Davidson Environmental Limited

Location and biological attributes of biogenic habitats located on soft substrata in the Marlborough Sounds

Research, survey and monitoring report number 675

A report prepared for:

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Summary

A variety of organisms act as ecosystem engineers forming three dimensional biogenic structures on the sea floor. These structures often provide habitat for an abundance and rich diversity of species, support commercial and recreational fisheries, provide the source for medical compounds and support many tourist industries. The most well known and studied biogenic habitats are tropical coral-algal reefs, the largest being the Great Barrier Reef stretching thousands of kilometres. Biogenic habitats in temperate regions are less well known but are undoubtedly biologically important.

Despite the importance of these habitats few areas supporting biogenic habitats in New Zealand have been formally identified and described in shallow New Zealand waters and even less are managed to ensure their values are retained. There is little doubt that biogenic habitats have been adversely impacted by human activity. These structures are often colonised by dense assemblages of fish and provide habitat for commercially important shellfish. They are therefore often targeted by commercial and recreational fishers who use dredges and trawls to capture their target species. Many biogenic habitats are calcareous or fragile structure making them vulnerable to this physical damage. Physical damage to these habitats has been recognised in tropical coral reef area where impacts are easily observed. In temperate areas, biogenic habitats are often located in deeper water and their presence and the level of impact remain largely unknown to most coastal managers.

This report identifies locations and describes the biological attributes of some biogenic habitats found on soft bottom substrata in the Marlborough Sounds. The report is limited to soft bottom substrata as these areas are most vulnerable to impacts from bottom towed devises and are therefore under the greatest threat from permanent loss.

It is hoped that this study provides the fundamental first step toward better understanding the importance of these habitats and provides coastal managers a challenge to ensure remaining areas do not continue to be reduced or ultimately disappear.

1.0 Introduction

Some plants and animals form three dimensional structures that provide habitat for a variety of other species. These structures are known as biogenic habitats and occur in many marine environments (e.g., Cocito 2004; Morton 2004; Smith et al., 2005). The most well known and studied biogenic habitats are tropical coral-algal reefs, the largest being the Great Barrier Reef stretching thousands of kilometres. Biogenic habitats support some of the most diverse communities in the world and also support commercial and recreational fisheries, provide the source for medical compounds and support many tourist industries. Smith et al. (2005) stated that lesser-known temperate biogenic habitats may also prove to be important by enhancing subtidal biodiversity, providing habitat for other organisms and influencing local hydrology and sedimentation, though on a smaller scale.

Fagerstrom (1991) assigned organisms to particular groups based on growth form and habit. Erect skeletonized mounds or branched organisms were assigned to "constructors" providing the volume and rigidity. The author also described encrusting organisms as "binders" that expand and unite the framework and the settling sediment. The last group was the "bafflers" that were defined as erect, non skeletal to poorly skeletonized organisms that act to reduce current velocity on the framework surface enhancing sediment deposition and cavity filling within the framework.

It has been demonstrated in many areas of the world that habitat complexity induced by biogenic habitats promotes biological diversity (Sorokin 1995; Dittman 1990; Lenihan 1999; Bianchi and Morri 1996; Bradstock and Gordon 1983; Ferdeghini and Cocito 1999). A variety of species are known to form biogenic habitats in temperate regions. Cocito (2004) stated that bryozoans are one of the most important bioconstructors in temperate regions. In New Zealand, Bradstock and Gordon (1983) stated that bryozoan mounds sampled in Tasman Bay supported an elevated faunal diversity due to the vast surface area provided by mounds. The authors recorded numerous polychaetes, bivalves, and crustaceans living amongst mounds and noted the presence of commercially and recreationally targeted fish living in association with these mounds. This area was subsequently protected from commercial dredging and trawling activities. Smith et al. (2005) noted that tubeworm mounds in Paterson Inlet were also favoured by local fishers, but warned that tubeworms were damaged by anchors.

Despite the importance of these habitats for biodiversity, medical and industrial applications (Briand 1991; Grkovic and Copp 2009) and commercial and recreational fishing and tourism, few areas supporting biogenic habitats have been formally identified and described in shallow New Zealand waters. Commercial and recreational fishers are aware of many of these areas as they target them for fishing; however, there has been a reluctance to reveal their location in fear that these areas would be closed to fishing. As a result, the location, size and biological attributes of these habitats remain poorly known to the scientific community.

Many biogenic habitats are located on soft bottom substrata and their often calcareous or fragile structure means they are vulnerable to impacts from physical damage (Bradstock and Gordon 1983; Lenihan and Peterson 2005) and pollution (Roberts et al., 2008). Traditional fishing methods such as dredging and trawling result in damage (Thrush, et al., 1998); however, there exist fishing methods that result in little or no impact. Problems associated with physical damage have been recognised in tropical coral reef area where the damage is easily observed. In temperate areas, biogenic habitats are often located in deeper water and their presence and the level of impact remain largely unknown to coastal managers.

This report aims to identify the locations and describe the biological attributes of some biogenic habitats in the Marlborough Sounds. This is the fundamental first step toward better understanding the importance of these habitats and provides coastal managers a challenge to ensure remaining areas do not disappear. The present report is small in scale and should not be regarded as a description of all biogenic habitats in the Marlborough Sounds. There is no doubt that many biogenic areas remain unknown to the science community. Sites identified in the present report should not therefore be regarded as complete.

2.0 Methods

2.1 Site selection

Potential survey sites were identified from a variety of sources of information. These included: (i) existing scientific literature; (ii) Marlborough District Council "Ecodata" database; (iii) Department of Conservation internally published reports; (iv) interviews with particular commercial and recreational fishers; (v) interviews with scientists and experts; and (vi) personal knowledge of the authors.

Prior to field work, potential study sites were short-listed due to funding limitations. The short-list of priority sites were restricted to sites that were (a) of particular scientific interest, (b) in locations or depths that could be physically surveyed, and/or (c) under immediate threat from human activities. In addition, at least one type of each biogenic habitat was selected for survey. Weather and logistical constraints sometimes meant that particular sites could not be sampled and others were sampled in their place.

2.2 Field work

In late winter and spring of 2008 prioritised biogenic habitats were investigated using a variety of techniques. Prior to field work the approximate boundaries of each habitat were plotted onto real time GPS mapping software (TUMONZ). Sites were initially investigated using one or more remote sampling techniques. The location of data collection points or transects were plotted onto the software database. A variety of remote sampling techniques were used in the present study.

2.2.1 Drop camera

An IKELITE underwater splash camera fixed to an aluminium shaft was lowered to the benthos and an oblique still photograph was collected where the frame landed. Each photograph was stored on a Sony digital camera on board the survey vessel. Each photograph could be viewed on board the survey vessel as an aid to the selection of subsequent photographs and to assist with determination of habitat boundaries. Photograph stations were selected in an effort to sample representative areas within the biogenic habitat and also to help determine the area occupied by each biogenic habitat. In some instances the vessel was left to drift while the benthos was viewed in an attempt to find the biogenic habitat or to locate the boundary of the habitat.

2.2.2 Humminbird side-imaging sonar

A Humminbird 1197c side imaging sonar combined with traditional 2D sonar was used to assist with identifying particular habitats and locating their position relative to the survey vessel. Particular biogenic habitats provided characteristic patterns on both side-imaging and 2D sonar that could be used to help determine the presence and boundaries of these habitats. Habitats identified by the side imaging and 2D sonar were ground truthed using the drop camera.

2.2.3 ROV

A VideoRay ROV (remote operated vehicle) was used on two occasions in Tory Channel to investigate deep areas outside the operating range of the drop camera. At each site high definition digital video footage was collected from areas around the anchored survey vessel.

2.2.4 Diver investigations

Following remote sampling, particular sites were investigated by divers. During diver inspections, notes on the habitat were collected and samples of particular biogenic and associated species collected for later identification. Photographs of representative areas and biogenic habitats were also collected during these dive inspections.

2.3 Biogenic habitat forming species selected for survey

In temperate waters a variety of organisms act as biogenic habitat formers. These include calcareous algae (rhodoliths), barnacles, sabellariid and serpulid polychaetes, vermetids, oysters, mussels, bryozoans, hydroids, sea squirts, seagrasses, algal forests, horse mussels and sponges. The following organism types were identified from biogenic habitats in the present study.

2.3.1 Rhodoliths

Rhodoliths are free-living calcified marine red algae that have a number of different growth forms (see Nelson 2009 for review). Rhodoliths deposit calcium carbonate within their cell walls to form hard structures. Unlike coral, rhodoliths do not attach themselves to the rocky seabed, rather, they are free living on the seafloor and can accumulate to form beds, normally subtidally. Individuals are thought to be slow growing and may be long-lived (greater 100 years) and may be found from the low intertidal to 150 m depth (Foster 2001).

Rhodoliths are often associated with increased biodiversity as numerous species are often found in association with these beds (Hily et al. 1992, Barbera et al., 2003). Rhodolith beds have been found throughout the world's oceans, including the Arctic near Greenland and waters off British Columbia, Ireland, Brazil, Raratonga, Canada and Australia (Foster 2001, Goldberg 2006). Living rhodolith beds are widely distributed throughout the Gulf of California, Mexico. In New Zealand rhodoliths have been documented from the Kermadec Islands, North and South Islands including the Marlborough Sounds and belong to four species in three genera (Harvey et al. 2005, Farr et al. 2009). Locally, rhodoliths beds have also been noted from the Abel Tasman coast, Tasman Bay (Davidson 1992). In Marlborough, rhodoliths are relatively small structures, <5 cm in height and form a cluster of small nodes.

2.3.2 Foliose red algae

Red algae often form extensive beds on soft sediments in a variety of sheltered locations around New Zealand. It is likely these beds influence biodiversity within and close to the beds by stabilising and modifying sediments, with consequent effects on sediment chemistry and nutrient recycling (at the sediment-water interface), as well as potentially providing refugia from predation for a variety of small fishes and benthic invertebrates.

Adamsiella chauvinii forms dense beds at a variety of sites in the Marlborough Sounds. Plants are relatively large up to 15 cm high with a tough and pliable texture. One or more leafy blades arise from a wiry stolon. The crimson blades have a midrib and lobes that are marginal or arise from the midrib. The holdfast is a small disc (Adams 1994). This alga is found from the southern North and South Islands, Stewart and Auckland Islands (Phillips 2002).

2.3.3 Tubeworms

A number of tubeworm species form mounds or dense aggregations or structures in the Marlborough Sounds. *Galeolaria hystrix* is a large double-keeled southern serpulid with a distinctive bright red branchial crown, recorded from Taranaki to Stewart Island, New Zealand (Hare 1992; Morton 2004), as well as in New South Wales and South Australia (Day and Hutchings 1979). It is a suspension feeder usually found as isolated individuals in shallow water (Brougham 1984; Glasby and Read 1998). In shallow environments, individuals seldom form aggregations (Brougham 1984); when they do, it is by gregarious behaviour in which attached adults induce adjacent larval settlement by both chemical and physical means (Brougham 1984; Kupriyanova et al. 2001). This species of tubeworm forms extensive mounds on soft bottom locations in Big Glory Bay, Stewart Island (Smith et al., 2005) and on rock and cobbles in Port Underwood, Marlborough Sounds (Davidson et al., 1995). Another tube forming species *Spirobranchus latiscapus* grows in association with *G. hystrix* mounds at least one site in the Marlborough Sounds.

Owenia petersenae is also a tube forming polychaete that forms low lying mounds at one known location in the Marlborough Sounds. *O. petersenae* is a relatively small worm that forms tubes made up of sand and shell fragments glued together in an overlapping fashion. Where conditions suit they can become abundant and their physical presence forms low lying mounds over the substratum. In New Zealand this species is normally not common outside sheltered harbours. The existence of an area where mounds formed biogenic habitat was discovered by a Department of Conservation survey of the Marlborough Sounds in 1990 (Duffy et al., in prep.). It remains the only location of this community type known from the Marlborough Sounds. The area has been subsequently surveyed as part of a marine farm consent during which it s nationally important status was confirmed (Davidson et al., 1995; Morrisey et al. 2009b).

At one location in the Marlborough Sounds the benthos from 3-6m depth is completely covered by the tubes of a small sabellid polychaete with distinctive white feeding tentacles. This tubeworm bed was discovered by Duffy et al. (in prep). during a Department of Conservation survey.

2.3.4 Bryozoans

Bryozoans often form mounds composed of tiny colonial animals that generally build stony skeletons of calcium carbonate, superficially similar to coral. In the Marlborough Sounds the most common and widespread mound forming species is *Celleporaria agglutinans*. Live colonies are orange in appearance and form solid structures that can be up to basketball size. It is commonly known as Tasman Bay coral or 'hard coral' and occurs from the Three Kings Islands to Foveaux Strait at about 3-220 m depth (Gordon 1989). Colonies grow on hard or soft substrata, however, colonies may initially settle onto shell material found in association with soft substrata. Colonies are usually found in areas swept by moderate to swift tidal currents such as headlands or channels.

Another mound forming species found in the Sounds is *Galeopsis porcellanicus.* Colonies of this species are white or cream in appearance and form many tiny fingers making up a structure up to basketball size. Colonies appear to initially settle onto shell material found in association with soft substrata. Colonies are usually found in areas with strong tidal currents, especially channels.

2.3.5 Horse mussels

Atrina zelandica or the horse mussel is a conspicuous, emergent bivalve mollusc. It is New Zealand ’s largest bivalve, reported maximum size is 400 mm in length but most are between 260-300 mm long and 110-120 mm wide. The shell remains firmly embedded in the substrate by its pointed anterior end, the animal anchored to particles in the sediment by its byssus. The crenellated posterior edge projects above the substrate, keeping the water intake clear of surface deposits and providing attachment for an array of algae (Nelson et al. 1992) and invertebrates such as sponges, hydroids and sea squirts.

Atrina are often patchily distributed on the 10 to 100 m scale and patches are composed exclusively of similar-sized individuals (Hewitt et al. 2002). They are found in muddy to sandy, soft-sediment habitats around the coast of New Zealand from extreme low water to 70 m depth, but are not recorded from Kermadec or Subantarctic Islands. A small population is known from the Chatham Islands (Marston 1996).

2.3.6 Other biogenic habitat forming species

A variety of other species that can form biogenic habitats are known from the Marlborough Sounds. These species usually establish in association with one of more dominant biogenic species, especially bryozoans. These species include compound ascidians, sponges and hydroids and best fit the bafflers category of biogenic habitat formers outlined by Fagerstrom (1991).

Seagrass or eelgrass (*Zostera* sp.) is also found in the Marlborough Sounds. Almost all beds are located in the intertidal estuaries and gently sloping shore of the sheltered parts of the Marlborough Sounds. The exception is a shallow subtidal bed located at Tipi Bay in Tory Channel. Eelgrass roots stabilise sediment while leaves provide habitat and food for a variety of invertebrate species. The location of eelgrass beds have not been surveyed in the Marlborough Sounds, however, observation suggest that eelgrass is most often encountered in Queen Charlotte Sound where beds are considerably larger than those found in other Sounds.

3.0 Results

A range of biogenic habitats on soft bottom substrata in the Marlborough Sounds have been surveyed and/or recognised from a variety of information sources (Figure 1).

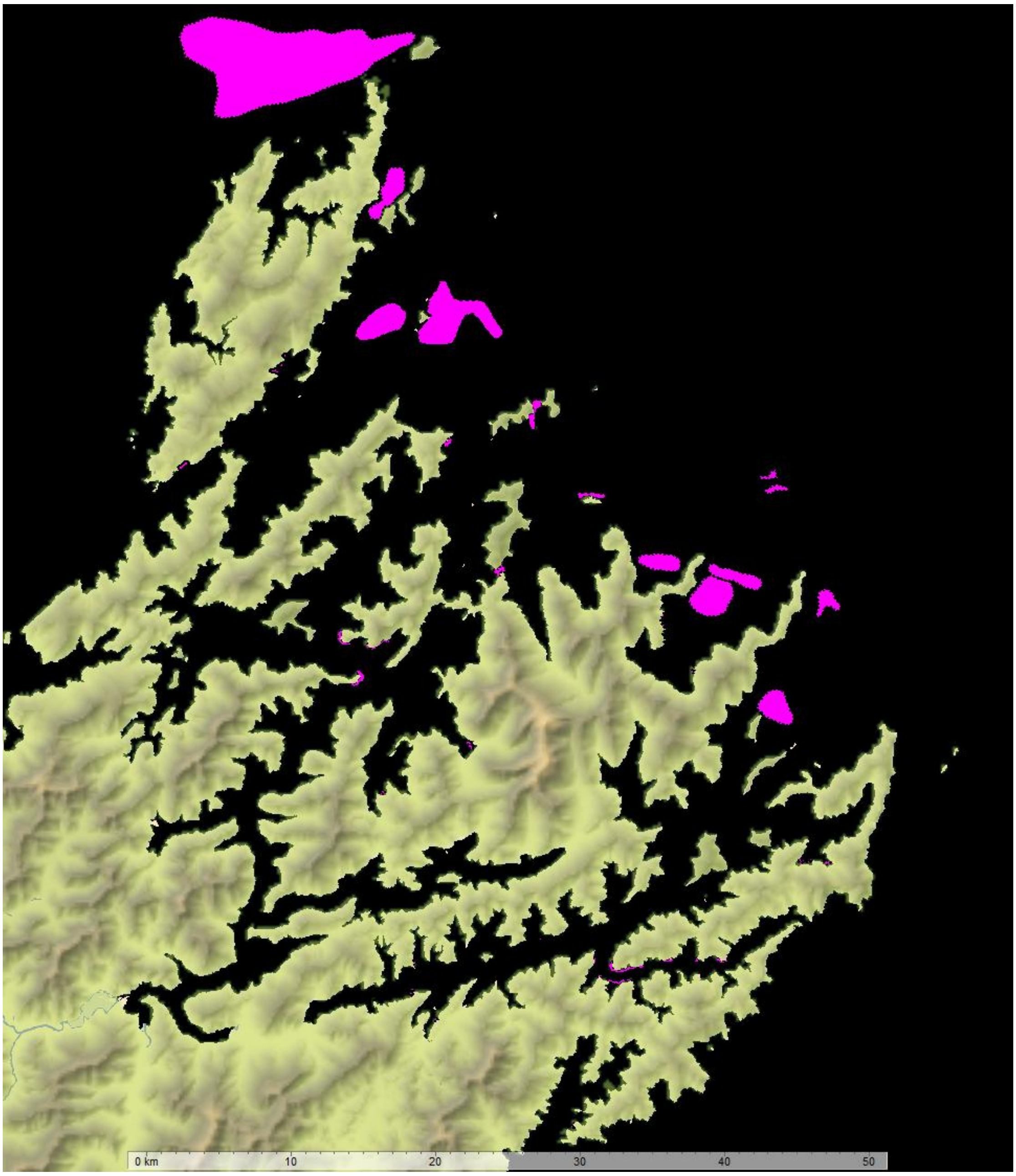

Figure 1. Location of biogenic habitats (pink) sourced or surveyed in the present study. Note many sites are very small and appear only as small dots at this scale.

3.1 Rhodolith beds

Harvey et al. (2005) collected rhodoliths in the Marlborough Sounds at D'Urville Island and identified the species as *Sporolithon durum*. Duffy et al. (in prep.) reported a rhodolith bed in Current Basin, D'Urville Island. During a marine farm impact study, Davidson (1999) discovered a small rhodolith bed in Picnic Bay, Pelorus Sound.

Rhodolith beds living on soft substrata were located and their boundaries surveyed at five locations in the Marlborough Sounds. The inshore waters between Catherine Cove and the south-western corner of D'Urville Island (Le Brun Peninsula) were also surveyed for rhodoliths but no further beds were discovered. The five rhodolith beds occupied approximately 53 ha in total, the largest bed being approximately 22 ha at Coppermine-Ponganui Bays (Figure 2, Table 1). All but one rhodolith bed were located around the D'Urville Island coast and only in Catherine Cove and Ponganui-Coppermine Bays (Figure 2). The remaining rhodolith bed was located in Picnic Bay, Tawhitinui Reach, Pelorus Sound (Figure 1). No other rhodolith beds are known from inside the sheltered shores of the main Sounds.

Rhodoliths were found between 6 to 26 m depth on relatively gently sloping shores in particular bay around D'Urville Island. These locations were characterised by a sheltered wave climate with Catherine Cove rhodoliths being absent from bays south of the shelter provided by D'Urville Peninsula. At most locations rhodoliths formed an almost 100 % cover over the underlying substrata (Plates 1 and 2). Densities appeared to decline in the shallows (< 6 m depth) and at depths > 26 m. In Picnic Bay, Pelorus Sound, rhodoliths did not reach depths recorded from D'Urville Island. A variety of other conspicuous species were observed in association with rhodolith beds. These included sponges, seastars, gastropods and blue cod.

Table 1. Centroid coordinates, depth, relative abundance and area occupied by known rhodoliths in the Marlborough Sounds. Coordinates are NZMG.

Site	Coordinates	Location	Area (ha)	Relative abundance	Depth range (m)
Rhodolith 1	2584624.4,6037777.2	Catherine Cove, D'Urville Island	5.9	Abundant	6-26 m
Rhodolith 2	2584397.0,6037104.6	Cherry Tree Bay, D'Urville Island	6.8	Abundant	6-26 m
Rhodolith 3	2583913.6,6036760.1	Cherry Tree Bay, D'Urville Island	16	Abundant	6-26 m
Rhodolith 4	2577585.3,6030194.3	Coppermine & Ponganui Bays, Current Basin	22.3	Abundant	6-26 m
Rhodolith 5	2580354.6,6020620.8	Picnic Bay, Tawhitinui Reach	1.9	Abundant	6-18 m

Plate 1. Rhodolith bed located in Catherine Cove, D'Urville Island.

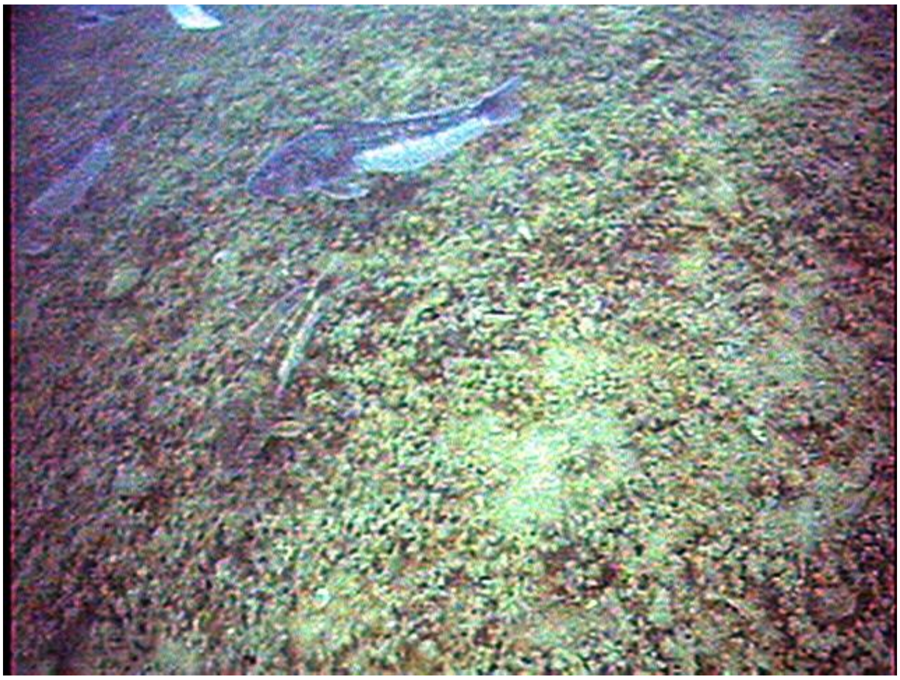

Plate 2. Rhodoliths located in Coppermine Bay, D'Urville Island.

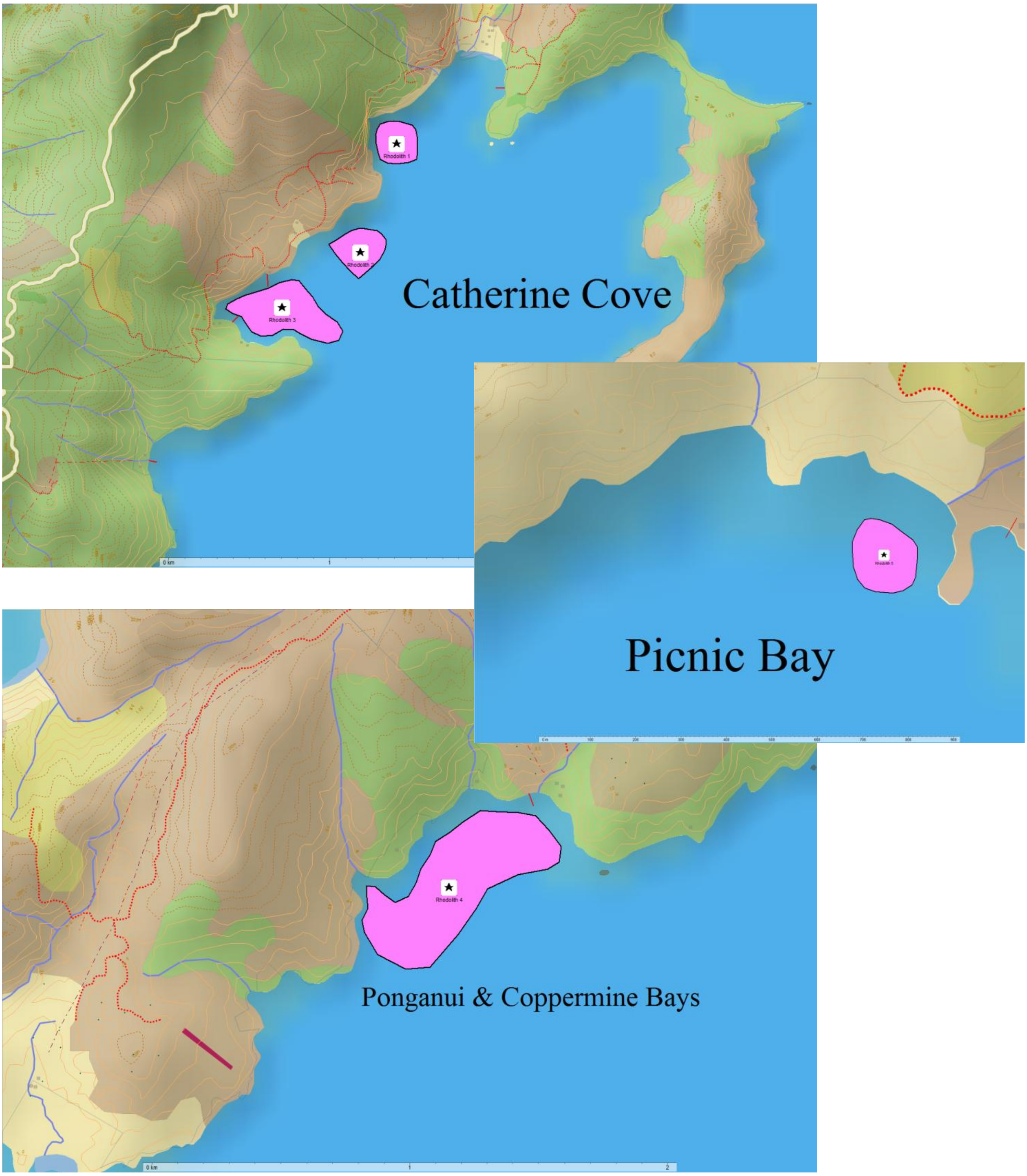

Figure 2. Rhodolith beds in Catherine Cove, D'Urville (top) Picnic Bay, Tawhitinui Reach, Pelorus Sound (centre) and Ponganui-Coppermine (bottom), Current Basin, D'Urville.

3.2 Foliose red algae beds

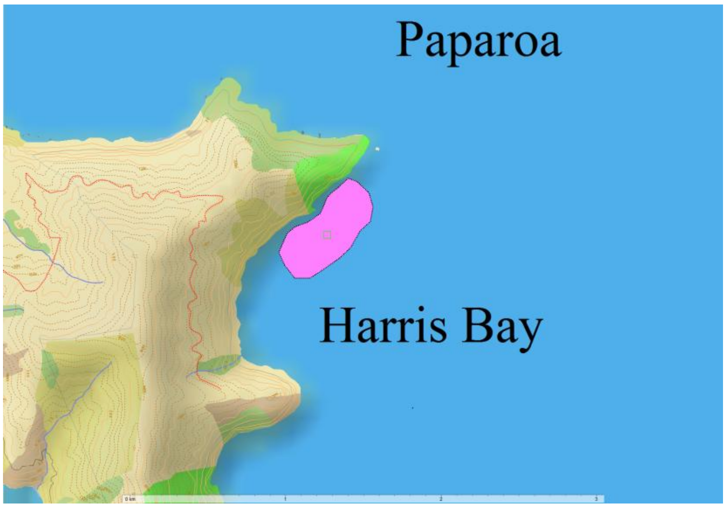

Figure 3. Red algae bed located in Harris Bay, Pelorus Sound.

Dense foliose red algae beds dominated by *Adamsiella chauvinii* were recorded from seven soft substrata locations in the Marlborough Sounds (Plates 3 and 4, Table 2). One 20.5 ha bed was located in Harris Bay outer Pelorus Sound (Figure 3), four beds were located in central Queen Charlotte Sound (Figure 4) one bed was recorded from Puriri Bay in East Bay and one in Port Underwood (Figure 5). Beds were usually located between approximately 12 to 24 m depth (Table 2). A variety of other species of red and brown algae were recorded in these areas but the dominant species was *A. chauvinii*. The percentage cover of red algae varied but was usually > 75% and often formed a 100% cover over the soft underlying substrata.

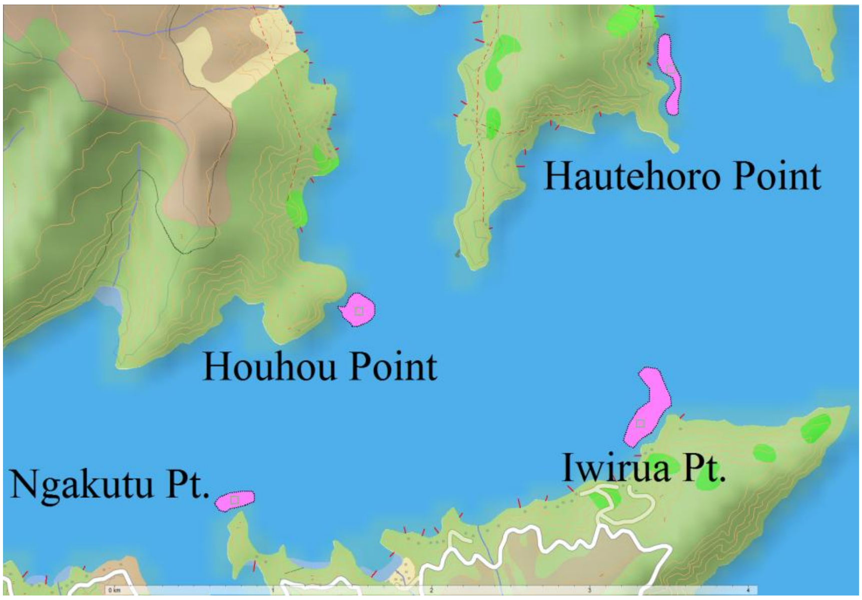

Figure 4. Location of red algae beds in inner Queen Charlotte Sound.

A variety of species were observed living in association with these algae beds. These often included scallop, soft tube tubeworms, sea cucumber, horse mussel and snake star (Plates 3 and 4). Egg cases of skate (probably rough) and elephantfish were also observed from red algae beds (Plate 5).

A variety of algal species living in association with *Adamsiella* beds were collected from HouHou Point, Queen Charlotte Sound (D'Archino et al., in press). Collections revealed the occurrence of a poorly known or undescribed red alga belonging to the genus *Pugetia* (Kallymeniaceae, Rhodophyta) associated with this biogenic habitat. Similarly, collections of alga from other biogenic habitats in the Sounds revealed the poorly known genera *Cryptonemia* and *Halymenia* (D'Archino et al. in press).

Plate 3. Scallop in a bed of foliose red algae (*A. chauvinii)* at Houhou Point.

Table 2. Centroid coordinates, depth, relative abundance and area occupied by known red algae beds in the Marlborough Sounds. Coordinates are NZMG.

Site	Coordinates	Location	Area (ha)	Relative abundance	Depth range (m)
Red alga 1	2595939.1,6031778.3	Harris Bay, Pelorus	20.5	Abundant	8-23 m
Red alga 2	2620660.7,6002747.9	Puriri Bay, East Bay	14.3	Abundant	14-24 m
Red alga 3	2591619.1,5994369.3	Houhou Point, Queen Charlotte Sound	3.2	Abundant	12-22 m
Red algae 4	2593587.3,5995896.6	Hautehoro Point, Queen Charlotte Sound	3.7	Abundant	12-22 m
Red alga 5	2590834.5,5993176.1	Ngakutu Point, Queen Charlotte Sound	2.1	Abundant	12-22 m
Red alga 6	2593394.4,5993658.0	Irirua Point, Queen Charlotte Sound	3.4	Abundant	12-22 m

Plate 4. Horse mussels, and parchment tubeworms in association with foliose red algae.

Plate 5. Skate egg cases in a bed of foliose red algae (*A. chauvinii)* at Houhou Point.

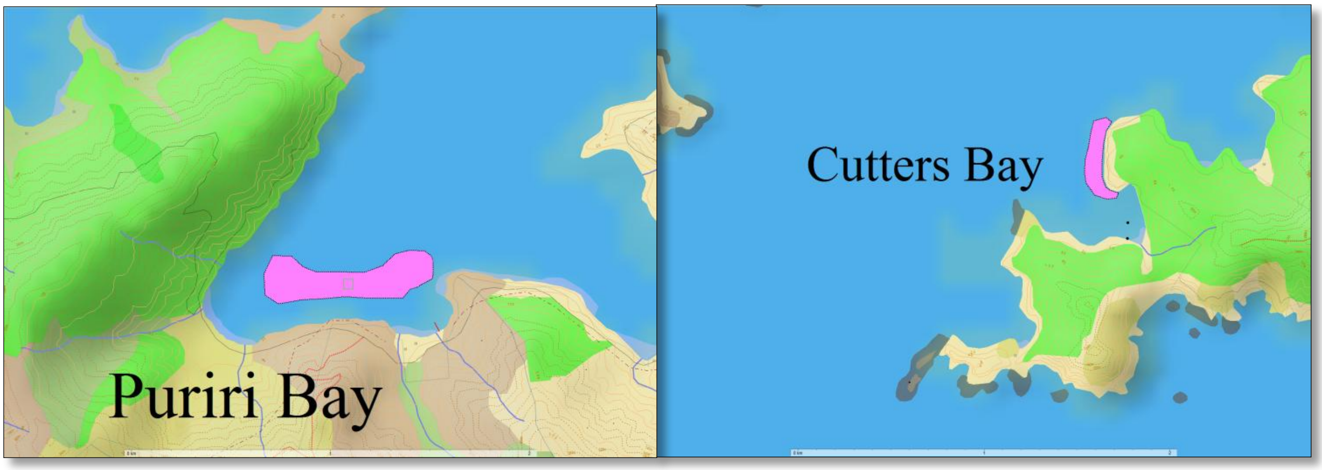

Figure 5. Location of red algae beds in Puriri Bay, East Bay (left) and Cutters Bay, Port Underwood (right).

3.3 Tubeworm mounds

Galeolaria hystrix and Spirobranchus latiscapus

Tubeworm mounds dominated by *Galeolaria hystrix* are widespread in the sheltered Marlborough Sounds. This species of tubeworm is, however, most often encountered as individual tubes growing on hard substrata. At particular locations where conditions are favourable they form three dimensional structures or mounds (Plates 5 and 6). Where these mounds exist, they are usually sparse or occasional, but at particular locations, they can be relatively common or abundant covering up to 100% of the substratum. Mounds can be found on hard and soft substratum. On soft substratum mounds appear to first establish on dead whole shell material. Once established, mounds continue to grow as new worms attach to existing members of the mound.

Perano Shoal is located at the entrance to Blackwood Bay some 10.5 km north-east of Picton (Figure 6). The Shoal peaks at approximately 6 m depth with a rocky outcrop; however, most of the Shoal is composed of fine sand, silt and broken and dead whole shell substrata. Perano Shoal is swept by moderate but regular tidal currents making is suitable for these

Figure 6. Location of tubeworm mounds at Perano Shoal, outer Blackwood Bay.

filter feeding tubeworms. On closer inspection, the tubeworm mounds were also composed of other tubeworm species including *Spirobranchus latiscapus* (Plate 6) and an unidentified *Serpula* sp. A number of small sepulid species were also observed taking advantage of the structure . A variety of other species were observed living in association with tubeworm mounds including blue cod, tarakihi, octopus, and burrowing anemone (*Cerianthus* sp.).

Two other areas where tubeworms form dense mounds were located in Port Underwood (Figures 7 and 8). These mounds were located in relatively shallow water and were first described by Davidson et al. (1995). Mounds were located at prominent headlands along the eastern shoreline of Port Underwood where tidal currents regularly bring food to these filter feeders. Tubeworm mounds are especially large at The Knobbies, the largest mounds observed from the three sites in the Marlborough Sounds. These mounds have mostly established on hard substrata (i.e. cobbles and bedrock) however, some mounds have established on adjacent soft substrata areas.

Plate 5 *Galeolaria hystrix* mounds at Perano Shoal.

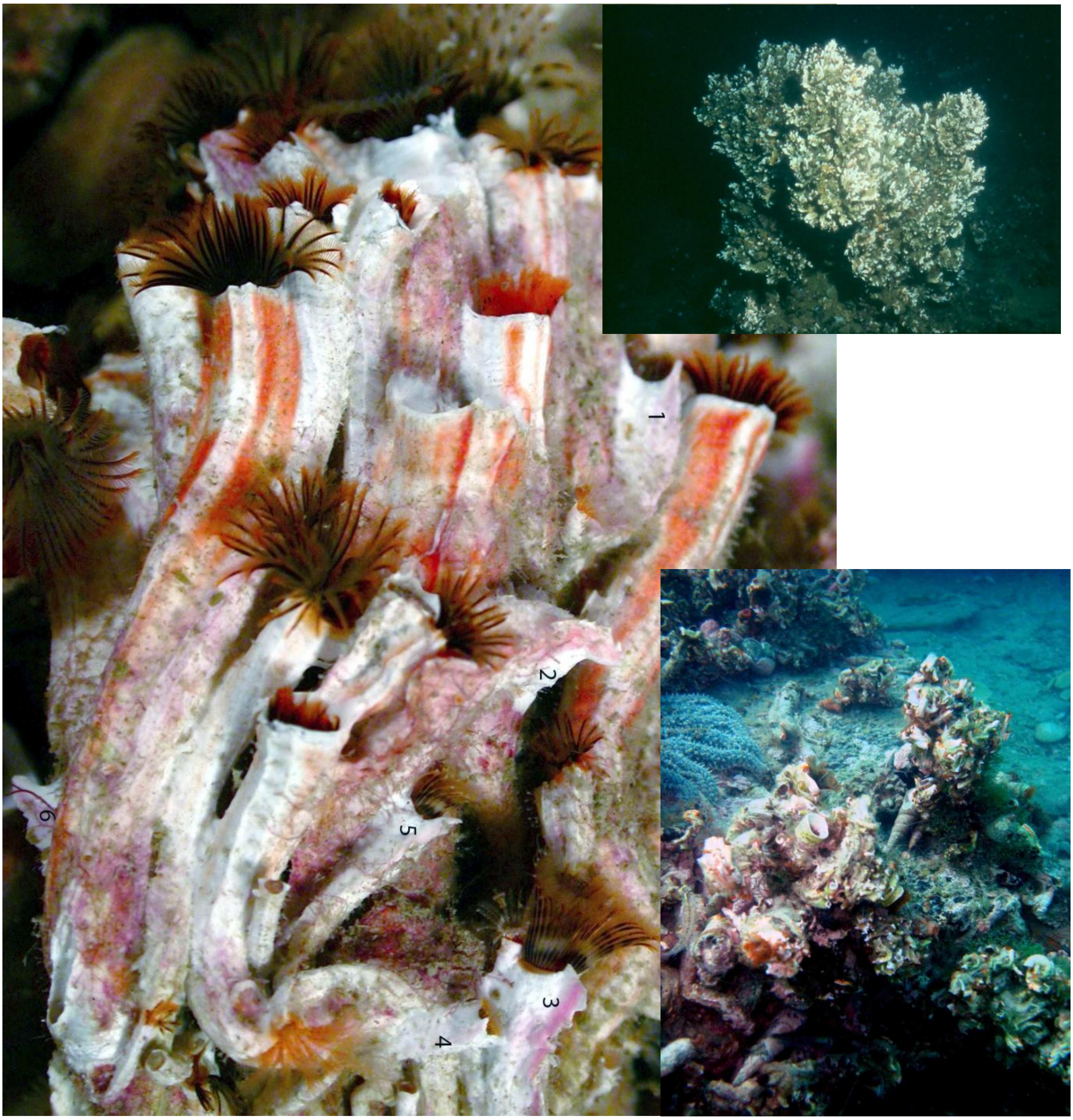

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Plate. 6 *Galeolaria hystrix* dominated mounds with a variety of associated species. The inserted numbers on left photograph show individual *Spirobranchus latiscapus* growing on *Galeolaria* tubes.

Table 3. Centroid coordinates, depth, relative abundance and known area occupied by biogenic forming tubeworm beds in the Marlborough Sounds. Note: shaded cells are tubeworms growing on hard and adjacent soft substratum. Coordinates are NZMG.

Site	Coordinates	Location	Area (ha)	Relative abundance	Depth range (m)
Galeolaria hystrix 1	2602317.6,5997391.2	Perano Shoal, Queen Charlotte Sound	3.8	Abundant	6-30+ m
Galeolaria hystrix 2	2607617.7,5988149.9	The Knobbys, Port Underwood	3.4	Abundant	3-12 m
Galeolaria hystrix 3	2606317.1,5986417.2	Whataroa Point, Port Underwood	0.9	Abundant	3-14 m
Owenia petersenae	2612883.0,6016071.8	Gannet Point	3.6	Abundant	10-12 m
Bispira bispira A.	2595088.6,5991817.7	Bobs Bay	2.9	Abundant	3-6 m

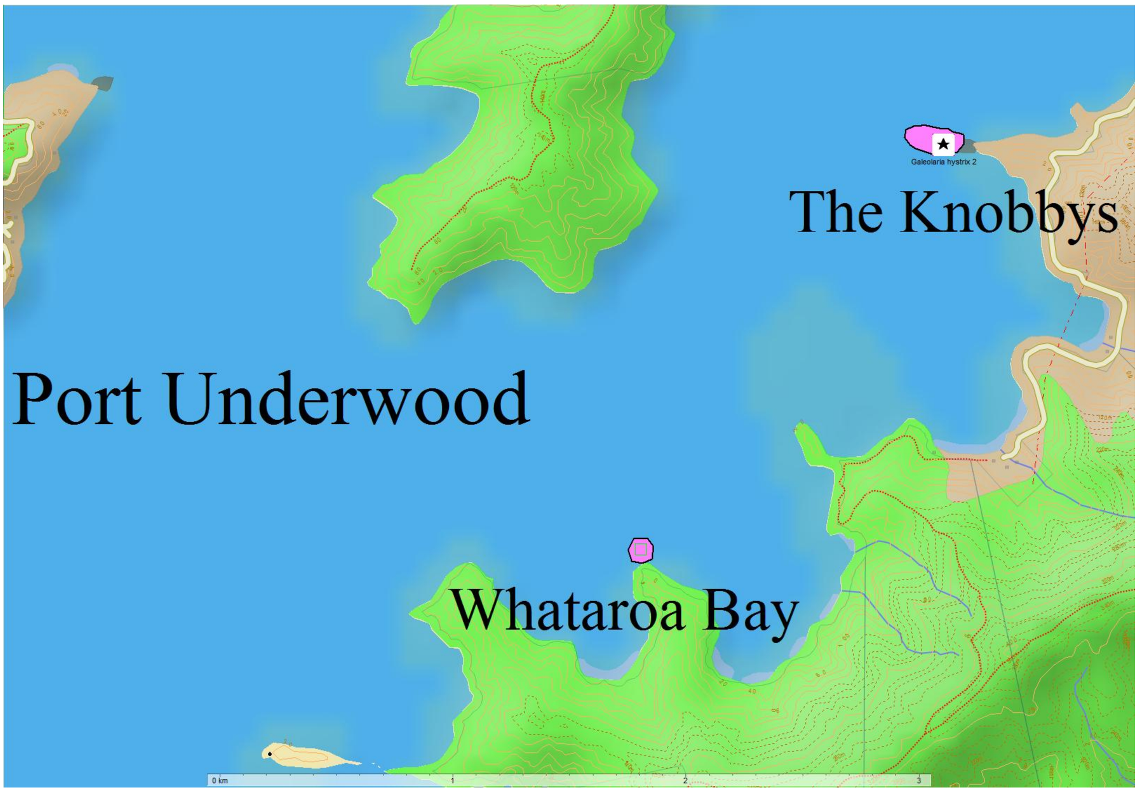


Figure 7. Location of *G. hystrix* tubeworm mounds in Port Underwood.

Owenia petersenae

At Gannet Point, Port Gore, low-lying mounds dominated by the tubeworm (*Owenia petersenae*) have colonised sand substrata between 10 and 20m depth and approximately 110-150 m distance from shore (Figure 8). In this zone biogenic mounds cover up to 90% of the

Figure 8. Location of *Owenia petersenae* bed at Gannet Point, Port Gore.

seafloor (Morrisey et al. 2009a, 2009b). A variety of other species including horse mussels, scallops, dog cockles and red macroalgae occur in association with tubeworm mounds.

Beyond 190m this community is replaced by a silt and fine sand with relatively few species and low abundance. This community assemblage is the only one of its type known in the Marlborough Sounds (Davidson et al. 1995). Colonies of this tubeworm are unusual as this species is not common outside sheltered harbours. The Gannet Point community is therefore significant at a national level.

Bispira bispira A.

At Bobs Bay in Picton Harbour a native sabellid tubeworm forms a dense cover or mat of tubes over the seafloor between 3 and 6 m depth (Figure 9). This tubeworm is relatively small with distinctive white feeding tentacles (Plate 7). At present the species is being treated as an undescribed native *Bispira bispira* A. This species has been recorded from one other site in the Marlborough Sounds as an individual from Blow Hole Point, Pelorus Sound. It is also known from Wellington Harbour, Whangarei Harbour, Mount Manganui, and Houhora Harbour in Northland.

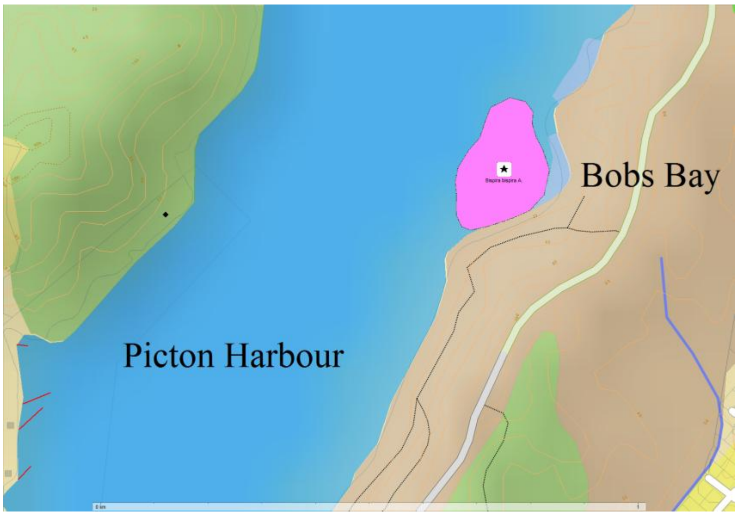


Figure 9 *Bispira bispira* (A) tubeworm bed located in Bobs Bay.

Plate 7. *Bispira bispira* (A) tubeworm bed located in Bobs Bay (photo Don Morrisey, NIWA).

3.4 Bryozoan beds

Soft bottom substrata with biogenic structures dominated by bryozoans were surveyed or identified from a variety of sources at 10 sites in the Marlborough Sounds. Two species of bryozoan C. agglutinans and *G. porcellanicus* formed three dimensional structures dominating the biogenic structure forming species at these sites.

The largest site is located along the north-western coast of D'Urville Island (Figure 10). This area has not been scientifically surveyed and the boundaries and biological attributes are based on information obtained from commercial fishers and a single mention in a scientific paper (Bradstock and Gordon 1983). It reportedly supports a bryozoan community dominated by the Separation Point coral. This area is regularly trawled by commercial fishers and it is probable that bryozoans have been damaged and their distribution reduced.

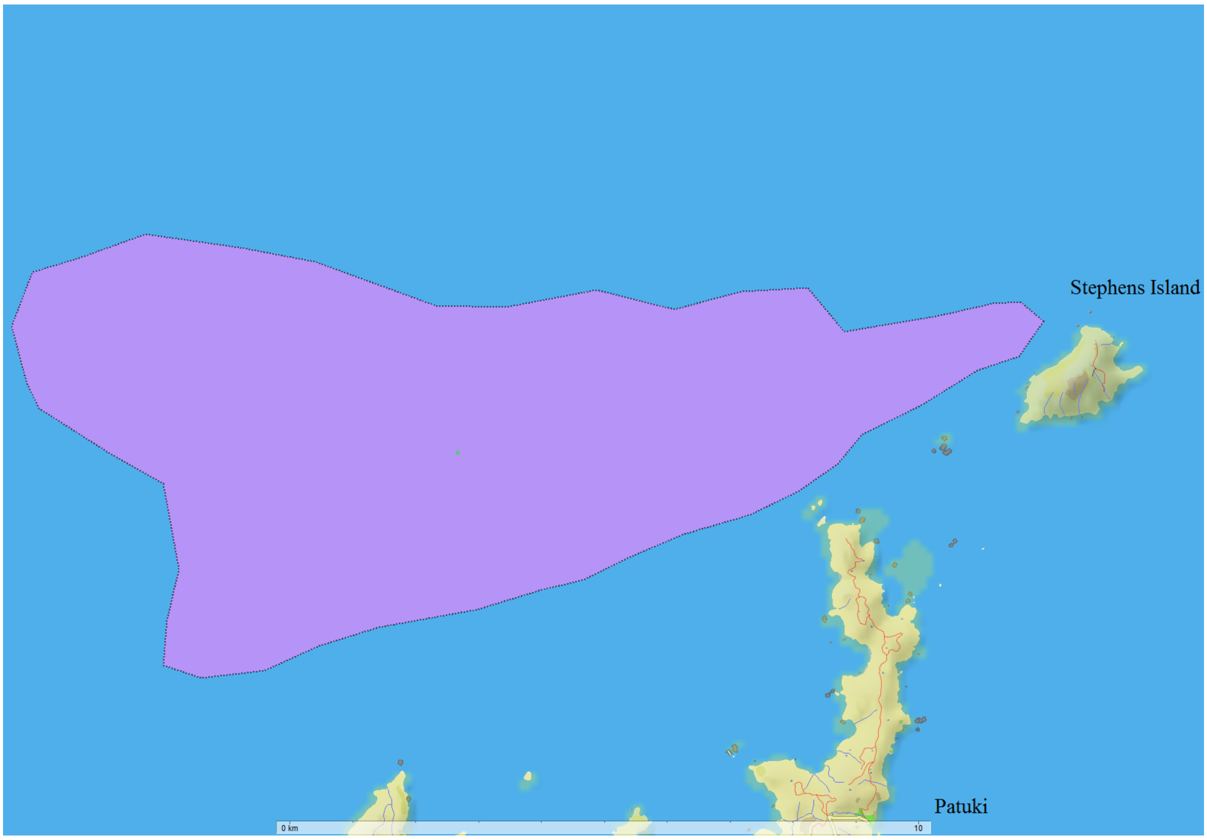


Figure 10. Bryozoan dominated biogenic site located north-west of D'Urville Island (approximate area identified by fishers).

A soft bottom seafloor dominated by bryozoans, mostly *C. agglutinans* and *G. porcellanicus* is located in the passage between the Rangitoto Islands and D'Urville Island (Figure 11) (Davidson and Brown 1994). There are isolated areas of rocky substrata in the passage that appear to have protected this approximately 430 ha area from commercial dredging and trawling. As a result this is the largest known intact area supporting dense bryozoan mounds in the Marlborough Sounds. Davidson and Brown (1994) reported a variety of species including tarakihi and blue cod living is association with these bryozoan beds. The boundaries of this area have not been accurately surveyed. The present boundaries are based on spot dives and depth soundings.

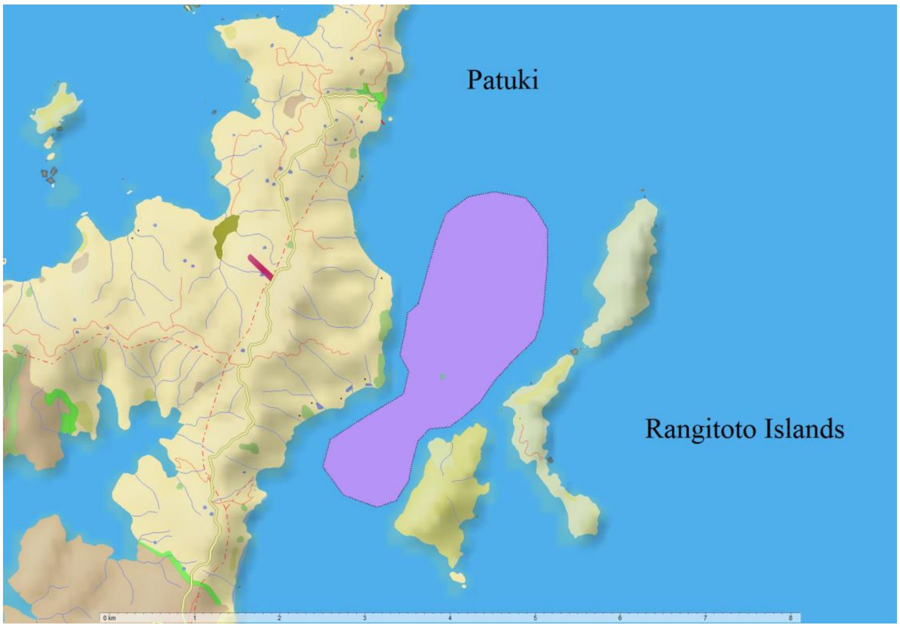


Figure 11. Bryozoan dominated biogenic site located in the Rangitoto Passage.

A 32 ha high density *G. porcellanicus* bed was located in Allen Strait at the southern end of Forsyth Island (Plate 8, Figure 12). In this area high numbers of mounds growing on combinations of soft and hard substrata are located through the Strait. This passage has also been colonised by a variety of current

Figure 12. Allen Strait bryozoan site.

dwelling species including anemones, hydroids, nesting mussels and colonial ascidians. Mats of living barnacles are found in the deeper and central parts of the Strait. The presence of the robust triplefin (*Grahamina capito*) also makes this site notable. The site is regularly fished by recreational fishers and high numbers of blue cod are always present in this area.

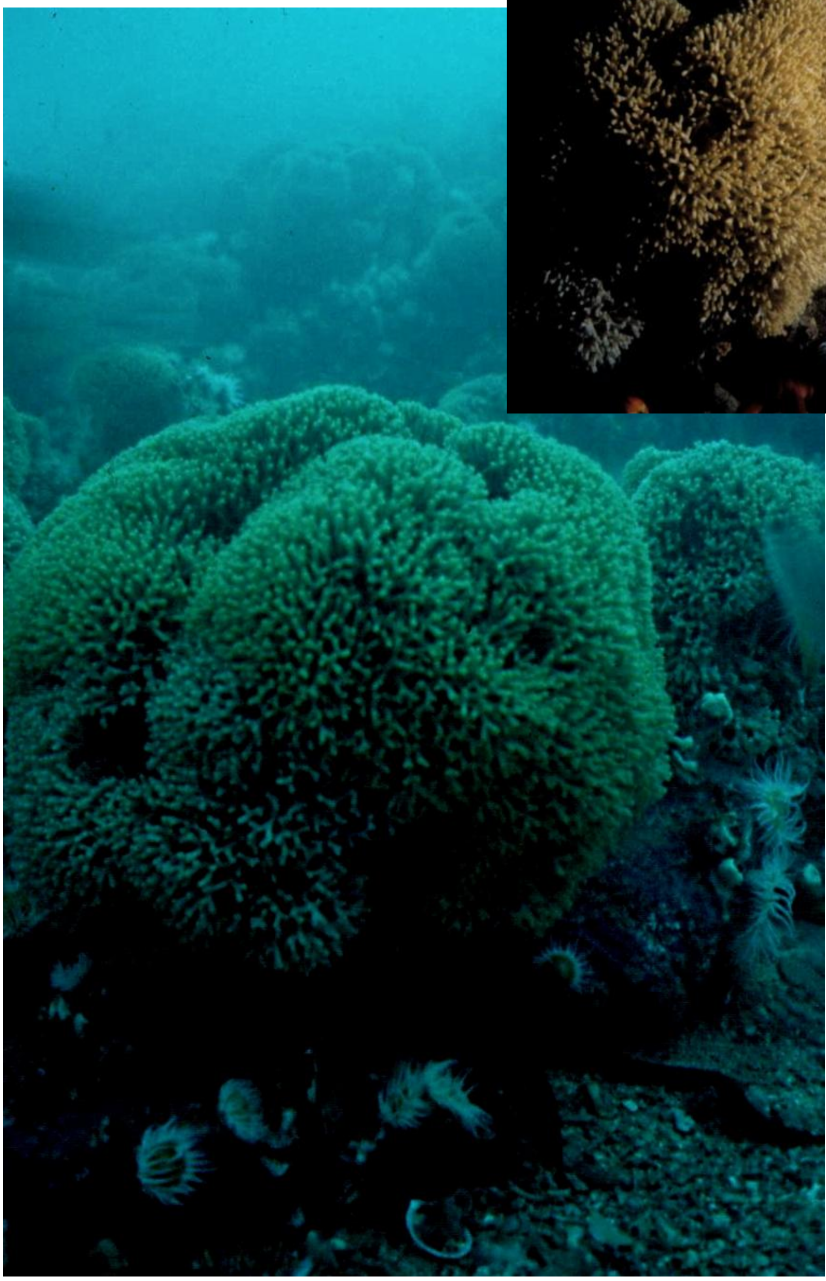


Plate 8. *G. porcellanicus* mounds located in Allen Strait.

Commercial fishers have identified two areas supporting bryozoan mounds in the Port Gore-Cape Jackson area. The Port Gore site (314 ha) is reportedly located between approximately 500 m to 4.4 km south-east of Cape Lambert, Port Gore. The bryozoan habitat is located on a sloping shore that drops into Cook Strait from the comparatively shallow areas located in the entrance to Port Gore. The second site is located east of Cape Jackson around the edges of a relatively steeply sloping shore that rises up from Queen Charlotte Sound to Cape Jackson. These areas have not been surveyed so their size, species composition intactness or level of damage from human activities remains unknown.

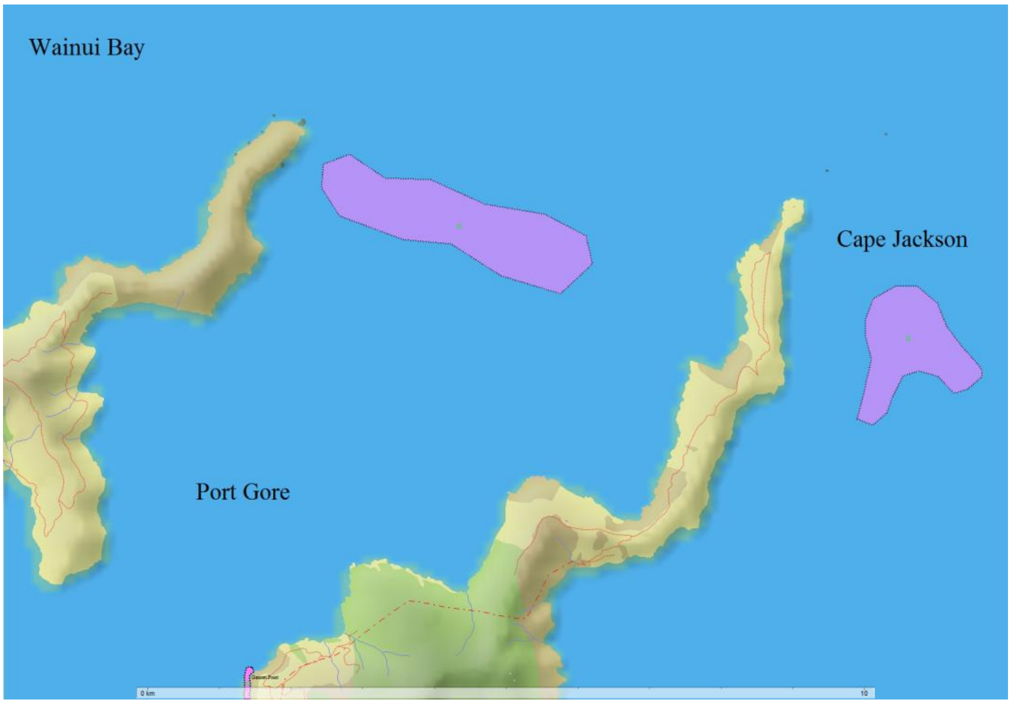


Figure 13. Approximate location of bryozoan beds located in Port Gore and east of Cape Jackson.

Table 4. Centroid coordinates, depth, relative abundance and known area occupied by biogenic forming bryozoans in the Marlborough Sounds. Coordinates are NZMG.

Site	Coordinates	Location	Area (ha)	Relative abundance	Depth range (m)
Bryozoan 1	2584420.5,6057827.9	North-west D'Urville	6288	Unknown	40-120 m
Bryozoan 2	2591723.0,6048737.8	Rangitoto, Eastern D'Uville Island	430	Abundant	10-40 m
Bryozoan 3	2599521.7,6022918.9	Allen Strait, Forsyth Bay	32.1	Abundant	10-34 m
Bryozoan 4	2615841.6,6022451.0	Port Gore	314	Unknown	25-60 m
Bryozoan 5	2622104.2,6020883.4	Cape Jackson	177	Unknown	70-120 m

3.5 Multispecies biogenic clumps (bryozoan, ascidian, sponge, hydroid, horse mussel, dead whole shell)

Biogenic habitat composed of combinations of bryozoans, ascidians, sponges, hydroids, horse mussels and dead whole shell were recorded from 14 sites in the Marlborough Sounds (Table 5). At these sites, no one species of biogenic habitat former dominated, rather clumps were formed by combinations of these species often living in association. Whole dead shell material comprised of species such as dead horse mussels and dog cockles were often a strong component at these sites.

Table 5. Centroid coordinates, depth, relative abundance and known areas occupied by biogenic clumps formed by various species in the Sounds. Coordinates are NZMG.

Site	Coordinates	Location	Area (ha)	Relative abundance	Depth range (m)
Biogenic clumps 1	2591327.6,6040028.1	Trio Island (west)	559	Sparse-common	35-44 m
Biogenic clumps 2	2595713.2,6040498.0	Trio Island (east)	1198	Sparse-common	25-40 m
Biogenic clumps 3	2605810.4,6028200.6	Titi Island, outer Sounds	52.5	Common	14-35 m
Biogenic clumps 4	2601727.1,6033578.3	Chetwode Island	71	Sparse-abundant	10-34 m
Biogenic clumps 5	2588475.9,6018057.7	Tapata Pt., Pelorus Sound	24	Sparse-abundant	10-55 m
Biogenic clumps 6	2590825.3,6017566.3	Tawhitinui Bay to Kauauroa Bay, Pel(	15	Sparse-abundant	10-55 m
Biogenic clumps 7	2590011.5,6015539.4	Tawero Point	31	Sparse-abundant	10-60 m
Biogenic clumps 8	2606041.6,5996207.6	Diefrfenbach Point (south)	6.3	Sparse-common	10-40 m
Biogenic clumps 9	2606404.4,5994860.9	Maraetai Bay, Tory Channel	3.4	Common	10-40 m
Biogenic clumps 10	2607800.9,5994380.3	Hitaua Bay, Tory Channel	20.4	Common-abundant	10-40 m
Biogenic clumps 11	2608163.6,5995223.6	Ruaomoko Pt. to Ngaionui Pt., Tory (	44	Common-abundant	10-40 m
Biogenic clumps 12	2611074.5,5995876.6	Wiriwaka Pt., Tory Channel	11	Common-abundant	10-40 m
Biogenic clumps 13	2613119.4,5995926.4	Tokakaroro Pt, Tory Channel	4.9	Common-abundant	10-40 m
Biogenic clumps 14	2614846.8,5995785.9	Te Uira-karapa Pt, Tory Channel	9.8	Common-abundant	10-40 m

Two relatively large soft bottom sites with a variable abundance of biogenic habitat were recorded from eastern and western side of the Trios Island, eastern D'Urville Island (Figure 14). On the eastern site of the Trios Island a relatively large shallow sand bank extends to the Chetwode Islands. Commercial fishers have reported that the sides of this bank historically supported biogenic structures. Based on a survey of this bank conducted during the present study, remnants of biogenic habitat were recorded from this area; however, only areas relatively close to the Trios Island supported densities of these species that formed biogenic habitat. It is probable that dredging and trawling has reduced the abundance and quality of biogenic areas along the slope of the wider area of the Trio Bank. The two areas that remain are 1198 ha (eastern) and 559 ha (western). It is possible that more biogenic habitat extends northwards from the western site towards the Rangitoto Island. This area was not surveyed during the present investigation.

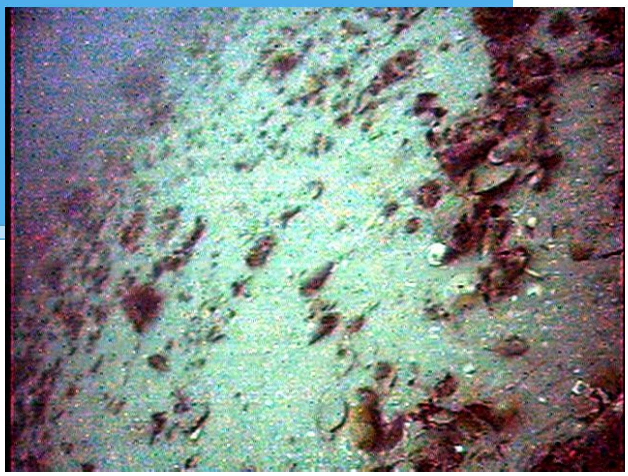


Figure 14. Location of biogenic clumps composed of combinations of bryozoan, ascidian, sponge, horse mussel and hydroid species and dead whole shell material from the Trio Islands area. Inset photo is from western Trio showing biogenic clumps comprising a variety of habitat forming species.

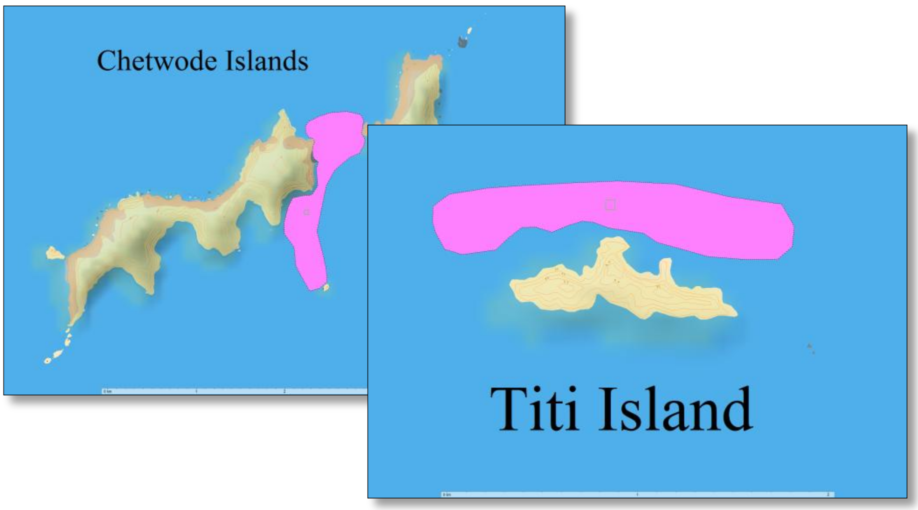
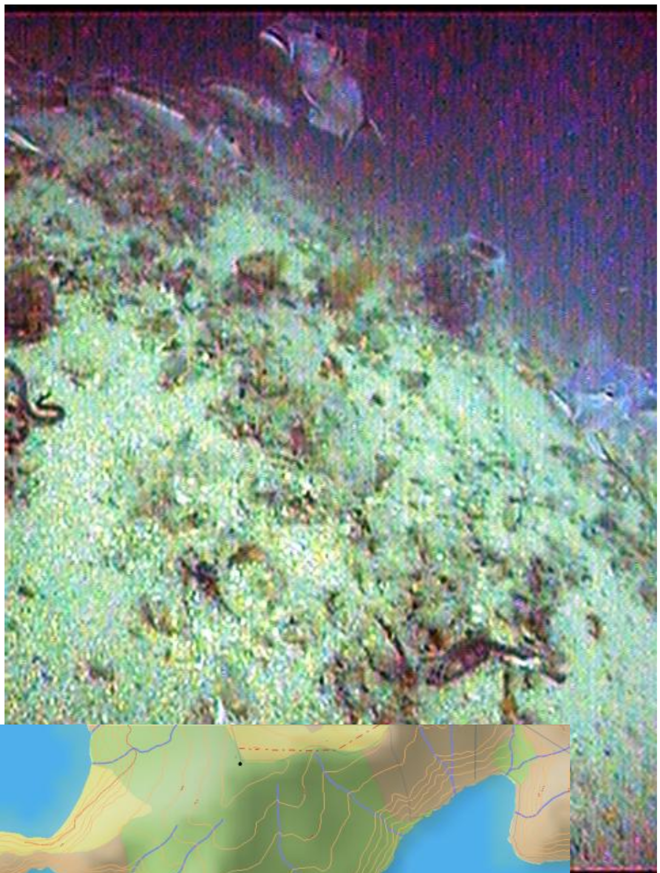


Figure 15. Location of biogenic clumps composed of bryozoan, ascidian, sponge, horse mussel and hydroid species and dead whole shell material from Chetwodes Island (left) and Titi Island (right).

Three areas that support biogenic habitats were recorded in the Tawero Point area (Figure 16). Biogenic structures were recorded on both hard (i.e. cobbles, boulder and bedrock) and adjacent soft substrata in these areas. These areas are all swept by moderate to strong tidal currents making it suitable habitat for biogenic species and species that live in association with these structure forming animals.



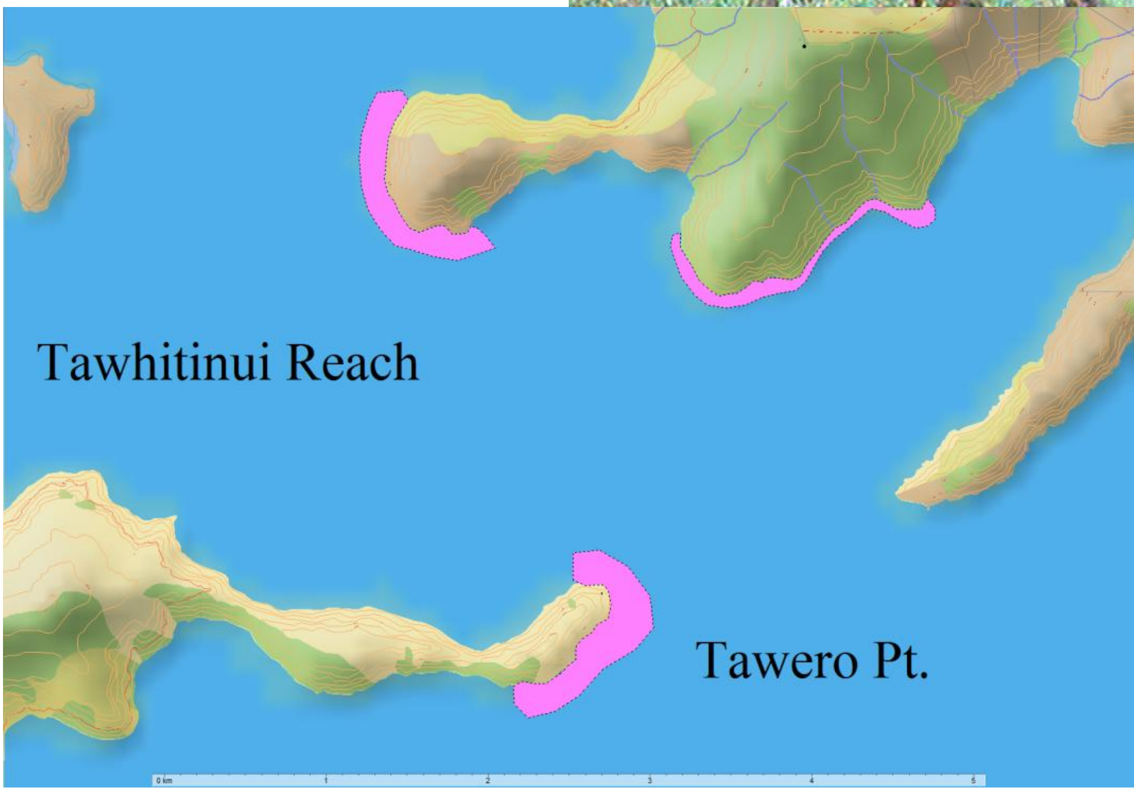


Figure 16. Location of biogenic features from the Tawero Point area. Insert photo: sponge, shell and hydroid dominated community with associated blue cod.

Six soft bottom areas in Tory Channel support a range of biogenic habitat forming species often in a high percentage cover over the benthos (Figure 17). These sites were all located along the sides of the main tidal channel of Tory Channel. The soft bottom is characterised by relatively coarse material including dead whole and broken shell. Biogenic mounds appear to often be initiated by the bryozoan (*C. agglutinans*), however, the mounds are often smothered by other biogenic habitat forming species such as sponges, hydroids, and ascidians (Plates 9 and 10). A variety of fish were observed in association with these sites including blue cod, tarakihi and sea perch.

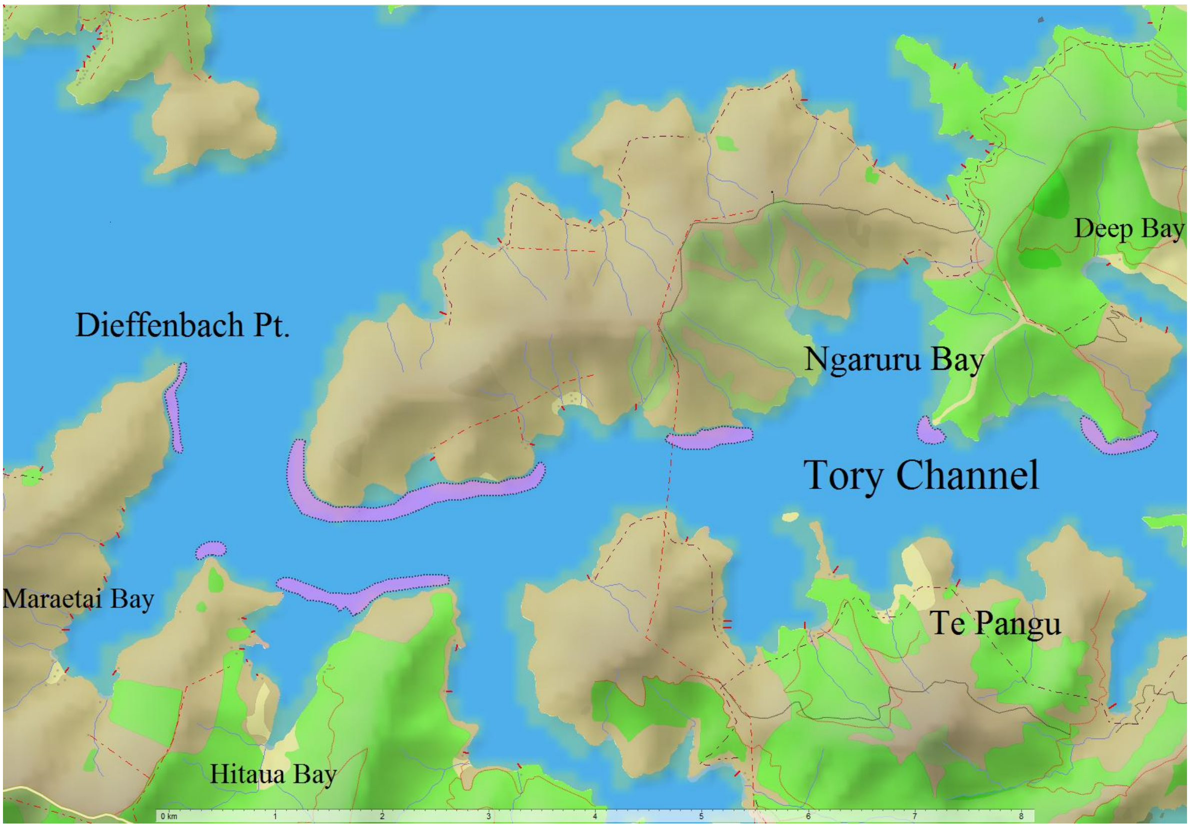


Figure 17. Location of known biogenic clump (bryozoan, ascidian, sponge, hydroid) dominated habitats on soft substrata in Tory Channel.

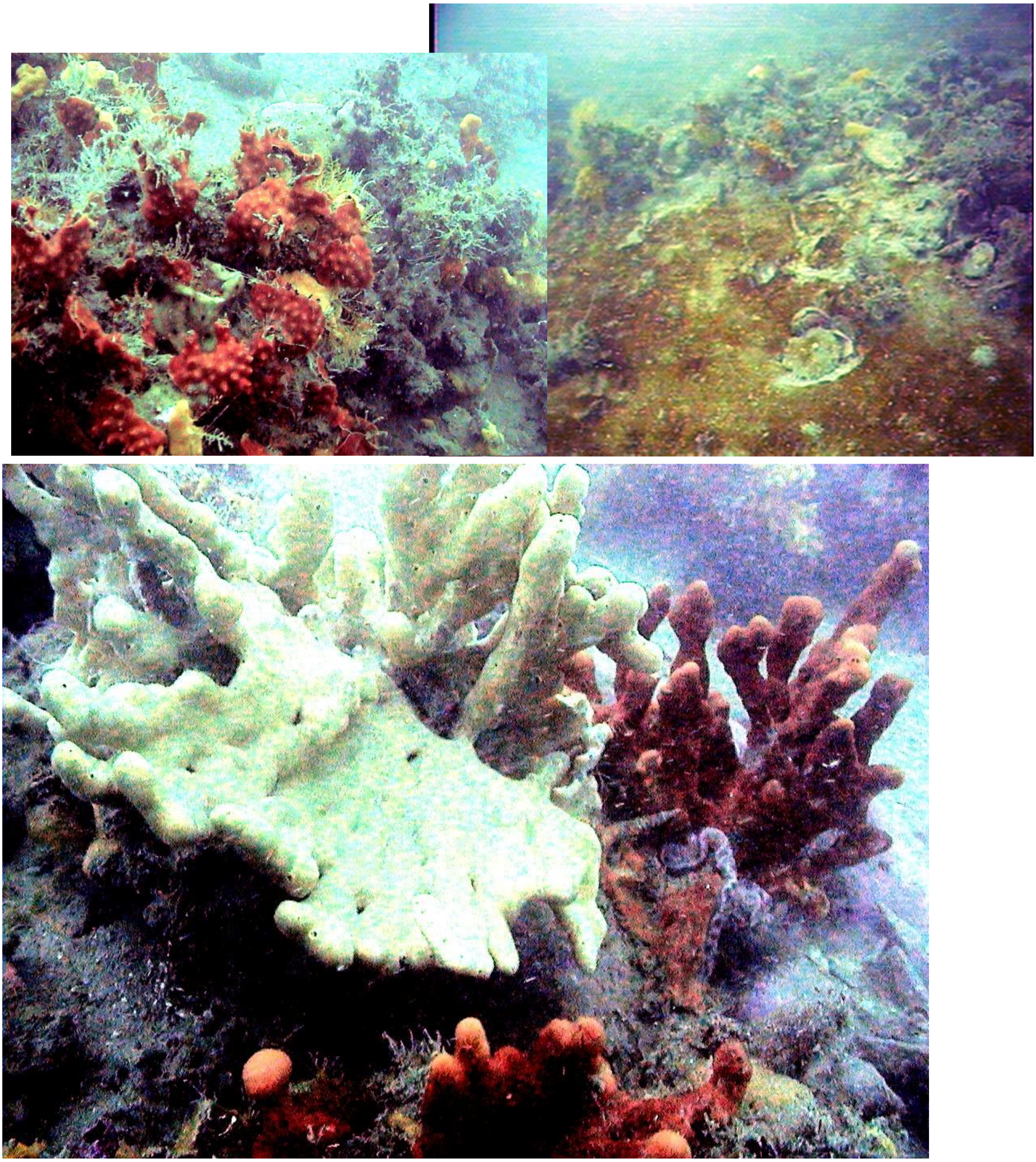


Plate 9. Biogenic structures formed by a variety of species. Mounds are often formed initially by *C. agglutinans* (see top left), but are colonised by a variety of other species including sponges (bottom) and hydroids (top right).

Plate 10. Biogenic structures on soft substrata in Hitaua Bay area, Tory Channel.

3.6 Horse mussels

Horse mussels in relatively high densities formed biogenic habitat at seven locations known in the Marlborough Sounds. Horse mussels were recorded from sparse to common abundance at a Crail Bay and a Clova Bay site (Table 6). Relatively few encrusting species were observed in association with these horse mussels compared to other areas in the Sounds.

Table 6. Centroid coordinates, depth, relative abundance and known area occupied by horse mussels forming a biogenic habitat in the Marlborough Sounds. Coordinates are NZMG.

Site	Coordinates	Location	Area (ha)	Relative abundance	Depth range (m)
Horse mussel 1	2591376.0,6007527.3	Crail Bay	6.3	Common-abundant	6-20 m
Horse mussel 2	2597429.1,6010864.3	Clova Bay	14.3	Common	6-14 m
Horse mussel 3	2610629.2,6023461.9	Wainui Bay	295	Unknown	10-24 m
Horse mussel 4	2614179.5,6021070.3	Port Gore (offshore)	636	Unknown	20.22 m
Horse mussel 5	2610786.7,6019197.8	Port Gore (inshore)	11.2	Abundant	6-22 m
Horse mussel 6	2618582.5,6013413.5	Motuarua Island	415	Common	6-20 m
Horse mussel 7	2622188.4,6002669.9	Te Aroha Bay (East Bay)	9.3	Common	6-25 m

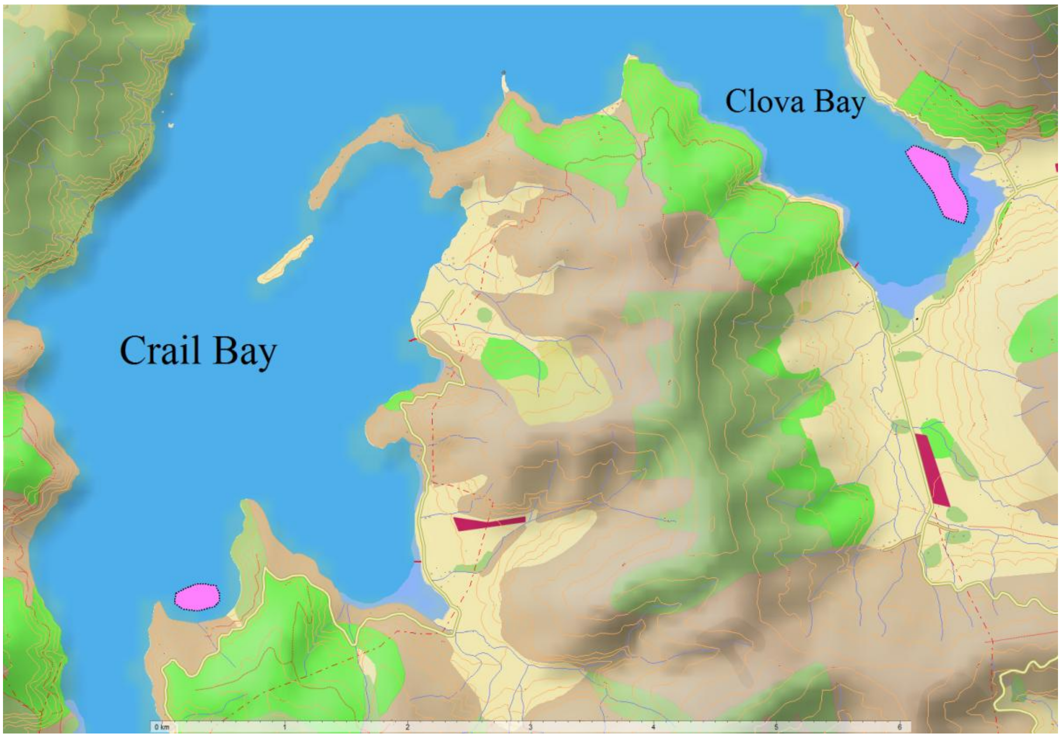


Figure 18. Horse mussel beds in Clova and Crail Bays.

Plate 11. Horse mussels at Crail Bay.

Two large offshore areas have been reported to support beds of horse mussels in Wainui Bay and Port Gore (historic NZOI data C. Hay). No recent surveys have occurred in these areas and the abundance and quality of the biogenic habitats are unknown. During this early work considerable numbers of macroalgal samples were collected and deposited in the herbarium at Te Papa. Many were listed in Nelson et al. (1992).

Duffy et al., (in prep.) reported dense horse mussels in association with giant kelp and a variety of other encrusting invertebrates from a relatively large area north of Motuara Island. The boundaries of this area have not been surveyed and remain approximate (Figure 20). A relatively small bed of horse mussels is known from Te Aroha Bay (Davidson and Pande 2002; Davidson and Richards 2005) (Figure 20). A variety of encrusting invertebrates has been observed in association with these horse mussels including, queen scallop, scallops, hydroids, ascidians, snake stars, and a number of gastropod molluscs.

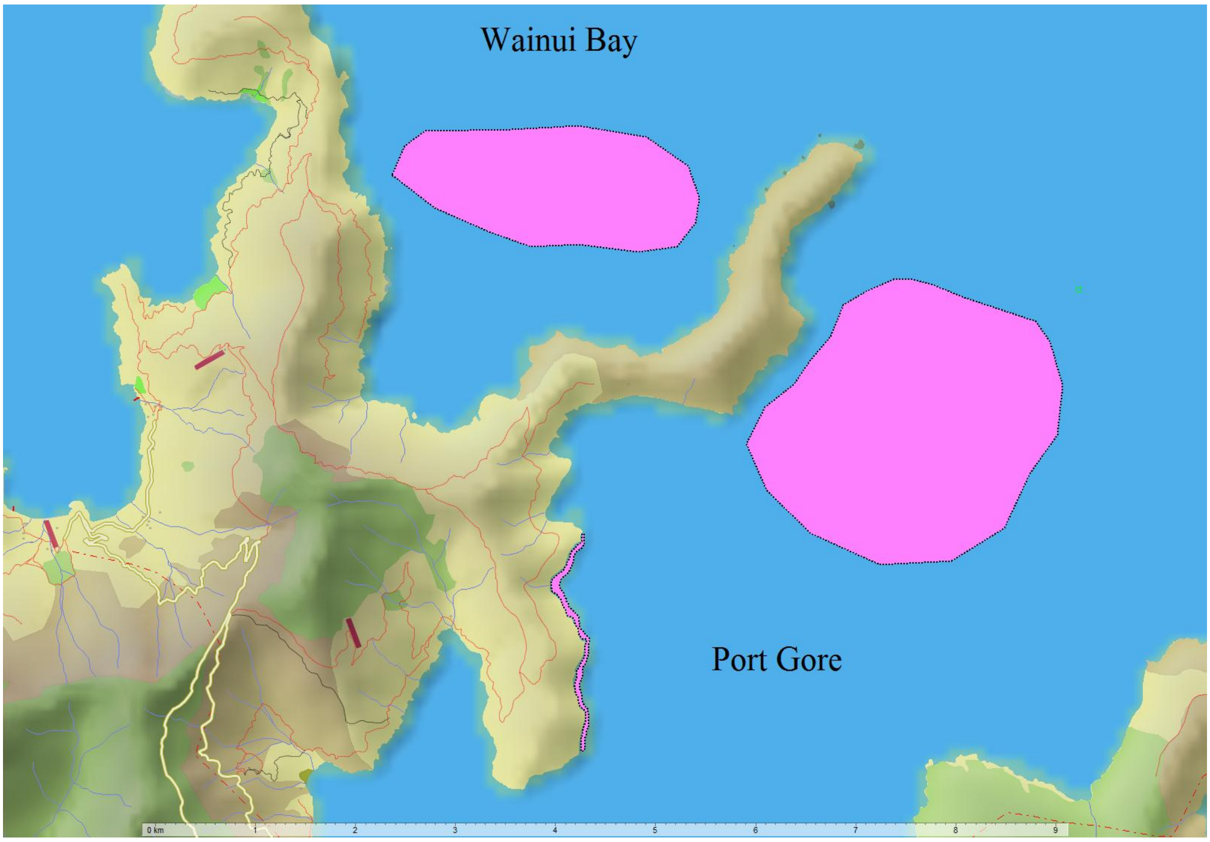


Figure 19. Approximate locations of offshore historic horse mussel beds located in Wainui and Port Gore and an inshore horse mussel bed in Port Gore.

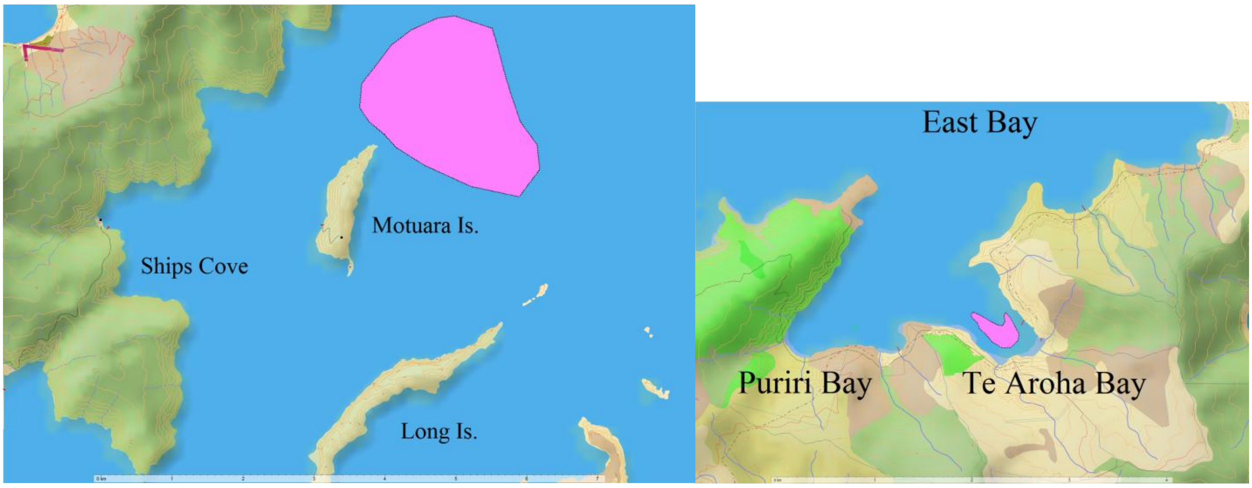


Figure 20. Location of horse mussel beds north of Motuara Island (approximate boundaries) and Te Aroha Bay, East Bay (right).

5.0 Discussion

A variety of organisms act as ecosystem engineers forming three dimensional biogenic structures that usually provide habitat for an abundance and rich diversity of species (Hicks 1971; Brown and Taylor 1999; Stewart 1982; Bradstock and Gordon 1983; Dittman 1990; Sorokin 1995; Bianchi and Morri 1996; Ferdeghini and Cocito 1999; Lenihan 1999; Bordehore et al. 2003; Steller et al. 2003; Chittaro 2004; Scharf et al 2006; Foster et al. 2007). Biogenic habitat forming species also perform a variety of other biological functions. Non-geniculate coralline algae for example, release compounds that have been implicated in the settlement and morphogenesis of a range of species including abalone (paua) larvae (Daume et al. 1999; Morse 1991; Morse et al. 1996; Moss 1999; Roberts 2001). Internationally some rhodolith species provide important habitat for commercially harvested fishes and shellfishes. Kamenos et al. (2004) found significantly higher numbers of juvenile queen scallops (*Aequipecten opercularis*) in pristine rhodolith beds in the north-east Atlantic compared to adjacent habitats and all other substrata surveyed.

A number of studies of fishes in marine reef and seagrass habitats have shown that habitat structure can play an important role in influencing juvenile survivorship (e.g. Heck and Thoman 1981, Persson and Eklov 1995, Rooker et al. 1998). Thrush et al., (2002) found that complex benthic habitat structure had a positive influence on juvenile snapper in northern New Zealand. The authors stated that given the 3D nature of biogenic features in sedimentary habitats, and the often high levels of predation on juvenile life stages, it is likely that if biogenic habitat structure plays a role in the population dynamics of a fish species, this role will be most important for juvenile life stages (Scarf et al. 2006). Morrison (1999) reported highest density scallop beds in Northland, New Zealand on coarse substrata such as shell gravel, rhodoliths and grit compared to substrata softer sediments such as mud.

Distribution of biogenic habitats in the Marlborough Sounds

In the present study, a variety of biogenic habitats were recorded from the Marlborough Sounds. Some habitats were dominated by one biogenic constructing species such as a bryozoan or horse mussel bed, while others were formed by a number of species found in relatively high abundance. For example, bryozoan mounds were often colonised by other biogenic species such as sponges, hydroids, tubeworms and ascidians. These secondary settling species all added to the three dimensional form of the habitat.

Largest biogenic habitats were recorded from outer Marlborough Sound locations with smaller and localised habitats being found from within the sheltered areas of the Sounds. This phenomenon is likely related to the environmental variables required by biogenic habitat forming species. For many species, water flow provided by tidal currents is preferred. Relatively large areas at particular locations in the outer Sounds provide good tidal flow, while inside the Sounds these areas are often small in size or localised around headlands or narrow tidal channels such as Tory Channel. Sedimentation rates may also influence the distribution of biogenic habitats within the Sounds. Sheltered areas of the Sounds often have relatively high turbidity and are dominated by silt and clay substrata. In the outer Sounds turbidity is lower and substrata is usually characterised by sand and shell substrata.

Some biogenic habitat forming species showed a preference for specific locations. For example, rhodoliths were found along the western shores of Catherine Cove, but were absent from the eastern shoreline southward to French Pass despite comparable depths and shore aspects being present. Even within Catherine Cove, rhodoliths were abundant within bays but were absent from areas adjacent to headlands. The reasons for this phenomenon are unknown, but this information may assist with the selection of other areas for survey in an effort to discover more rhodolith beds in the future.

There is little doubt that the distribution, abundance and composition of biogenic habitats has altered since the arrival of humans to the Marlborough Sounds. Some of the outer Sounds areas surveyed were reported by fishermen as supporting dense biogenic habitat; however results showed that only sparse three dimensional habitats remain. It is therefore probable that the present distribution of biogenic habitats in the Marlborough Sounds is a combination of environmental variables and the impact of human related activity.

Threats to biogenic habitats

Commercial fishing for demersal fishes and benthic invertebrates is commonly undertaken with mobile fishing gear that can inflict damage to seafloor habitats (Dayton et al., 1995; Engel and Kvitek, 1998; Jennings and Kaiser, 1998; Watling and Norse, 1998; Kefalas et al., 2003; Thrush et al 2006) and reduce biodiversity (Thrush et al. 2001; Thrush and Dayton 2002; Hewitt et al. 2005; Airoldi et al. 2008). Habitat damage from dredges used more often in relatively shallow inshore waters and designed to excavate invertebrates partially or completely buried beneath the surface of the seafloor, are generally much more severe than the damage caused by bottom trawls (Collie et al., 2000). Furthermore, impacts on and recovery from bottom-disturbing fishing gear vary with habitat type; generally smaller effects and more rapid rates of recovery are found for infauna in sedimentary habitats and the most severe and long-lasting damage in biogenic habitats that emerge from the seafloor (Peterson et al., 1987; Collie et al., 2000).

Trawling and dredging in biogenic habitats results in the reduction of the three-dimensional benthic structure often leading to bare or flattened habitats; a reduction or the complete loss of the habitat and a subsequent reduction in biological diversity (Airoldi et al. 2008, Jackson 2008, Nelson 2009). Trawling and dredging deposits sediment over a wide area around fished tracks and suspension feeders suffer from clogged gills, while algae such as rhodoliths can be smothered. Kamenos et al. (2003) looked at the heterogeneity of substrates in dredged versus non-dredged rhodolith beds and found non-dredged beds had higher structural heterogeneity, and that much of the rhodolith bed was killed post-burial by a lack of light. Similar results are reported by Bordehore et al. (2003) examining the impacts of otter trawling on rhodolith beds in Spain, and by Riul et al. (2008) who observed decreases in primary production of up to 70% when rhodoliths were buried by a thin sediment layer.

Dredging can also have a negative impact on the target species. Morrison (1999) reported a dredge mortality to sub-legal scallops in Northland, New Zealand with the number of undersize animals killed per legal animal harvested estimated at 1.7 and 2.8 : 1, depending on the size frequency structure of the fished bed. Lenihan and Peterson (2005) stated that a major cause of the steep decline of the biogenic reef building American oyster was the loss of oyster habitat through the use of dredging. Unexpectedly, the authors reported that hand harvest of oysters from non-dredged areas produced 25-32% more oysters per unit of time compared to traditional dredging, while dredging reduced the height of reef habitat by 34% compared to 6% caused by diving. The authors stated that conservation of the habitat and sustainability of the fishery would be enhanced by fishers switching from dredging to diving methods. The authors also argued that oyster loss hurts not only the oyster fishery but, more importantly, imperils the ecosystem services provided by the oysters. These included provision of emergent habitat and reef-dependent prey resources for many fish and crustacean populations of commercial and recreational importance (Peterson et al., 2000; Lenihan et al., 2001; Peterson et al., 2003), and the promotion of biodiversity by provision of hard-bottom habitat in fields of mobile sediments (Wells, 1961).

Cranfield et al. (2003) reported on a widespread loss of bryozoan beds in Foveaux Strait due to extensive dredging for oysters. Cranfield et al. (2001) reported areas where these habitats were returning suggesting these habitats were capable of recovery. Jiang and Carbines (2002) found that diet of blue cod from dredged areas were different to areas where biogenic habitats were recovering. In the present study, evidence of human related impacts was observed on occasion. At Te Aroha Bay, recreational scallop dredge tracks were observed bisecting the horse mussel bed with individual mussels showing signs of damage and/or disturbance. Anecdotal evidence was provided by discrepancies between fishers' accounts of biogenic habitats and the quality of habitats recorded during the present study. For example, fishers described abundant biogenic habitat along the sides of the Trio Bank located east of the Trio Islands. During the present survey at total of 54 drop camera photos were collected with only one photograph showing abundant biogenic habitat. The reliability of anecdotal information based on fishers' perceptions and scientific information has been investigated and found to often be in agreement (Rochet et al., (2008). The most probable explanation for the change in habitat quality is therefore likely to be related to human related impacts.

Biogenic structures and their associated communities are also vulnerable to impacts from various land-based activities (e.g. land clearance leading to increased sedimentation of adjacent marine areas, agricultural run-off from high intensity farming resulting in eutrophication of inshore waters). Large tracts of the Sounds were cleared in the 1800's and early 1900's for farming. More recently large areas have been used for pine forest production. Although not observed during the present study directly it is probable that sedimentation has altered the extent, quality and distribution of biogenic habitats inside the Sounds. For example, red algal beds were relatively rare in the Pelorus Sound and where present were confined to the outer Sound. This Sound is subjected to high turbidity events from the Pelorus River in flood. In contrast, relatively large red algae beds were widespread in Queen Charlotte Sound where no major freshwater river is present. Aquaculture also has the potential to impact on biogenic habitats. Peña and Bárbara (2008), found that 19 rhodolith beds in the vicinity of mussel farming or aquaculture were partially or totally degraded.

The recovery of some biogenic habitats may be slow or may never occur. Hall-Spencer and Moore (2000) compared the effects of scallop dredges used on a previously unfished rhodolith bed in Scotland with similar beds that had been fished. A single tow of three dredges (~230m^2 ground contact) was found to have effects that remained clearly discernible four years after dredging.

Identification and management of biogenic habitats

Internationally, the process of identification and management of areas that support biogenic habitats has started due to the biological and human related values of these areas. Nelson (2009) stated that deleterious impacts on calcified algae for example, will in turn have very serious implications for the recruitment of invertebrates and the maintenance of biodiverse and nursery habitats.

In New Zealand limited information is known about the location of biogenic habitats. In many areas, commercial fishers have kept their existence secret for fear of area closures or restrictions. In some instances biogenic habitats in inshore waters have been recognised and some level of management executed (Bradstock and Gordon 1983), but in many cases no management of these areas has been implemented. Exceptions do exist in New Zealand with large areas of the Hauraki Gulf closed to dredging due to its importance as a juvenile snapper area, while a relatively large area in Tasman Bay is close to commercial dredging to protect bryozoan mounds.

On 15 November 2007 17 areas in New Zealand's Exclusive Economic Zone (EEZ) were closed to bottom trawling, providing protection to an area of seabed habitat equal to 1.2 million square kilometres, or an area four times the landmass of New Zealand. This is the largest single marine protection initiative in a nation's Exclusive Economic Zone (EEZ) anywhere in the world. New Zealand has now protected 32 % of its EEZ from bottom trawling. The total protected area includes (a) 28 % of underwater topographic features (including sea mounts); (b) 52 % of sea mounts (underwater mountains over 1000 metres in height); and (c) 88 % of active hydrothermal vents. These protected areas are, however, all located in deep water (www.fish.govt.nz/en-nz/Environmental/Seabed+Protection+and+Research/Benthic+Protection+Areas.htm). The Ministry of Fisheries has stated that in the short term (to 2013), the focus of marine protection will shift to the Territorial Sea (from the coast to the 12-mile limit), where the problems are more immediate and most acute and where the risks to marine biodiversity are greatest and where the highest economic, social and cultural values are found.

6.0 Conclusions

A variety of areas in the Marlborough Sounds that support biogenic habitats are outlined in the present report. Few areas have been described or mentioned in the scientific literature; instead most are new or have been identified by fishers or the public during the present investigation. Some of these areas have been surveyed by a variety of techniques, while others were surveyed many years ago and the presence and quality of these habitats is uncertain. Some areas have not been surveyed but have been included in the present report as the anecdotal information warrants their future investigation.

Historically in New Zealand there have been few scientific studies investigating biogenic habitats. Smith et al. (2005) described biogenic habitats in Paterson Inlet and suggested that legislative protection of the Big Glory Bay serpulid reefs could be justified on the basis of the importance of shelter and hard substrate in biodiversity and abundance of both sessile and motile species.

It is strongly recommended that more research in New Zealand is carried out in relation to biogenic habitats. It is suggested that the focus of such work should be: (1) identification of the location, distribution and boundaries of biogenic habitats (2) description of the composition and quality of these habitats, especially those that have not been scientifically surveyed, (3) study into the ecology of these areas, especially in relation to their importance as a habitat and an enhancer of increased biodiversity, (4) identification of the threats to these areas, and lastly (5) provide options and implement management of these biologically important areas to ensure their values are protected.

Acknowledgments

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