopsammia rostrata, Oculina virgosa*) dominate the seabed (>15% cover at the scale of m^2) over areas 100s m^2 to a few km^2. Reefs and thickets can be identified by using direct sampling or, ideally, by imaging the seabed.

Obtaining video or photographs of the seabed allows stony coral reefs or thickets to be detected without causing any damage to these sensitive habitats. Using small box-corers or grabs will provide discrete samples that allow for the detection of stony coral reefs or thickets while causing relatively limited damage to the habitat. The occurrence of a single specimen of a thicket forming species in two successive point samples (e.g., box core or grab) is sufficient to indicate the likely presence of a coral thicket (Table 3-2). Towed sampling gear such as dredges and sleds, while also suitable for the initial detection of structure-forming stony coral species, will likely cause significant habitat damage if sampling is repeated in a limited spatial area or frequently across a wider extent. If towed gear sampling reveals the presence of one or more structure-forming species, this is sufficient to indicate the possible presence of a stony coral thicket. Thereafter the extent of the habitat should be determined either by multiple point sampling with a relatively small box-corer or grab, or ideally by seabed imaging techniques.

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3.13 Xenophyophore beds

3.13.1 Description

Xenophyophores are very large, single celled protozoans, in the phylum Foraminifera, whose protoplasm is contained largely in branched, transparent, organic tubes or sheaths (Tendal 1975, Pawlowski et al. 2003, Hayward et al. 2012). They live on the seabed and form a complex test or clump up to 25 cm in diameter made up of mineral grains, sponge spicule fragments and organic debris (Levin and Gooday 1992, Hayward et al. 2012). The form of the test may be spherical, plate-like, irregular or a ball of anastomosing walls or tubes (Figure 3-23). Most of any xenophyophore is dead matter; living plasma makes up <5 % of the test volume (Tendal 1975, Haywood et al. 2012). Xenophyophores may easily be mistaken for broken and decayed parts of other animals, such as sponges, other foraminifera, coelenterates, bryozoans and ascidians, or for inorganic concrements (Tendal 1975). Seven species have been recorded from New Zealand, three of these are endemic. The fragile nature of xenophyophores and the difficulty of identifying fragments suggests that perhaps double the number of species may be expected (Hayward et al 2012).

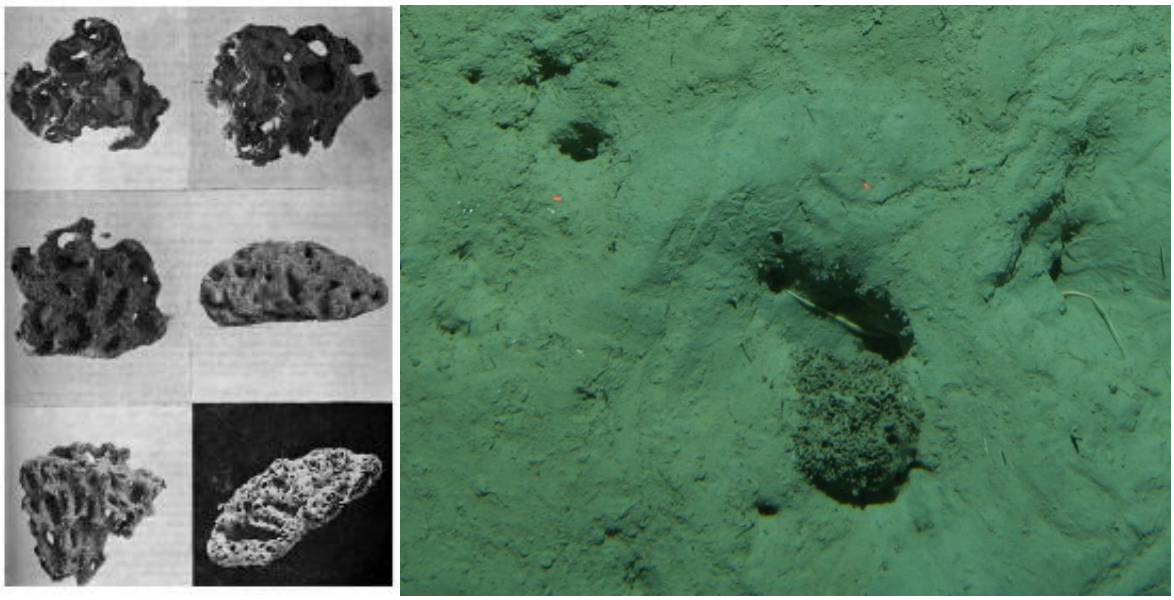

Figure 3-23:Xenophyophores. Left panel of b/w images—Upper left: *Reticulammina lamellata*, top view; X 1.5. Upper right: *R. labyrinthica*, top view; X 2.2. Middle left: *R. novazealandica*, top view; X 1.5. Middle right: *R. novazealandica*, side view; X 0.8. Lower left: *Syringammina fragilissima* fragment, side view; X 3.2. Lower right: *S. tasmanensis*, side view of sectioned paratype; X 1.8. (from Tendal 1975). Right panel – xenophyophore as seen in situ. Red laser dots are 20 cm apart (NIWA).

Xenophyophores appear to be fast growing (Hayward et al. 2012). They feed on fine particles such as bacteria from the seabed or from the water column directly above. Species that form complex tests are thought to act as small, passive particle traps and have an associated fauna of bacteria, small foraminifera, polychaete worms, snake stars and small crustaceans (Levin et al 1986, Levin and Goody 1992). Where xenophyophores occur, there can also be higher infaunal densities (Levin et al. 1986). Abundant xenophyophores provide significant spatial complexity on the ocean floor at the scale of tests (cm) and patches (kms) (Levin and Gooday 1992).

3.13.2 Distribution

Xenophyophores appear to be particularly abundant below areas of high surface productivity (Hayward et al. 2012). To date sampling locations within the New Zealand EEZ are on the eastern, northern and western continental slopes of New Zealand, and on the Chatham Rise at depths of 500-1300 m (Tendal and Lewis 1978, Haywood et al. 2012). In situ photographs show some species reaching densities of 1 or more per m^2 of sea floor (Tendal and Lewis 1978, Hayward et al. 2012).

3.13.3 Diagnostics

Based on New Zealand observations a xenophyophore bed can be considered to be present if average densities of all species present equal or exceed 1 specimen per m^2 sampled using any method (Table 3-2). Xenophyophores are fragile and frequently disintegrate when captured by towed sampling devices so the presence of fragments of specimens may be the only indication. Specimens are more likely to survive whole in point samples such as those obtained using box cores, multi-cores or grabs. Xenophyophores will be readily apparent in images of the seabed if taken at the standard NIWA towed camera survey height of 2.0-2.5 m above the seabed.

A potential secondary indicator is the presence of a *Paleodictyon* or striking regular pattern on the surface of the seabed (e.g., Figure 3-24) that may indicate the presence of a buried Xenophyophore. Confirmation awaits in situ sampling (perhaps by submersible) of specific seabed *Paleodictyon* to determine the species responsible.

Figure 3-24:Sea floor *Paleodictyon*, 1800 m, SW Challenger Plateau, may indicate the presence of a buried Xenophyophore (NIWA).

3.13.4 References

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Table 3-2: Diagnostic table for identifying sensitive marine benthic habitats.

Habitat	Primary indicators	Secondary Indicators
Beds of large bivalve molluscs	A bed of large bivalves exists where living and dead specimens of bivalve species: • are found to cover 30% or more of the seabed in a visual image, or • comprise 30% or more by weight or volume of the catch in a sample collected using towed gear, or • comprise 30% or more by weight or volume in successive point samples.	None
Brachiopod beds	A brachiopod bed exists if: • one live brachiopod occurs per m^2 of seabed sampled using towed gear, or • one or more live specimens occur in successive samples obtained using point sampling gear.	Areas of hard bottom, free of fine sediment, in locations of high water movement.
Bryozoan thicket	A bryozoan thicket (here the term thicket is used synonymously with the terms bed, reef, meadow, etc.) is present if: • colonies of large frame-building bryozoan species cover at least 50% of the seabed in visual imaging surveys over an area between 10 - 100 m^2, or • colonies of large frame-building bryozoan species cover at least 4% of the seabed in visual imaging surveys over an area that exceeds 10 km^2, or • one or more colonies of large frame building bryozoan species occur per m^2 of seabed sampled using towed sampling gear, or • one or more large frame building bryozoan species is found in successive point samples.	None
Calcareous tube worm thickets	A sensitive tube worm thicket is present if: • one or more tube worm mounds are visible for each 250 m^2 of seabed covered during an imaging survey, or • 2 or more intertwined specimens of a mound forming species of tube worm are found in any point sample, or • tube worm species comprise 10% of the catch by weight or volume in towed samples.	Large tube worm mounds, >1 m high and >5 m in diameter, may be detectable in deep water using multibeam acoustic survey equipment.

Chaetopteridae worm fields	A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species: • occupy 25% or more of the seabed in imaging surveys covering an area of 500 m^2 or more, or • contribute 25% or more of the volume of a sample collected using towed gear, or • occur in two successive samples collected using point sampling gear.	A secondary indicator of the presence of chaetopteridae worm fields is the characteristic bed forms evident in multibeam surveys, showing mounding with well-defined outer edges.
Deep-sea hydrothermal vents	A hydrothermal vent is encountered if any occurrence of live specimens of known vent species is found in a visual image or any sample. Species currently known to be specific to hydrothermal vents in New Zealand waters include: • *Vulcanolepis osheai,* • *Ashinkailepas kermadecensis,* • *Gigantidas gladius,* • *Vulcanidas insolatus,* • *Alvinocaris niwa,* • *A. longirostris,* • *A. alexander,* • *Lebbeus wera,* • *Nautilocaris saintlaurentae,* • *Gandalfus puia,* • *Xenograpsus ngatama,* • *Paralomis hirtella,* • *Bathyaustriella thionipta,* • *Siboglinum* sp.*,* • *Oasisia fujikurai,* • *Lamellibrachia juni,* • *Sclerasterias eructans,* • *Parachnoidea rowdeni,* • *Pyrolycus moelleri,* and • *Symphurus thermophiles*.	In seabed photographs and video, other characteristic indicators of hydrothermal vents include: patches of white bacterial mats and yellow sulphide minerals on sediments or rocks, chimney structures and cracks and fissures emitting fluids.
Macro-algae beds	Detection of a single occurrence of any specimen of a red, green or brown macro-alga is sufficient to indicate that this habitat has been encountered.	The presence of rocky reefs within the upper 200 m of offshore waters anywhere in the EEZ is a strong indicator of the possible occurrence of macro-algae beds.
Methane or cold seeps	A methane or cold seep exists if a single occurrence of one of the following taxa is found in a visual image or any sample: • large siboglinid tubeworm	Detection of characteristic water-column acoustic flares in single- or multi-beam echo-sounder traces indicates the

	Lamellibrachia sp. • vesicomyid clam *Calyptogena* sp. • mussels in the family Bathymodiolinae; • solemyid clams (*Acharax clarificata*); • the sponges *Stelletta* n. sp. and *Pseudosuberites* sp., and • ampharetid, dorvilleid, and pogonophoran (*Siboglinum* sp.) polychaete worms.	strong probability of a seep and the need to look out for other indicators. There is a possibility for confusion with fish aggregations. The absence of such acoustic flares is not an indication that seeps are not present.
Rhodolith (maerl) beds	A rhodolith bed exists if: • a single specimen of a rhodolith species is found in a sample obtained using mobile or point sampling gear, or • there is more than 10% cover of living coralline thalli in a visual image.	None
Sea pen field	A sea pen field exists if: • one or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or • two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear.	None
Sponge gardens	A sponge garden exists if metazoans of Class Demospongiae, Class Hexactinellida, Class Calcerea or Class Homoscleromorpha: • comprise 25% of successive samples obtained using point sampling gear, or • comprise 20% or more by volume of any sample taken using towed gear, or • occupy 25% or more cover in a visual imaging survey over an area of 100 m^2 or more.	None
Stony coral thickets or reefs	Stony coral thickets exist when live or dead colonies of structure-forming species (*Madrepora oculata, Solenosmilia variabilis, Goniocorella dumosa, Enallopsammia rostrata, Oculina virgosa*): • cover 15% or more of the seabed in a visual imaging survey covering 100 m^2 or more, or • one or more specimens of thicket forming species are found in two successive point samples, or • one or more structure-forming	None

	species is found in a sample collected using towed gear.	
Xenophyophores (sessile protozoan) beds	A xenophyophore bed can be considered to be present if: • the density of all species present (including fragments) equal or exceed 1 specimen per m^2 of seabed sampled.	A potential secondary indicator is the presence of a *Paleodictyon* or striking regular pattern on the surface of the seabed that may indicate the presence of a buried Xenophyophore.

4 Discussion

Although we have proceeded with the best available information and have been mindful of the need for legal clarity, the definitions provided above should be regarded as preliminary and work-in-progress. In only a few cases were habitats defined in the scientific literature in terms of density, percentage cover or catch rate of the habitat forming group by various sampling gear. In many cases we have had to draw upon our own field experience to provide a working definition. In a few cases, such as methane seeps and hydrothermal vents, where the fauna are highly specialised, the criteria are a clear binary yes/no decision. In other cases, such as for sponges, large bivalves, and bryozoans, where densities and biomasses on the seabed can vary over a very wide range, the definition is contestable. Definitions are complicated for environments such as bivalve beds and sponge gardens as the species that comprise these habitats can vary tremendously in size, longevity and morphology, making the task of defining a common threshold more difficult. In these cases the possibility of splitting the environment into a number of separate habitats should be considered at some stage in the future.

For instance, bivalve species vary tremendously in size – the horse mussel may reach over 400 mm in length, while queen scallops may reach only 6 mm – so general definitions based on bed extent and/or biomass that are expected to apply across species with widely different characteristics will pose problems. In addition, the life spans of bivalve species vary, and so will their susceptibility to, and ability to recover from, disturbance. When disturbance is infrequent relative to recovery time, and only a small portion of the bed is disturbed, the system should remain stable[2]. In general terms, long lived bivalves will be most sensitive. Given these issues, rather than large bivalve beds forming a single habitat type, separate habitat status could be considered for horse mussel beds, dog cockle beds, etc. Alternatively, it may be most appropriate to group species according to factors such as their size, longevity, dispersal capabilities and habit (i.e., infaunal, emergent, patch/ aggregation form).

The definitions attempted to take into account the differing scales and selectivity of the gear likely to be used by operators to sample the seabed. Seabed imaging, while non-destructive, is only useful for identifying macrofauna and flora and can provide estimates of habitat patchiness and density over large areas. At standard NIWA survey heights (usually 2.5-3 m

[2] Thrush, S.F.; Lundquist, C.J.; Hewitt, J.E. (2005). Spatial and temporal scales of disturbance to the seabed: a generalized framework for active habitat management. American Fisheries Society Symposium 41:639-649.

above the seabed) brachiopods, for instance, are not easily discernible. Towed gear such as sleds collect an integrated sample over larger (often unknown) areas from which it is difficult to obtain robust estimates of species density, but they do provide specimens with which to identify species. The selectivity of mobile sampling gear such as beam trawls and dredges may mean that smaller organisms are under-represented, but this is dependent on the mesh size used in the sampling device. Samples taken by point sampling gear such as box-corers and grabs make it possible to determine the densities of organisms in softer sediments but may under-sample larger organism such as sea pens, and are ineffective on harder substrates.

The fragility of some habitats such as bryozoan thickets, calcareous tube worm thickets, stony coral thickets and xenophyophore beds can lead to gross under representation of some habitat forming species or colony size if sampled by fixed or mobile sampling gear.

In defining sensitive marine benthic environments we took into account the above issues concerning the size, morphology, and density of the habitat forming different species, their susceptibility to disturbance, and scale and the selectivity of the equipment used to sample them. Invariably this has led to differences among habitat definitions in the % covers, densities, or catch rates used to determine the lower threshold of habitat occurrence.

In defining sea floor biogenic habitats, what is generally lacking is information that matches changes in density or biomass of particular habitat forming species with habitat functionality. This should be a research priority. Work on this particular problem is presently being undertaken as part of a PhD research programme on bryozoan thickets on the Otago shelf but the twelve other habitats defined in this report require similar research effort.

Exploration of New Zealand's marine environment is still at an early stage and much of the marine environment and the diverse communities contained remains poorly charted. Swath mapping using a multi-beam acoustic system offers the opportunity to define seabed habitats over wide areas, if carried out at the required frequencies to finely detail bathymetry and provided backscatter data is collected so that surface texture can be defined. To date only about 855,000 km^2 or 15% of the total area has been swath-mapped to a standard necessary to map benthic habitats. At present rates of collection it will take another 50 years before the seabed in the Territorial Sea, EEZ and ECS is fully swath mapped. Further exploration over the next few years will, without doubt, yield further benthic habitats that may be sensitive to the types of sampling considered here. In these cases new definitions will need to be formulated and regulations for the EEZ Environmental Effects Act updated to take these new discoveries into account.

5 Acknowledgements

This report was greatly improved and assisted by regular feedback on the habitat entries from the MfE team led by Joshua McLennan-Deans and Wendy Parker. We thank Wendy Parker and Emily Hockly for many useful comments on the draft report. We thank Malcolm Clark for reviewing and greatly improving the final report.

6 Appendix 1: Examples of seabed sampling gear

Examples of seabed sampling activities with a minor or lesser impact include:

- Point sampling of the seabed (both non-extractive and extractive), including:
  - Crewed submersibles, remotely operated vehicles (ROV) (Figure 6-1a and b), and autonomous underwater vehicles (AUV) that may carry a variety of point sampling gear
  - Benthic lander with seabed probes (Figure 6-1c)
  - Penetrometer testing
  - Grabs (Figure 6-1d)
  - Suction cores
  - Coring (which may include single, box, multi, piston or vibro-coring) (Figure 6-1e and f) and gravity corer (Figure 6-2).
- Mobile sampling of the seabed (both non-extractive and extractive), including:
  - Sleds (Figure 6-3a and b)
  - Beam trawls (Figure 6-3c)
  - Dredging (using “rock dredges” with a mouth of $1m^2$) (Figure 6-3d)

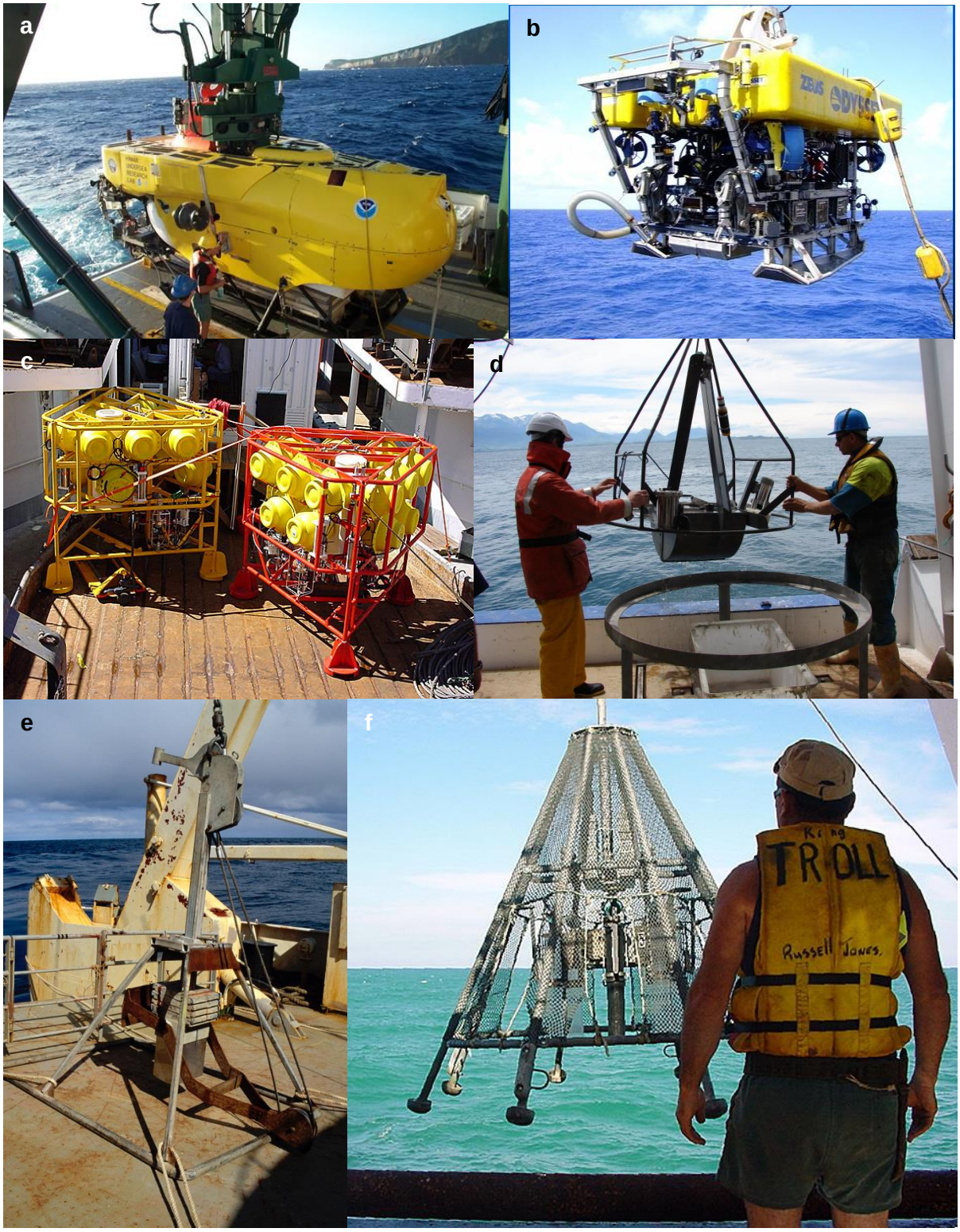

Figure 6-1: Point sampling of the seabed. (a) Pices crewed submersible, (b) Odyssey remotely operated vehicle, (c) benthic lander, (d) van Veen grab in closed position, (e) Reineck box corer, (f) multicorer (all images NIWA).

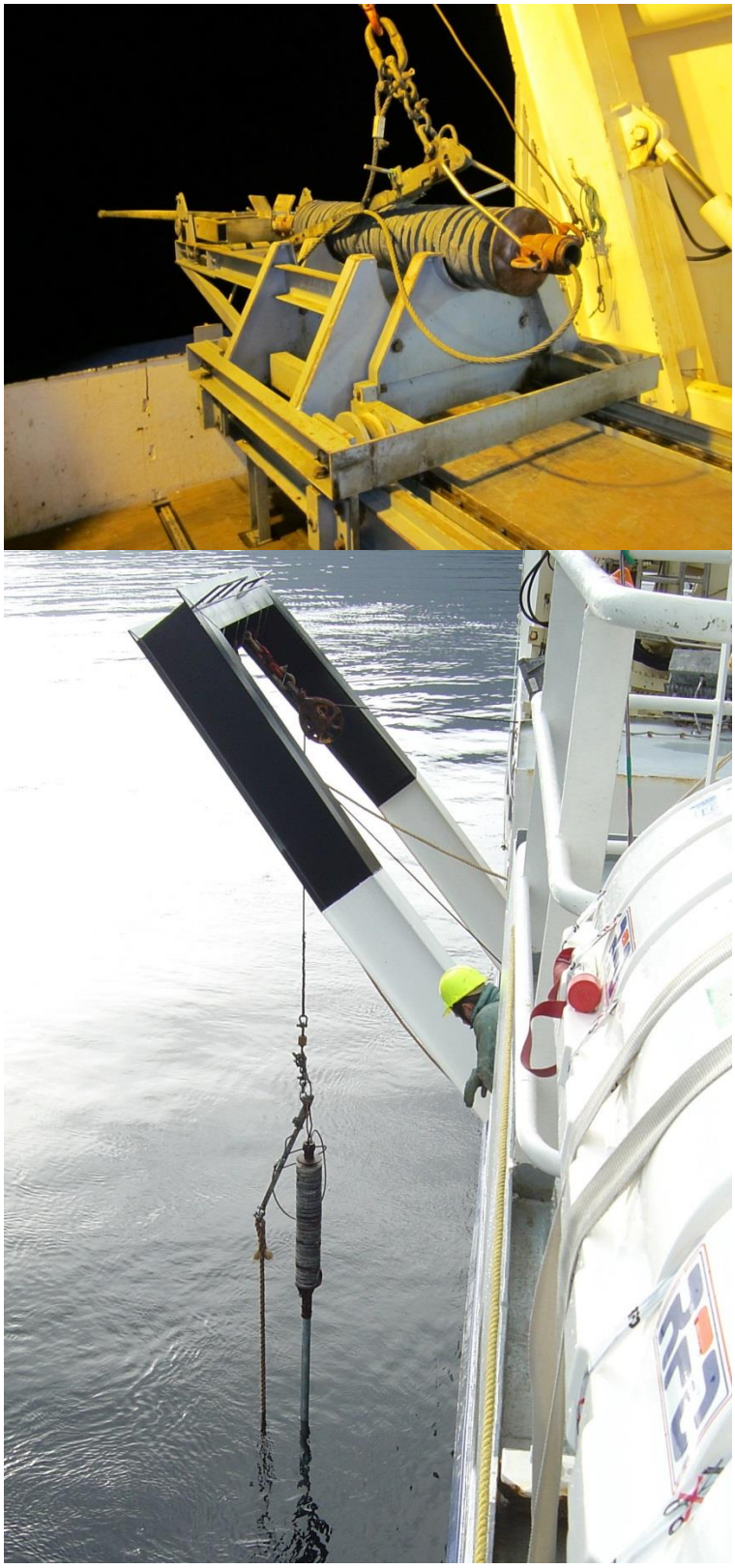

Figure 6-2: Gravity corer. (top panel) corer in its cradle. The barrel is 6 m long and total length is 8.5 m, (bottom panel) corer during deployment (all images NIWA).

Figure 6-3: Mobile sampling of the seabed. (a) small epibenthic sled, (b) large epibenthic sled, (d) Agassiz beam trawl, (e) rock dredge and spares on RV Tangaroa (all images NIWA).