Davidson Environmental Limited

Significant marine site survey and monitoring programme (survey 5): Summary report 2018-2019

Research, survey and monitoring report number 943

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Summary

Davidson and Richards (2015) conducted the first survey and monitoring programme of Marlborough's significant marine sites in the summer of 2014 - 2015. Their study focused on sites initially described in Davidson *et al*. (2011). Davidson and Richards (2015) investigated sites located in Queen Charlotte Sound, Tory Channel and Port Gore using protocols detailed in Davidson *et al.* (2013). The second and third survey events were conducted in the outer north-western Marlborough Sounds and Croisilles Harbour (Davidson and Richards, 2016; Davidson *et al*., 2017). Sites investigated in the present study were in the Pelorus Sound biogeographic region.

A variety of qualitative and quantitative methods were adopted (Davidson *et al.,* 2013). Methods varied between sites depending on site specific environmental factors and information needs outlined in Davidson *et al.* (2014). As part of the present survey programme, a remote HD video and still photograph GoPro Hero 4 (black) fitted with a macro lens and a Hero 7 was also used to collect HD media at selected sites.

A total of 11 sites are described in the present report. At four existing significant sites, additional data were collected and presented (Tennyson Inlet, Penzance Bay, Ouokaha Island and Deep Bay). Of these, it is suggested that two sites be increased in size. Four potential new significant sites (Hitaua Bay Head, Rat Point Reef, Nikau Bay outer coast, and Gold Reef Bay (west)) were described. Of these, Hitaua Bay had been a significant site previously. Three sites were investigated that did not support biological values likely to be sufficient to warrant ranking as a significant site.

For the existing significant sites, proposed increases were: Tennyson Inlet 673.22 ha and Deep Bay 0.07 ha. These increases were due to either an improvement in the level of detail or redefining of the boundaries. No existing significant sites declined in size.

Parts of the Tennyson Inlet significant site were impacted by the exotic tubeworm in the Family Chaetopteridea. This worm was abundant at many locations between 4 to 12 m depth. It is possible these tubeworm beds may influence egg-laying elephantfish.

Direct human impact was observed at Ouokaha Island where approximately 11% of tubeworm mounds had been likely impacted by anchoring. Indirect human impact from sedimentation was observed at proposed new site along the coast north and south of Nikau Bay. Inorganic rubbish was observed under a moored boat in Penzance Bay.

Specialists in research, survey and monitoring

This report makes recommendations to the MDC expert review panel. These recommendations may not be adopted by the expert panel. Therefore, the status of each site remains pending until assessment occurs (see Davidson *et al.,* 2013 for the process).

Marlborough's significant marine sites are likely remnants of larger areas reduced or lost due to historic anthropogenic activities. Davidson and Richards (2015) stated that, based on their 2015 survey, it was clear some of the remaining significant sites were being degraded or lost. The present study suggests some significant sites are naturally protected from physical disturbance by natural structures such as rock and reef systems, however, some sites are still vulnerable to damage and loss. Protection of significant sites therefore remains a priority for coastal managers.

Note: Raw data collected during the 2018-2019 season were collated into excel spreadsheets and supplied to MDC for storage (e.g. HD video, photographs). The present report is a therefore a summary and does not include all raw and compiled data.

Table 1. Summary of recommended significant sites.

Attribute	Values
Suggested significant site area (ha) *	1922.11
Potential new sites*	4
Potential site removed*	0
Increase in area (ha) *	693.59
Decrease in area (ha) *	0
Overall change (ha) *	693.59
Sites *	Work conducted/recommendations
Site 3.9 Tennyson Inlet (stable protected catchment)	Adjust boundaries, protect significant site from most forms of physical disturbance
Site 3.28 Penzance Bay (elephantfish egg-laying)	Update database, protect significant site from most forms of physical disturbance
Site 3.26 Ouokaha Island (tubeworm mounds)	Update database, protect from all forms of physical disturbance
Site 5.5 Hitaua Bay Head (estuary and cockle bed)	Establish significant site and protect from most forms of disturbance
Site 5.7 Deep Bay (subtidal cockles)	Adjust boundaries, protect significant site from most forms of physical disturbance
Rat Point (reef)	Establish significant site and protect from all forms of disturbance
Nikau Bay outer coast (biogenic community)	Establish significant site and protect from all forms of disturbance
Gold Reef Bay (west) (biogenic community)	Establish significant site and protect from all forms of disturbance
Pukatea Bay (east)	Reject as a significant site
Pigyard Bay (west)	Reject as a significant site
Catherine Cove (north)	Reject as a significant site

*Recommended but subject to expert peer review

1.0 Background

The Resource Management Act requires local authorities to monitor the state of the whole or any part of the environment (s35 2(a)). Additional obligations also exist, such as maintaining indigenous biodiversity (s30 1(g)(a)). The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna is a matter of national importance (Section 6(c)).

Since 2010, the Marlborough District Council (MDC) has supported a programme for surveying and assessing marine sites within its region. A key milestone in this programme was the publication of a report identifying and ranking known ecologically significant marine sites in Marlborough (Davidson *et al.*, 2011). The assembled group of expert authors developed a set of criteria to assess the relative biological importance of a range of candidate sites. Sites that received a medium or high score were ranked "significant". A total of 129 significant sites were recognised and described during that process.

The authors stated their assessment of significance was based on existing data or information but was not complete. Many marine areas had not been surveyed or the information available was incomplete or limited. The authors stated that ecologically significant marine sites would exist but remain unknown until discovered. In addition, some significant sites were assessed on limited information. Further, some existing sites required more investigation to confirm their status. The authors also stated that many sites not assessed as being significant had the potential to be ranked at a higher level in the future as more information became available. They also recognised the quality of some existing significant sites may decline over time due to natural or human related events or activities. The authors therefore acknowledged that their report had limitations and would require updating on a regular basis.

Two subsequent reports were produced. Davidson *et al.* (2013) produced a protocol for receiving information for new candidate sites and for reassessing existing ecologically significant marine sites. The aims of that report were to ensure a rigorous and consistent process that establishes:

(1) The level of information required for new candidate sites.

(2) The process for assessment of new sites and reassessment of existing sites.
(3) A protocol for record keeping, selection of experts and publication of an updated ecologically significant marine sites report.

Davidson *et al*. (2014) provided a report outlining "guidance on how to continue a survey and monitoring programme for ecologically significant marine areas in Marlborough and to assist with the management and overarching design of such work to optimise the collection of biological information within resource limitations". This report had the following objectives:

(1) Provide survey and monitoring options for MDC to consider based on different levels and types of investigation (e.g. health checks, regular monitoring, surveys of new sites, and surveys to fill information gaps at existing sites).
(2) Prioritisation of survey and monitoring based on factors such as ecological distinctiveness, rarity and representativeness, as well as vulnerability, issues and threats to marine values.
(3) Recommend a simple, robust, and repeatable methodology that enables site health to be monitored and assessed.
(4) Provide guidance on the assessment of a site's health that can be conveyed to Council and the community in a simple but effective way that will aid tracking of changes in site condition.

In particular, Davidson *et al.* (2014) aimed to add to the ecologically significant marine sites programme by providing guidance for the collection, storage and publication of biophysical data from potential new significant sites as well as existing sites. The biological investigation process was separated into three main elements:

(1) Survey of new sites;
(2) Collection of additional information from existing significant sites or sites that previously were not ranked as being ecologically significant; and
(3) Status monitoring of existing significant sites (i.e. site health checks).

1.1 Field survey 1 and expert peer review

Davidson and Richards (2015) undertook the first survey following the protocols outlined in Davidson *et al.* (2013, 2014). The authors focused on selected sites detailed by Davidson *et al.* (2014) in Queen Charlotte Sound, Tory Channel and Port Gore. These areas were selected by a joint MDC/DOC monitoring steering group that also considered advice from Davidson

Environmental Ltd. At the time, it was agreed that the work should focus on biogenic habitats because of their biological importance (e.g. substratum stabilisation, increase biodiversity, juvenile fish habitats, food sources). Biogenic habitats were also prioritised as they have a history of being adversely affected by a variety of anthropogenic activities (Bradstock & Gordon, 1983; Morrison, 2014).

The work presented by Davidson and Richards (2015) was then reviewed by the expert review panel and their findings produced in Davidson *et al*. (2016). Davidson *et al.* (2016) stated: "The expert panel was reconvened to reassess the new information for the 21 sites and sub-sites outlined in Davidson and Richards (2015). The review report presents the findings of that reassessment. It also comments on issues associated with physical disturbance of significant sites supporting benthic biological values and appropriate management categories for the protection of those values."

The expert panel also made alterations to some of the seven criteria originally used to assess significant sites as developed by Davidson *et al*. (2011).

The Panel's overall findings recommended that:

(1) three sites be removed from the list of significant sites due to the loss or significant degradation of biological values (Hitaua Bay Estuary, Port Gore (central) horse mussel bed, and Ship Cove).

(2) the offshore site located north of Motuara Island be removed and replaced with a small area located around a rocky reef structure.

(3) adjustment to the boundaries of most of the remaining significant sites in accordance with the recommendations of Davidson and Richards (2015).

Based on the removal of the three sites and several boundary adjustments, a total of 1544 ha was removed and 113.8 ha added at the significant site level. The overall change between that recorded in 2011 and 2015 was a loss of 1430.8 ha of significant sites.

1.2 Field survey 2 and expert peer review

Prior to the 2015-2016 field work season, a report outlining potential or candidate sites for survey and/or monitoring was produced (Davidson, 2016). That report was used to guide the selection of sites surveyed and described in the second field survey report by Davidson and Richards (2016).

Davidson and Richards (2016) reported on a total 15 sites and sub-sites. The authors suggested that five sites and sub-sites be increased in size (178.4 ha total), while eight sites and sub-sites be reduced (-214.6 ha). One site remained unchanged between surveys (Hunia king shag colony). A new site was also described at Lone Rock, Croisilles Harbour (rhodoliths bed = 4.68 ha). Penguin Island (suggested Site 2.37) was initially described by Davidson *et al*. (2011) as part of a larger site (Site 2.12) and was not therefore recorded as an increase. This site was resurveyed as it supported a different range of habitats and communities compared to the original larger site (2.12). The remaining sites and sub-sites increased or declined in size due to an improved level of survey detail. No sites were identified as no longer supporting significant values.

The Davidson and Richards (2016) report was reviewed by the MDC expert peer review panel (Davidson *et al*., 2016). The expert peer review panel accepted all but one boundary modification proposed by Davidson and Richards (2016). The panel recommended that the Chetwode significant site (2.20) remain unchanged and only be enlarged when further data were collected to support an increase in size.

The review panel also suggest one change to the Davidson *et al*. (2011) criteria. Criteria 7 (adjacent catchment modification) was amended to include a "not applicable" option in recognition of sites located in areas little influenced by catchment effects.

The new rank is: **NA = The site is little influenced or is not influenced by catchment effects.**

The reviewed boundary refinements suggested by Davidson and Richards (2016) led to both increases and decreases to the size of individual significant sites and an overall decline of 262.6 ha between 2011 and 2016.

For each significant site, the expert peer review panel assessed anthropogenic threats based on (1) the level of anthropogenic disturbance and (2) the site's vulnerability (Table 2). This assessment was based on the review panel's knowledge of the biophysical characteristics of each significant site (e.g. personal knowledge and/or from the literature).

Similar approaches have been adopted by Halpern *et al.* (2007) and further adapted for the assessment of New Zealand's marine environment by MacDiarmid *et al.* (2012). Robertson and Stevens (2012) described an ecological vulnerability assessment (originally developed by UNESCO (2000)) for use at estuarine sites in Tasman and Golden Bays. The UNESCO methodology was designed to be used by experts to represent how coastline ecosystems were likely to react to the effects of potential "stressors".

Anthropogenic disturbance is the known or expected (based on experts' experience) level of impact associated with human-related activities. Disturbance levels range from little or no disturbance (low score) to sites regularly subjected to disturbance (high score). Impacts range from direct physical disturbance to indirect effects, including from the adjacent catchments.

Vulnerability is the sensitivity of habitats, species and communities to disturbance and damage. Scores ranged from relatively robust species or habitats such as coarse substrate/mobile shores and high energy kelp forests (low vulnerability score) to extremely sensitive biological features such as lace corals and brittle tubeworm mounds (high vulnerability score).

Table 2. Selected environmental variables used to assess the vulnerability of significant sites to benthic damage from physical disturbance.

Variables	Descriptions, definitions and examples
Anthropogenic disturbance level	
Low	Little or no human associated impacts. Catchment effects low (i.e. vegetated, stable catchments).
Moderate	Light equipment and/or anchoring disturbance. Well managed catchment.
High	Subjected to regular and heavy equipment, seabed disturbance, and/to catchment effects high due to modification or poor management.
Vulnerability	
Resilient (low or unlikely)	Algae forest, coarse substrata, moderate or high energy reef, high energy shore, short-lived species.
Sensistive (moderate)	Horse mussels, soft tubeworms, shellfish beds, red algae bed, low current (sheltered reefs).
Very sensitive (high)	Massive bryozoans, sponges, hydroids, burrowing anemone.
Extremely sensitive (very high)	Lace or fragile bryozoans, tubeworm mounds, rhodoliths.

1.3 Field survey 3 and expert peer review

A total of 10 sites were described during the study of 2016-2017. One site (Titi Island) was split into 3 sub-sites while one site (Rangitoto Islands) was split into four sub-sites. Sub-sites were defined as having comparable habitats and communities, but each sub-site was physically separate. One new sub-site was added to an existing set of three sub-sites at Hunia (Port Gore). In total, 15 sites and sub-sites were investigated.

Three new sites were investigated and described (6.04 ha). Three sites increased in size by a total of 583.3 ha (Sites 1.2, 2.10 and 2.33). Increases were due to an improvement in the level of survey detail. Four sites declined in size by a total of 458.9 ha (Sites 2.6, 2.27, 2.30 3.1). Declines were due to a combination of improved information and, in two cases (Sites 2.30

and 2.27), a loss of habitat likely due to physical damage. No existing significant sites were recommended for removal.

1.4 Field survey 4 and expert peer review

A total of 14 sites were described during the study of 2017-2018. Six potential new significant sites (Woodlands west rhodoliths, Ouokaha Island coast, Tuhitarata Bay reef, Matai Bay tubeworms, Penzance Bay elephantfish egg-laying, Treble Tree coastline) were described. Matai Bay tubeworms and Penzance Bay elephantfish egg-laying sites were located within the larger Tennyson Inlet site.

Three existing significant sites increased in size by a total of 146.2 ha: site 3.9 = 143.12 ha, site 3.12 = 1.175 ha and site 3.15 = 1.9 ha. Those increases were due to either an improvement in the level of detail or redefining of the boundaries. Four sites declined in size by a total of 112.68 ha (Sites 3.7, 3.8, 3.11 and 3.25). Declines were mostly due to the improved level of information, however small areas of site 3.8 (Fitzroy elephantfish egg-laying habitat) were impacted by marine farms and therefore removed. Parts of this significant site (i.e. Garne and Savill Bays) were impacted by the exotic alga *Asperococcus bullosus* (Nelson and Knight, 1995). This brown alga was abundant and often covered much of the benthos. Further, these bays appeared siltier compared to historic observations conducted in the 1990's. It is unknown if one or both factors explain the decline in elephantfish egg cases recorded during the present study. Another exotic species was also widespread at site 3.8. A tubeworm in the Family Chaetopteridea was abundant at many locations between 4 to 12 m depth. It is possible these tubeworm beds may also influence egg-laying elephantfish.

Direct human impact was observed at three of the potential new significant sites (site 3.23 Woodlands west, site 3.26 Ouokaha Island, site 3.29 Treble Tree coast). At site 3.26, *Galeolaria hystrix* tubeworm mounds had been overturned, probably from anchors or anchor chains used by recreational fishers. At site 3.23, farm anchor blocks had been dragged through the rhodolith bed. At site 3.29, evidence of commercial dredging was observed. No existing significant sites were recommended for removal.

Overall, the Expert Panel (Davidson *et al*., 2018a) accepted all the boundary modifications proposed by Davidson *et al*. (2018). Five new sites were also accepted by the Panel, while one site (Treble Tree coast) proposed by Davidson *et al*. (2018) will be reassessed in the future once more data is collected.

2.0 Study sites (present study)

All sites investigated during the present study were in Pelorus Sound (i.e. Pelorus Sound biogeographic area identified in Davidson *et al*., 2011) (Figure 1, Table 3). Study sites were in central and inner Pelorus Sound, including Kenepuru Sound, Hikapu Reach, Beatrix complex, Fitzroy complex, Tennyson Inlet and Waitata Bay. Most sites had existing data collected during the Davidson *et al*. (2011) study or from a variety of sources including DOC studies and marine farm investigations.

3.0 Methods

A variety of standard survey methods were adopted to investigate sites. Different survey methods were used at each site depending on the level of survey required (i.e. survey or monitoring) and the environmental variables at each site (e.g. depth, water currents, water clarity).

In the 2018-2019 survey season, an algal bloom was present for most of the summer reducing water clarity. Further, water clarity remained low due to large storm events during the summer of 2017-2018. Both these factors acted to reduce the quality of photographic and video media.

3.1 Sonar imaging

Sonar investigations were conducted at selected sites using a Lowrance HDS-12 Gen 2 and HDS-8 Gen2 linked with a Lowrance StructureScan^{TM} Sonar Imaging LSS-1 Module. These units provide right and left side imaging as well as DownScan Imaging^{TM} and were linked to a Point 1 Lowrance GPS Receiver. The unit also allows real time plotting of StructureMap^{TM} overlays onto the installed Platinum NZ underwater chart. A Lowrance HDS 10 Gen 1 unit fitted with a high definition Airmar 1KW transducer was used to collect traditional sonar data from the site. Sonar data were converted into a Google Earth file to overlay onto Google Earth imagery.

3.2 Drop camera stations and site depths

At each drop camera station, a standard resolution Sea Viewer underwater splash camera fixed to an aluminium frame was lowered to the benthos and an oblique still photograph was taken where the frame landed. The locations of photograph stations were selected to obtain a representative range of habitats and targeted any features of interest observed from sonar (e.g. reef structures, cobbles). On many occasions, the survey vessel was allowed to drift for short periods while the benthos was observed on the remote monitor. Field notes were collected and appended to the relevant data spreadsheet.

3.3 Percentage cover estimation

The percentage cover of biological features (e.g. rhodoliths, macroalgae, biogenic clumps) from GPS-positioned drop camera images were estimated both in the field by the boat observer and in the laboratory on the computer screen. Percentage cover was estimated into 5% class intervals by the same trained recorder at all sites and for all images to ensure consistency. All photo images were numbered and coded to a GPS position, depth and a percentage cover score.

3.4 Underwater HD video and still photographs

HD underwater video was collected using a remote GoPro Hero 4 (black) or Hero 7. The camera was either (a) mounted on a purpose-built frame and tripod or (b) hand operated by a diver. The camera also collected HD still photographs at 5 second intervals. Depending on water conditions, the GoPro Hero 4 was often fitted with a macro-lens to improve video resolution, especially at close quarters.

When the GoPro was remotely lowered to the benthos, the survey vessel was allowed to move in a controlled fashion across a selected area. Video footage and photos were collected by allowing the camera to settle on the benthos and then intermittently moved across the benthos. The area selected for investigation was based on findings from the low-resolution camera and sonar data. The start and end GPS positions for video footage were recorded.

3.5 Surface photos

A representative surface photo was collected from most sites using a Samsung S8 in panoramic mode. Selected surface photos have been included in the Excel spreadsheets, while all photos collected are held on the MDC database.

3.6 Species sampling

No species samples were collected during the present study.

3.7 Elephantfish egg case counts

Divers collected quantitative data on the density of elephantfish egg cases at two sites chosen within the known area where egg cases have been previously recorded in Penzance Bay, Tennyson Inlet on 6th March 2019. At each sample site, divers each counted egg cases from either four or ten 10 m^2 quadrats. The total number of 10 m^2 quadrats sampled was 28.

From each quadrat, divers recorded depth (m) and the number of live and hatched egg cases. Quadrats were sampled haphazardly by divers swimming at least 5 m distance between the finish and start of each quadrat. Quadrats were sampled by deploying a 1 m^2 metal frame contiguously a total of 10 times. The GPS position at a centroid position at each site was also recorded.

3.8 Tubeworm mound densities and damage estimates

Divers collected quantitative data on the density and level of damage for tubeworm mounds (*Galeolaria hystrix*) from three transects installed at Ouokaha Island, Crail Bay on 6th March 2019. A lead line transect marked at 5 m intervals was deployed from the survey vessel onto the benthos prior to each dive. The transect line was deployed perpendicular to the coast at three locations along the western side of the island (north, middle and south).

At each transect, divers swam from the low tide mark to a depth where rocky substrata ceased (i.e. 45 to 55 m distance from low water). Divers recorded the number of tubeworm mounds from a 4 m wide swath. The size of each mound was estimated and recorded (height, length, width) and each mound was ranked as damaged or undamaged. A damaged mound was classified as having broken parts of the colony.

Divers also recorded depth (adjusted to datum) and dominant substratum every 5 m distance along the transect. The GPS position at the start position of each transect was also recorded.

3.9 Excel site sheets and data

Data collected from each site during the present study were entered using a predesigned Excel template. Data sheets include a summary page and several other pages comprising data, maps, photos, sonar images and sample coordinates. A complete set of data for each site is stored on the MDC database. The spreadsheets also outline other data types that have been stored at MDC for each site (e.g. video clips).

3.10 Ranking

No assessment or ranking of sites was carried out during the present investigation. Recommendations for each site are, however, included in page 1 of the Excel site spreadsheets. Each year, the expert review panel conducts a ranking exercise based on the findings and recommendations from the present report. The panel's findings are produced in a separate report for each sample year.

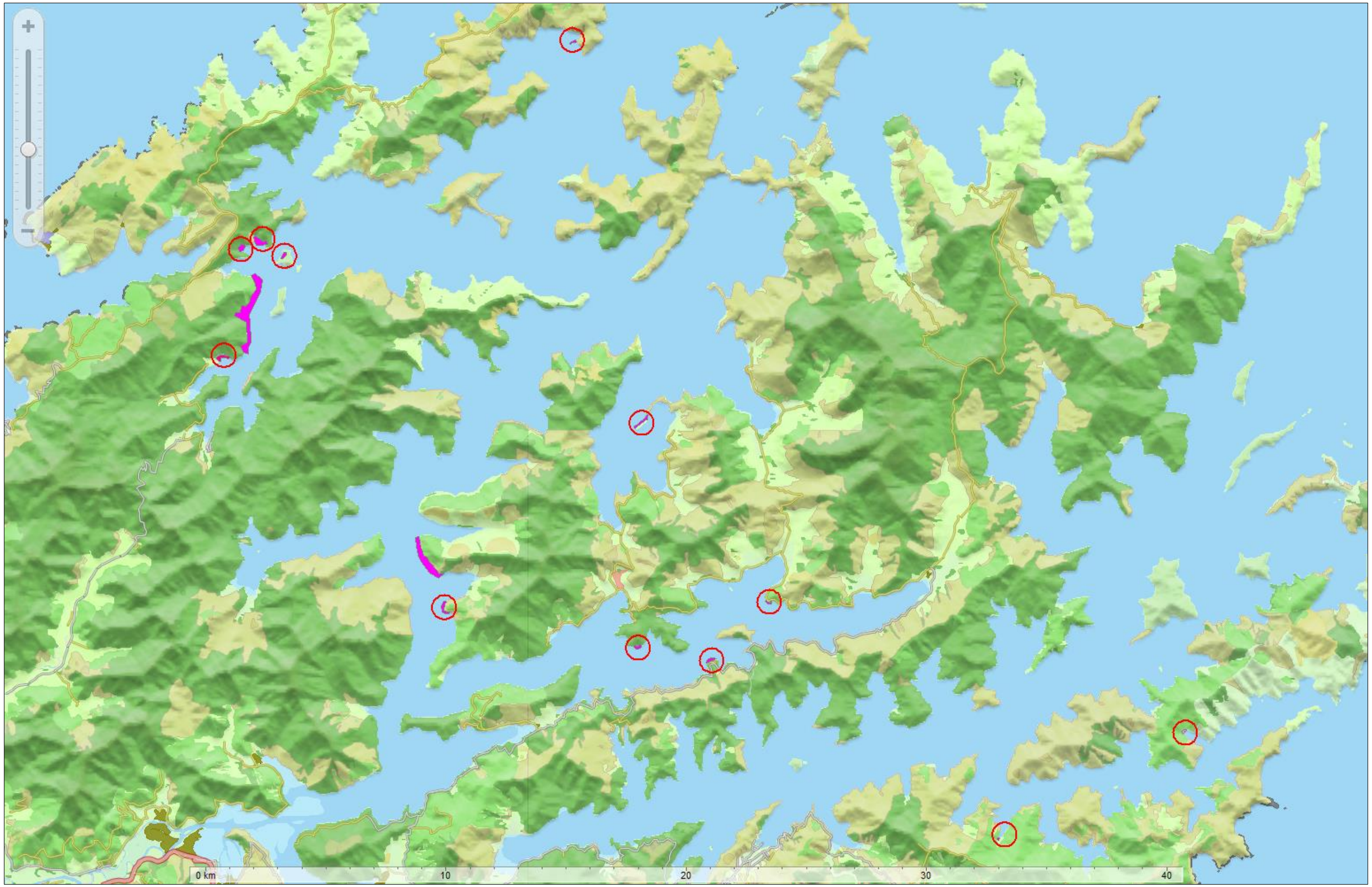

Figure 1. Location of sites surveyed during the present study (survey sites = pink polygons and circles).

4.0 Results and recommended changes

Survey data from the 2018-2019 season are summarised in the present report. Detailed data (maps, photos, video, sonar) are either produced or listed in separate Excel spreadsheets. All media, raw data and spreadsheets have been supplied to MDC to be stored in an MDC database.

4.1 Site changes

Thirteen distinct areas were investigated during the present study (Figure 1). Not all areas investigated have been proposed as significant sites (Table 3). Regardless of their importance, all survey areas are discussed in section 4.5 and the raw data held by MDC.

One site (Penzance Bay elephantfish egg-laying site 3.28) was located within the boundaries of the larger Tennyson Inlet site (3.9). No sub-sites were described in the present report (i.e. sub-sites are defined as having comparable habitats and communities but are physically separated by a relatively short distance).

Based on data collected during the present study, the following is recommended:

1. Site 3.9 Tennyson Inlet: adjust boundary to include areas surrounded by stable protected catchments.
2. Site 3.28 Penzance Bay elephantfish egg-laying: update data base to include new egg case density data.
3. Site 3.26 Ouokaha Island western coast: update site database to include new tubeworm density and damage data.
4. Site 5.5 Hitaua Bay estuary and shallow subtidal: reinstate area as a significant site.
5. Site 5.7 Deep Bay subtidal cockle bed. update database to include new density and size data.
6. Rat Point Reef: establish a new site to encompass the large Pelorus Sound reef.
7. Nikau Bay (outer coast) biogenic habitats: establish two sub-sites to encompass current swept biogenic communities.

8. Gold Reef Bay (west) biogenic community: establish new site to encompass biogenic community.
9. Reject Pukatea Bay (west), Pigyard Bay (west) and Catherine Cove (north) areas as due to insufficient data supporting values that would be considered significant.

4.2 Suggested site changes

Four new candidate or potential significant sites were described during the present study totalling 22.6 ha (Table 3). Two existing significant sites increased in size by a total of 673.39 ha but most of this increase occurred at one site in Tennyson Inlet (Table 3). Increases to existing sites was due to either improvements in data (Site 5.7 Deep Bay) or additional area applied based on assessment criteria (i.e. site 3.9 boundaries increased to reflect DOC managed land). No sites surveyed in 2019 declined in size. Three sites investigated did not support biological features that would likely be regarded as significant (Table 3).

4.3 Substratum and habitats

Five existing significant sites were characterised by soft substratum, while all others were combinations of soft and rocky substrata (Table 3). Significant sites located on soft substratum are considered the most vulnerable and threatened type of site as they are less resilient and can easily be damaged or destroyed by anthropogenic physical damage. Soft sediment sites are also vulnerable to sediment smothering as they are often located in offshore areas and less influenced by water currents and movement that often keep shallow and inshore habitats free of fine sediment.

The present study focused on sites with soft and rocky substrata. Some sites supported biogenic community types (e.g. tubeworms, ascidians, hydroids). These community types are often fragile, slow growing, and have been reduced in extent and quality world-wide (Airoldi and Beck, 2007). Other sites supported species or communities regarded as important due to their rarity or restricted distribution (e.g. Site 3.26 tubeworms) or the species present (Site 3.28 elephantfish egg-laying habitat).

Biological features of note recorded in the present study are:

Biogenic structures

Numerous studies have highlighted the importance of marine biogenic structures. Kuti *et al*. (2014) reported that complex habitats like coral reefs attracted many times the abundance of reef fish compared to simpler habitats. De Smet *et al*. (2015) reported that biogenic reefs composed of the tube-building polychaete *Lanice conchilega* increased the biodiversity in otherwise species-poor environments. Rabaut *et al.* (2010) reported that biogenic tubeworm structures were important to juvenile flatfish. The ecological functions provided by biogenic habitats are diverse and can include the elevation of biodiversity, bentho-pelagic coupling, sediment baffling, protection from erosion, nutrient recycling, the provision of shelter and food for a wide range of other organisms, and even the creation of geological features over longer time scales (Bradstock and Gordon, 1983; Turner *et al*., 1999; Carbines and Cole, 2009; Wood *et al*., 2012; Morrison *et al*., 2014). Morrison *et al*. (2014) stated a range of biogenic habitats also directly underpin fisheries production for a range of species through (1) the provision of shelter from predation; (2) the provision of associated prey species; in some cases, (3) the provision of surfaces for reproductive purposes, e.g. the laying of elasmobranch egg cases; as well as (4) indirectly, in the case of primary producers through trophic pathways.

Elephantfish egg-laying

The elephantfish, *Callorhinchus milii*, is the New Zealand and Australian representative of an ancient shark family (chimaeroid family, Callorhynchidae) found only in the Southern Hemisphere. Two other species of *Callorhinchus* occur, one each in South Africa and South America (Didier, 1995). Regular elephantfish egg-laying occurs at a small number of sites in the Marlborough Sounds. Egg laying occurs in November to January with hatching about six months later in May to July (Francis, 1997). Elephantfish egg-laying sites in the Marlborough Sounds are of scientific interest as they represent sites where egg cases can be reliably collected using SCUBA.

Shellfish bed

Shellfish have several important roles in the environment. For example, they provide important regulating services (e.g. shellfish reefs can protect shorelines from storm surges or waves by adding structure to what might otherwise be bare mudflat). Shellfish beds increase habitat complexity, potentially making it more inviting to juvenile fish in search of refuge from predators, or as a haven for other intertidal invertebrates.

Bivalves are filter-feeders and can improve water quality by removing anthropogenic sources of nutrients such as nitrogen by consuming phytoplankton from the water column. Overall, the list of potential regulating benefits continues to grow, from bio-irrigation, bioturbation, sediment and shoreline stabilisation, essential fish habitat, shellfish habitats, significant filtering capacity, eutrophication control, and enhanced benthic-pelagic coupling.

Site 3.28. Penzance Bay elephantfish egg-laying site.

Table 3. Summary of sites surveyed in 2019 including recommended changes and the reasons for site change.

Site	First described as signficant site	Original area (ha)	Recommended area (ha)	Change (ha)	Change %	Benthos type	Reason for change	Notes
Site 3.9 Tennyson Inlet (stable protected catchment)	2011	1211.68	1884.9	673.22	55.6	Rocky and soft	Reassessment of boundary	
Site 3.28 Penzance Bay (elephantfish egg-laying)	2018	6.68	6.68	0	0.0	Soft	No change	Quantitative data collected
Site 3.26 Ouokaha Island (tubeworm mounds)	2018	6.5	6.5	0	0.0	Rocky and soft	No change	Quantitative data collected
Site 5.5 Hitaua Bay Head (estuary and cockle bed)	2015	1.86	1.96	0.1	5.4	Rocky and soft	Recovery of habitats	Quantitative data collected
Site 5.7 Deep Bay (subtidal cockles)	2011	1.8	1.97	0.17	9.4	Soft	Improved detail of survey	Quantitative data collected
Rat Point (reef)	2019		2.03	2.03	100.0	Rocky & soft	New site	
Nikau Bay outer coast (biogenic community)	2019		16.5	16.5	100.0	Rocky & soft	New site	
Gold Reef Bay (west) (biogenic community)	2019		1.57	1.57	100.0	Soft	New site	
Pukatea Bay (east)				0		Soft	Insufficient values found to justify a new site	
Pigyard Bay (west)				0		Soft	Insufficient values found to justify a new site	
Catherine Cove (north)				0		Rocky & soft	Insufficient values found to justify a new site	
Total			**1922.11**					
Increase to significant sites				693.59				
Decrease to significant sites				0				

New site =	

4.5 Significant sites

4.5.1 Site 3.9 Tennyson Inlet (stable and protected catchment)

Tennyson Inlet is located at the western end of Tawhitinui Reach, 22 km north of Havelock (Figure 2). It has a main reach with many small bays including Tawa, Tuna, Deep and Matai Bays (Godsiff Bay). The Inlet is well separated from the rest of the Sound due to its geographic location. As a result, water residency time is likely to be some of the longest in the Sounds. There is a relatively low variety of subtidal habitats and species compared to other areas in the Marlborough Sounds (Davidson *et al*., 2011).

Tennyson Inlet is recognised as the largest bay complex in the Marlborough Sounds, mostly surrounded by stable and protected native forest catchments (Davidson *et al*., 2011; Stevens, 2018) (Plate 1). Recent work in Tuna, Duncan and Harvey Estuaries shows they are cobble and gravel dominated with very little mud and support beds of intertidal seagrass and relatively intact saltmarsh (Stevens, 2018). Catchment nutrient and sediment loads are low and there is therefore a low risk of eutrophication (L. Stevens, pers. comm.).

Plate 1. Ngawakawhiti Bay in inner Tennyson Inlet.

In 2017-2018, Davidson *et al*., (2018) collected 221 drop camera stations from the eastern shore and as far north as Penzance Bay along the western shore. Authors reported the Inlet supported habitats and species that appeared typical of central sheltered Pelorus Sound. The authors stated the influence of stable forested catchments is apparent in the estuaries (Stevens, 2018), however, the effect on subtidal marine communities may only become apparent with any future quantitative sampling. In the present study, the remaining western coast north of Penzance Bay adjacent to protected forested catchments was surveyed (Figure 2). Again, subtidal marine communities were visually comparable to habitats from central Pelorus Sound.

Anthropogenic issues

Tennyson Inlet is comprised of habitats and a community types visually comparable to much of central Pelorus Sound. What makes Tennyson Inlet special are the stable and protected catchments that minimise catchment effects (Stevens, 2018). Catchment effects have been recognised as one of the main anthropogenic impact sources in New Zealand (MacDiarmid *et al*., 2012; MFE, 2016). As such, the marine environment of Tennyson Inlet represents an area in a relatively natural, pre-human or "natural" state. Despite this, human impacts exist.

Human impacts and use are relatively low in Tennyson Inlet compared to much of Pelorus Sound (Table 4). Bray and Struick (2006) netted the area for fish from 1971 to 2004 in Te Mako Estuary and reported a steady and large decline in catches. The authors suggested these declines were likely related to a variety of anthropogenic activities (e.g. overfishing, dredging habitat loss). Settlements exist at Duncan, Penzance and Elaine Bays, but most of the area has little or low terrestrial habitation. A DOC hut is situated on the coast in Matai Bay. People transiting between the hut and mooring (3524) have caused localised impact on estuarine vegetation (i.e. trampling). Isolated holiday houses are in bays along the north-western shore and north-east of Elaine Bay. Forestry blocks exist on private land in the Tennyson Inlet catchment and Elaine Bay. Replanting of existing and planting of new forestry blocks require careful consideration and, if permitted, need to be carefully managed to ensure the low sedimentation properties of this area are maintained.

Commercial dredging and trawling activities are excluded from Tennyson Inlet. The level of recreational dredging is unknown, but it is recommended that recreational dredging be aligned with the commercial exclusion. Any dredging in an area recognised as having a high degree of "naturalness" is ecologically incompatible.

Exotic tubeworm (Chaetopteridea sp.) were abundant at some locations along the Tennyson coastline, including the north-western coastal edges of Tennyson Inlet between Penzance Bay and Elaine Bay surveyed in 2019 (Plate 2). Both adult and juvenile worms were observed during the 2019 survey. In New Zealand, there have been many recent reports of the parchment-like tubes of *Chaetopterus* littering beaches, especially after storms (Wikipedia, 2018). Since about 1995, large areas of shallow sea have been invaded by the worm believed to be *C. variopedatus*. Since about 1995, divers reported seeing whole areas of the seabed covered in parchment-like tubes in northern New Zealand (http://www.seafriends.org.nz/indepth/invasion.htm). Its presence along the southern side of Garne Bay was noted in the early 1990s by Duffy *et al*. (in prep.) and again in 2018 at several locations along the western shores of the Fitzroy complex (Davidson *et al*., 2018).

Exotic algae *Asperococcus bullosus* (Nelson and Knight, 1995) was recorded from Ngawhakawhiti Bay by Davidson *et al*. (2018). When abundant, this species smothers the benthos and may deter elephantfish from laying eggs as this species of shark selects a particular range of substrates to lay egg cases.

Plate 2. Exotic Chaetopterid tubeworms present along the north-western shores of Tennyson Inlet.

Table 4.
Assessment of anthropogenic impacts for Site 3.9 (Tennyson Inlet).

Original area of significant site (ha)	1211.7
Recommended area of site (ha)	1884.9
Change to original site	Increase
Change (ha)	673.2
Percentage change from original (%)	55.6%
Human Use	Low (moorings overlap with the significant site in Penzance Bay)
Vulnerability	Low-moderate (site supports habitats in a relatively natural state. Biggest threat is increased sedimentation).
Impact observed	Fishing has depleted fish stocks. Forestry operations exist in outer north-western Tennyson Inlet and Tuna Bay. Hut and mooring present in Matai Bay. Commercial dredging and trawling is excluded. The level of recreational dredging is unknown.

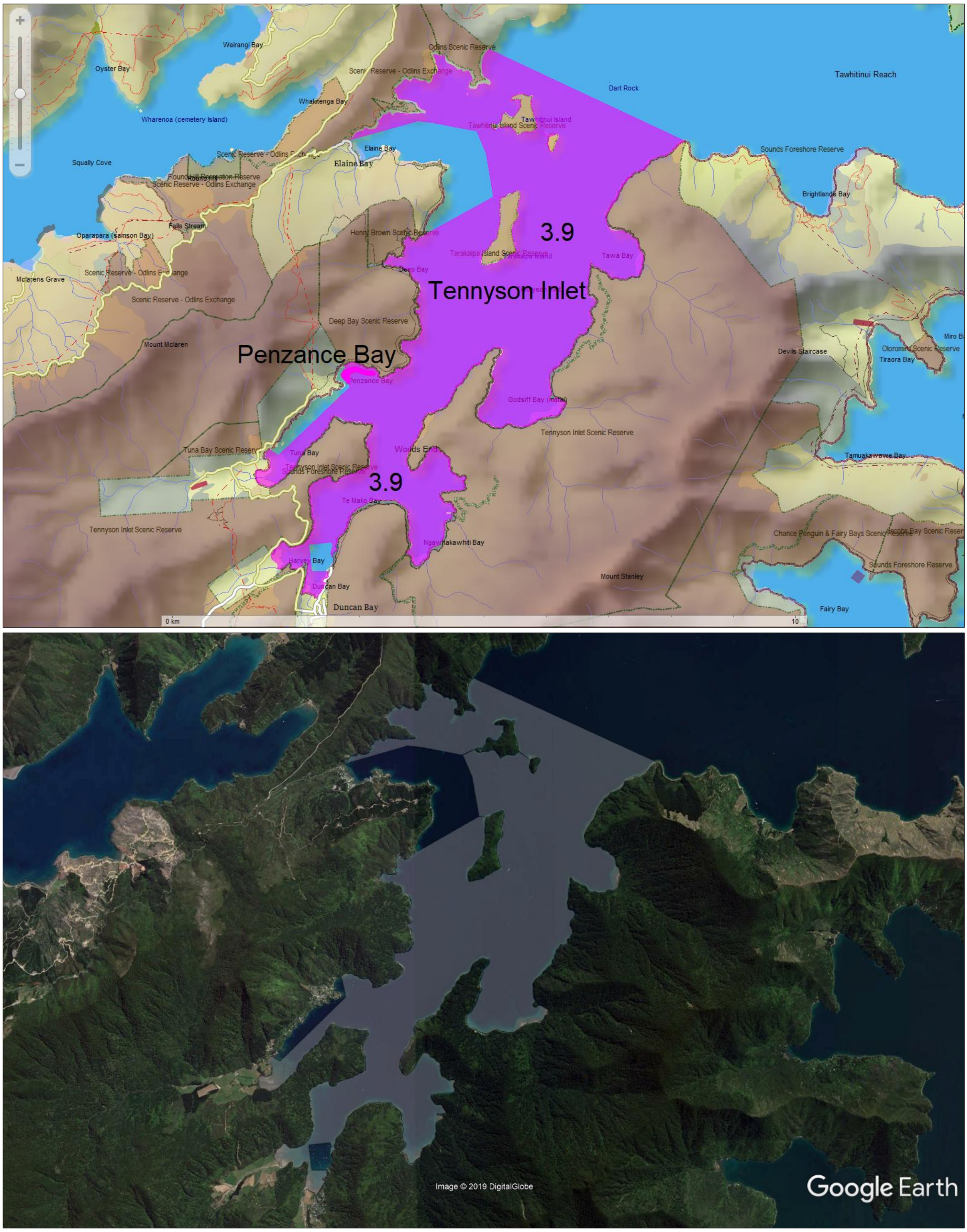

Figure 2. Tennyson Inlet significant site (pink polygon). Top = DOC estate (brown), bottom = aerial photo.

4.5.2 Site 3.28 Penzance Bay (elephantfish egg-laying)

Penzance Bay is located along the northern shores of Tennyson Inlet (Figures 2 & 3). The Bay supports a small settlement of mostly holiday homes, a jetty and launching ramp. The site overlaps with the Tennyson Inlet significant site (site 3.9) (Davidson *et al*., 2011; Davidson *et al*., 2018).

Dr Ken Grange (NIWA) reported elephantfish egg cases in Penzance Bay. Davidson *et al*., (2018) surveyed the bay using drop camera imagery and confirmed the bay supported live and empty egg cases (Figure 3, Plate 3). The author stated that based on qualitative observations, the site supported the highest abundance of egg cases for any known egg-laying area in the Sounds.

The present survey implemented a quantitative dive survey of elephantfish egg cases at two stations in Penzance Bay (Figure 3, Table 5). The density of live egg cases ranged from 0.4 to 3.25 egg cases per 10 m^2. The density of hatched egg cases ranged from 2.5 to 9.25 egg cases per 10 m^2. These are the highest densities presently recorded from the Marlborough Sounds.

Figure 3. Elephantfish egg-laying significant site in Penzance Bay (red polygon) and diver sampled stations.

Plate 3. Hatched (front) and live elephantfish egg case (back) in Penzance Bay.

Table 5. Elephantfish egg case data from east and west diver sample stations.

Penzance Bay (east) 6/3/2019 41 05.160, 173 46.204 Sample area = 10 m^2.

Diver 1	Depth (m)	Alive	Hatched	Diver 2	Depth (m)	Alive	Hatched
1	13	0	0	1	13	0	0
2	13	0	3	2	13	2	1
3	11	0	2	3	11	0	0
4	10	0	0	4	10	2	2
5	10	1	2	5	10	1	4
6	11	0	6	6	11	2	5
7	9.5	0	9	7	9.5	3	2
8	10	0	8	8	10	2	5
9	9.5	1	6	9	9.5	1	3
10	8.5	2	6	10	8.5	3	3
Mean		0.40	4.20			1.60	2.50
SD		0.70	3.22			1.07	1.84
SE		0.07	0.15			0.09	0.11

Penzance Bay (west) 6/3/2019 41 05.209, 173 46.060 Sample area = 10 m^2.

Diver 1	Depth (m)	Alive	Hatched	Diver 2	Depth (m)	Alive	Hatched
1	8.5	2	7	1	8.5	1	8
2	8	2	10	2	8	1	10
3	8	1	12	3	8	4	5
4	7.5	2	6	4	7.5	7	14
Mean		1.75	8.75			3.25	9.25
SD		0.50	2.75			2.87	3.77
SE		0.06	0.15			0.15	0.18

Anthropogenic Issues

Elephantfish females select particular sites in the Marlborough Sounds to lay their egg cases. Based on field observations, this appears to mostly occur on shallow shores dominated by combinations of sands, fine sand, silt, and shell. Other sites in the Sounds where egg laying occurs are the Fitzroy Bay complex and inner Queen Charlotte Sound.

Egg cases in Penzance Bay are protected from recreational dredging due to the presence of moorings, however, traditional block and chain mooring may damage egg cases. Further, inorganic rubbish likely originating from moored vessels was observed by divers around some vessels (e.g. sanding discs). Sedimentation is also a concern at this site as any sediment generated from the adjacent settlement could alter sediment composition in the bay (Table 6).

Table 6. Assessment of anthropogenic impacts, Site 3.28 (Penzance Bay elephantfish egg-laying).

Original area of significant site (ha)	6.68
Recommended area of site (ha)	6.68
Change to original site	None
Change (ha)	0
Percentage change from original (%)	NA
Human Use	High (a settlement is located adjacent to the site. Moorings are located inside the site).
Vulnerability	Unknown (it is unknown how resilient egg cases are to physical disturbance).
Impact observed	Chain drag was observed around moorings

4.5.3 Site 3.26 Ouokaha Island (tubeworm mounds)

Ouokaha Island is an approximately 4.02 ha island located at the southern tip of Hopai Peninsula, Crail Bay (Plate 4). The significant site is located along the western side and the channel between the island and Hopai Peninsula (Figure 4).

Plate 4. Looking eastward at the western shoreline of Ouokaha Island.

Hay (1990b) stated "At about 22 m depth, most of the bedrock is covered with shelly debris and muddy sand. This marks the upper limit of a zone of horse mussels, *Atrina zelandica*, which extends to 27 m depth. Below this depth, there is a thick, gooey mud with a few burrows and dead shells. Horse mussels support a rich epibiota of sponges, chitons, window oysters, fan shells and brachiopods. The ribbed red brachiopod, *Terebratella sanguinea*, is very abundant below 17 m depth and is free living on shell fragments or pieces of polychaete worm tube and dead brachiopod valves. Near the southwestern end of the peninsula, especially, there are large, brittle mounds of colonies of the tubeworm *Galeolaria hystrix*. Scallops were found sporadically below about 15 m depth. The large starfish, *Coscinasterias*, is also common at this depth and was observed feeding on juvenile *Atrina* as well as a variety of bivalves."

Davidson *et al*. (2018) documented the presence of tubeworm mounds (*Galeolaria hystrix*) from drop camera and diver searches along the western shores of the island (Plate 5). The authors stated mounds were not sufficiently abundant to form a tubeworm zone; however, the site represents one of the best examples of an area supporting *Galeolaria* tubeworm mounds in Pelorus Sound. Davidson *et al*. (2018) stated the presence of horse mussels and the associated epibiota associated with horse mussels as described by Hay (1990b) were not observed along the western side of the island.

During the present study, divers collected data on the abundance of tubeworm mounds along three transects (Figure 4). Divers also quantified the extent and occurrence of damaged mounds. Transects extended 45 and 55 m from low water. Depths along transects ranged from low water to a maximum of 17.4 m. Tubeworm mounds were recorded from 1.2 m to 13.5 m depth with no mounds recorded beyond 40 m distance from low water (Table 7). A total of 6 mounds were recorded from transect 1, 6 mounds from transect 2 and 5 mounds from transect 3. Of the total 17 mounds recorded, two were damaged (11.7%). Mounds were up to 60cm long, 40 cm high and 35 cm wide. The overall density is approximately 1 mound for every 35 square meters.

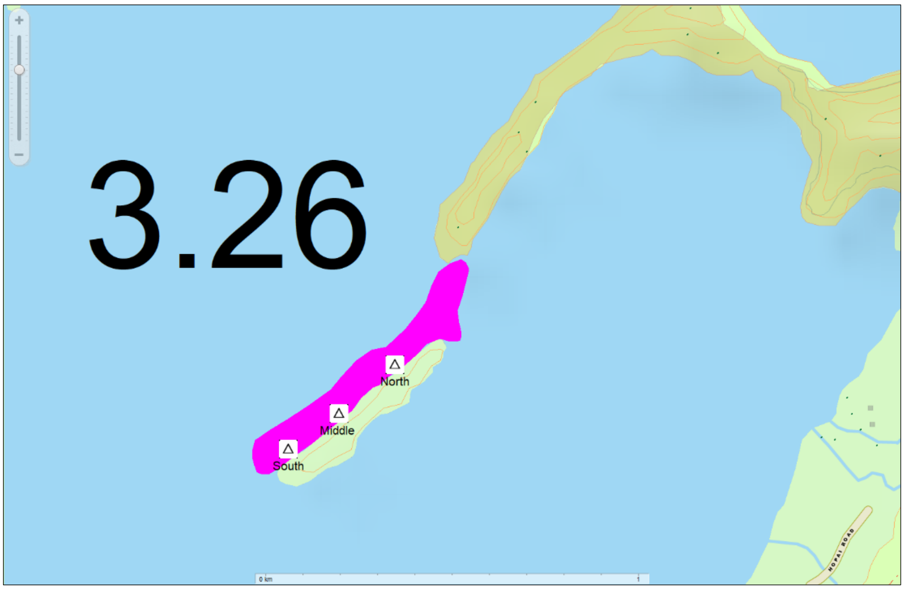

Figure 4. Significant site 3.26 (red polygon) and location of transects along the western shores of Ouokaha Island.

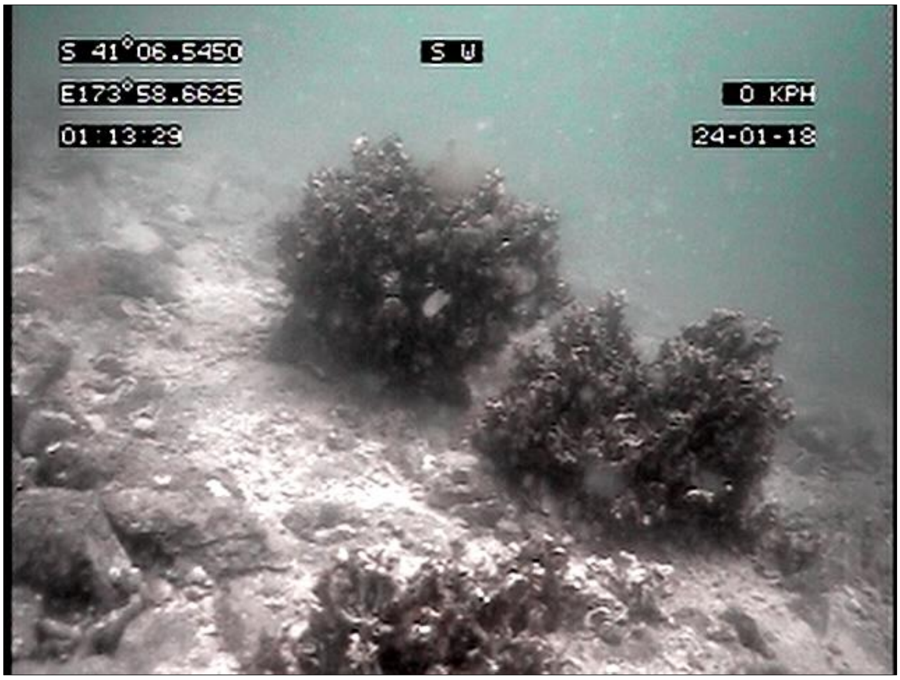

Plate 5. *Galeolaria hystrix* tubeworm mounds at Ouokaha Island.

Table 7. Tubeworm and transect data collected from the western shore of Ouokaha Island. Note transect sample width = 4 m).

Distance (m)	Depth (m)	Substratum	Distance range (m)	*Galeolaria* undamaged	*Galeolaria* damaged	Estimated sizes (Length x height x width) (cm)
Transect 1 north (41 06.541, 173 58.709)						
0	0	Cobble, boulders, sand and shell				
5	0.8	Cobble, boulders, sand and shell	0-5			
10	2.9	Cobble, boulders, sand and shell	5-10			
15	4.7	Cobbles, sand and shell	10-15	1		50 x 30 x 20
20	6.8	Cobbles, sand and shell	15-20			
25	8.9	Cobbles, sand and shell	20-25	2	1	40 x 40 x 20; 50 x 20 x 35; 30 x 30 x 20
30	10.9	Cobbles, sand and shell	25-30	2		20 x 20x 20; 30 x 20 x 20
35	12.3	Cobbles, sand and shell	30-35			
40	14	Cobbles, sand and shell	35-40			
45	15.3	Cobbles, sand and shell	40-45			
50	16.3	Sand and shell, cobbles	45-50			
55	17.4	Sand and shell	50-55			
Transect 2 middle (41 06.612, 173 58.603)						
Distance (m)	Depth (m)	Substratum	Distance range (m)	*Galeolaria* undamaged	*Galeolaria* damaged	Estimated sizes (Length x height x width) (cm)
0	0	Cobble, boulders, sand and shell				
5	1	Cobble, boulders, sand and shell	0-5			
10	2.1	Cobbles, bedrock, boulders, sand and shell	5-10	1		50 x 25 x35
15	3.9	Bedrock, cobbles, boulders, sand and shell	10-15	2	1	60 x35 x35; 45 x30 x35; very large mound damaged
20	5.4	Cobbles, bedrock, boulders, sand and shell	15-20	2		45 x 25 x 30; 25 x 20 x 20
25	7.4	Cobbles, boulders, sand and shell	20-25			
30	9	Cobbles, boulders, sand and shell	25-30			
35	11	Cobbles, sand and shell, small boulders	30-35			
40	12.8	Cobbles, sand and shell, small boulders	35-40			
45	14.9	Sand, shell, cobbles, small boulders	40-45			
50	16.7	Sand and shell, small boulders	45-50			
Transect 3 south (41 06.665, 173 58.507)						
Distance (m)	Depth (m)	Substratum	Distance range (m)	*Galeolaria* undamaged	*Galeolaria* damaged	Estimated sizes (Length x height x width) (cm)
0	0	Cobble, boulders, sand and shell				
5	1.2	Cobble, boulders, sand and shell	0-5	1		20 x 15 x 20
10	2.3	Cobble, boulders, sand and shell	5-10			
15	4.5	Cobble, boulders, sand and shell	10-15			
20	6.4	Cobble, boulders, sand and shell	15-20	1		25 x 25 x 20
25	8.3	Cobble, boulders, sand and shell	20-25	1		15 x 10 x 20
30	10.1	Cobble, boulders, sand and shell	25-30			
35	11.7	Cobble, boulders, sand and shell	30-35	1		15 x 20 x 15
40	13.5	Sand, shell, cobbles, small boulders	35-40	1		30 x 20 x 25
45	15.2	Sand, shell, cobbles	40-45			

Anthropogenic issues

The presence of rocky substratum along this site reduces the chance of physical damage from dredging and trawling, however, recreational fishers regularly fish in this area and sometimes deploy anchors that can damage tubeworm mounds (Plate 6). Based on present diver collected data, approximately 11% of mounds show damage. It is unknown if damaged mounds recover or die. If they die, the cumulative effect of anchor and chain damage will eventually lead to a decline in their abundance at this significant site.

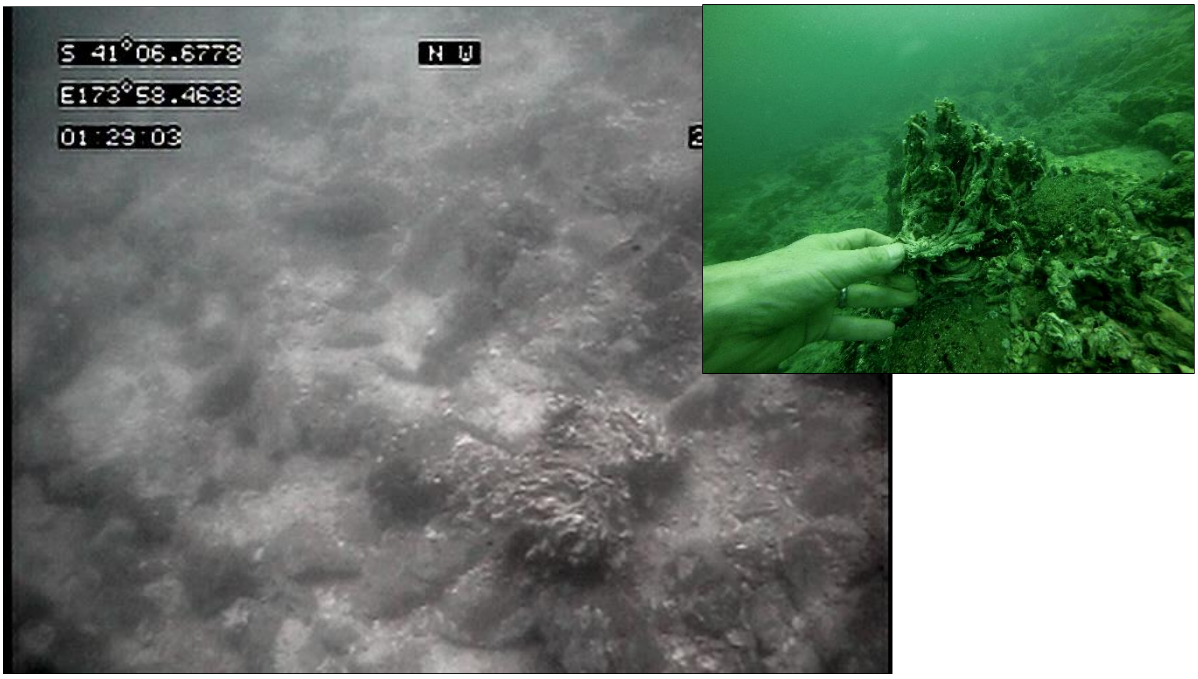

Plate 6. Damaged tubeworm mounds at Ouokaha Island (24/1/2018).

Table 8. Assessment of anthropogenic impacts for Site 3.26 (Ouokaha Island coastline).

Original area of significant site (ha)	6.5
Recommended area of site (ha)	6.5
Change to original site	No change
Change (ha)	0
Percentage change from original (%)	NA
Human Use	Moderate (popular site for recreational fishers, anchors and anchor chains impact tubeworm mounds).
Vulnerability	High (tubeworm mounds are fragile and easily damaged).
Impact observed	Damaged tubeworm mounds observed by drop camera and recorded by divers.

4.5.4 Site 5.5 Hitaua Bay (estuary and cockle bed)

Hitaua Bay is located on the southern shoreline of Tory Channel, towards the western entrance to Queen Charlotte Sound (Figure 5, Plate 7). It has 5 km of coastline, a sea area of 84.6 ha, and is approximately 920 m across the bay mouth. Hitaua Bay is 18 km by water from Picton and 15 km from Cook Strait.

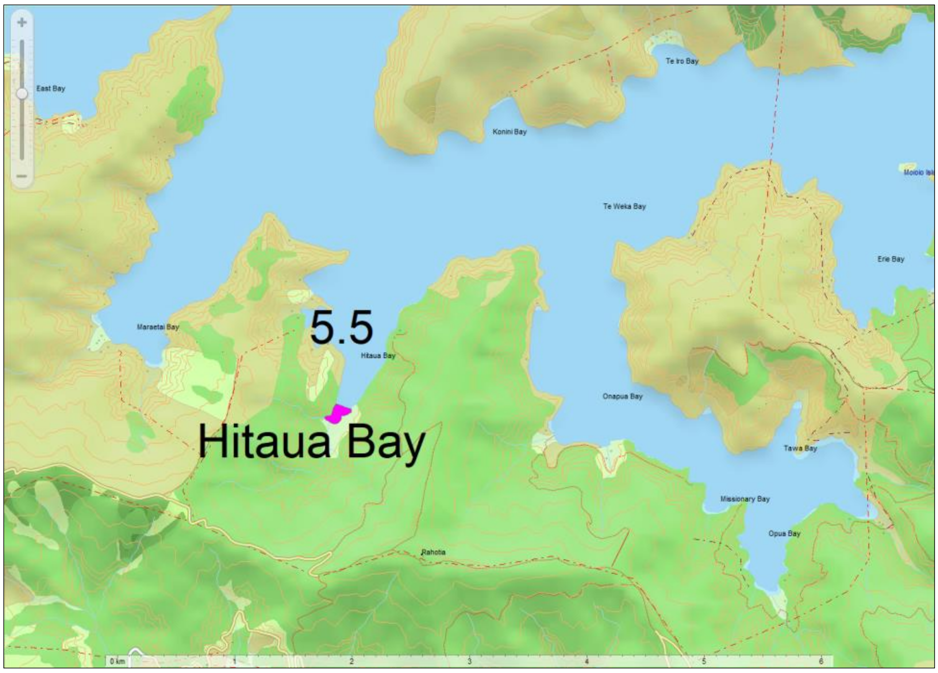

Figure 5. Location of Hitaua Bay significant site 5.5.

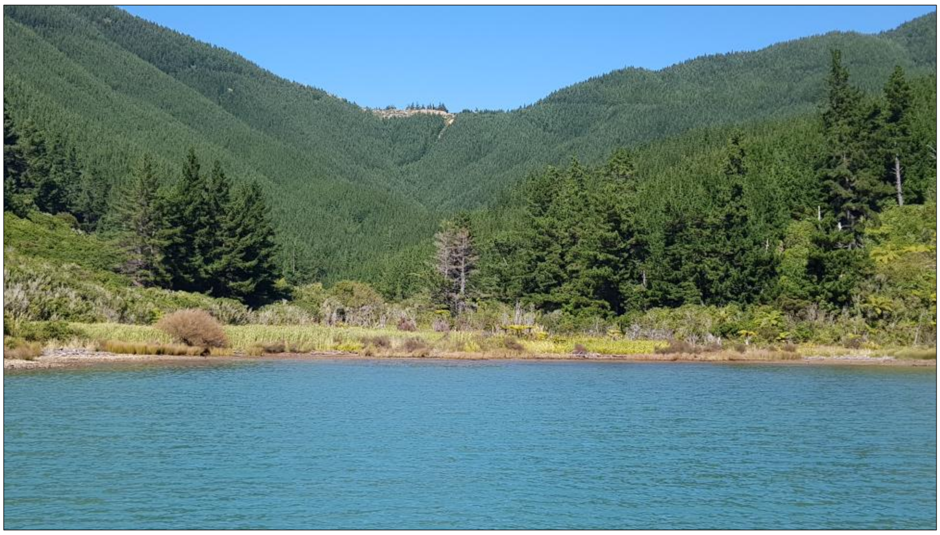

Plate 7. Head of Hitaua Bay, March 2019.

Hitaua Bay Estuary was ranked as the best example of an estuarine habitat in the Tory Channel biogeographic area (Davidson *et al*., 2011). Davidson and Richards (2015) resurveyed the area and stated "although it still supports estuarine habitats, it appears to have recently been influenced by the deposition of fine sediment from the logged catchment. Observations show a build-up of fine sediment over and around intertidal cobbles and a disappearance of some intertidal species compared to a baseline survey conducted in 2003" (Plate 8). The authors also stated, "cockles do remain in comparable densities to 2003, however their mean size appears to have declined." Davidson and Richards (2015) concluded "the site is no longer the best example of an estuarine habitat in Tory Channel and it is recommended that it be removed from the list of significant sites." The review panel agreed, and the site was removed as a significant site (Davidson *et al*., 2015).

The present survey confirmed much of the sediment that smothered the intertidal has been re-worked and appears to have declined over much of the cobble area (Plate 8). Further, eelgrass patches have returned in March 2019. Fine sediment is still present in the intertidal and forms a soft sediment habitat at the south-western corner of the site.

Cockles in 2003 were dominated by larger individuals but were in low densities compared to 2015 when their abundance increased but larger cockles were uncommon (Figure 6). In the present study, the density remained high but large cockles >40 mm width returned into the population.

Topshell (*Melagraphia aethiops*) density on cobbles were sampled in 2003 on two occasions and in March 2019. Densities were not collected in 2015 as they were only present on larger cobbles/small boulders and were virtually absent from most of the intertidal shore (Plate 9). Topshell densities in 2003 ranged from 13 to 200 per m^2 compared to 4 to 72 per m^2 in 2019. The recovery of intertidal topshells showed an improvement in 2019 but has not reached 2003 levels.

Plate 8. Estuary cobbles at stream. Top = 2003, Middle = 2015, Bottom 2019.

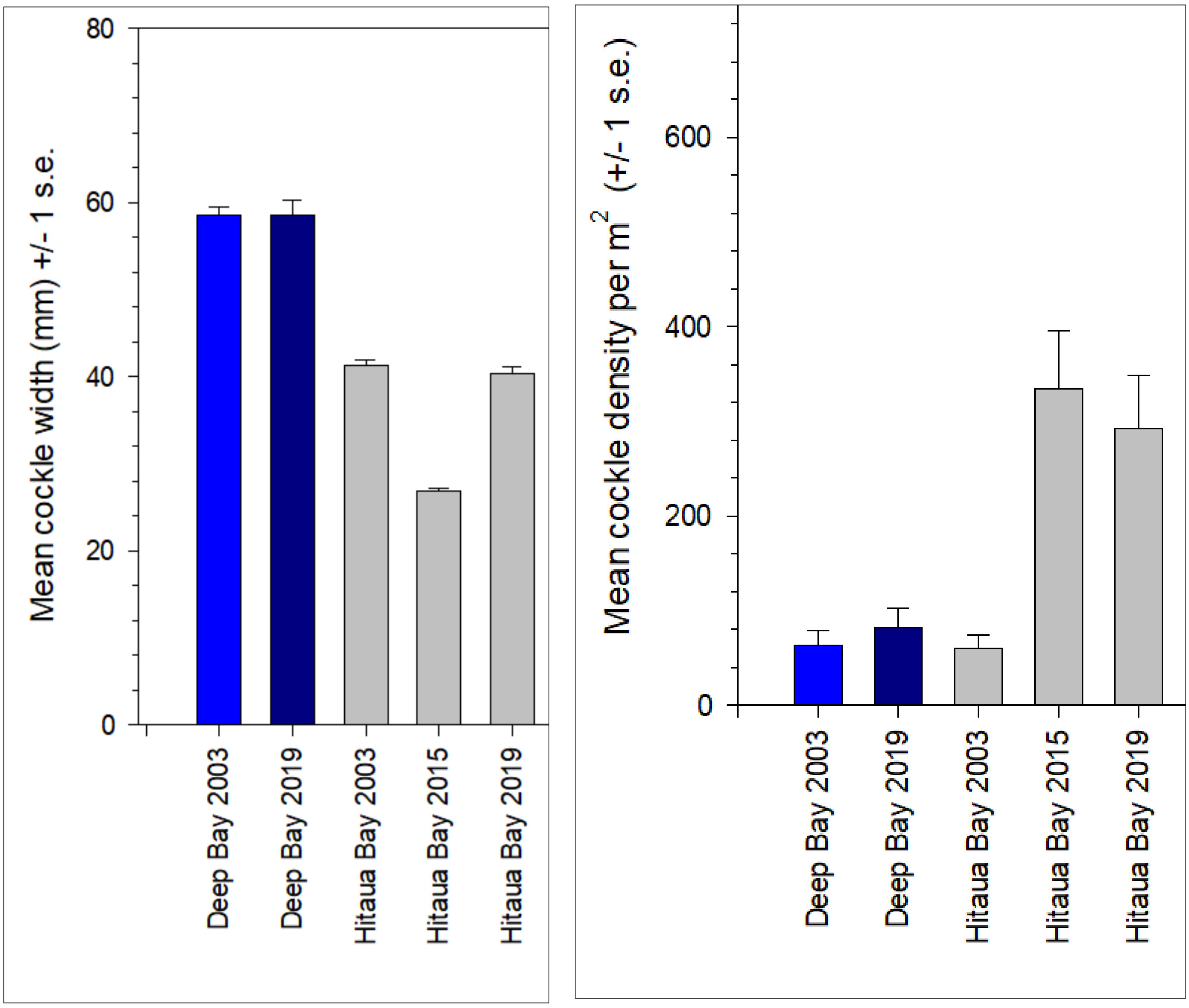

Figure 6. Mean cockle width (mm) and density (per m^2) from Hitaua Bay in 2003, 2015 and 2019.

Plate 9. Cobbles in stream at head of Hitaua Bay (top = 2015, bottom = March 2019).

Anthropogenic issues

The head of Hitaua Bay is characterised by estuarine and a shallow subtidal environment dominated by soft and rocky substrata. These habitats are vulnerable to smothering by sediment from the adjacent catchment after periods of heavy rain. Sediment inputs are exacerbated during heavy rain events after logging of the exotic forest has occurred (Table 9). This site has been previously impacted by sedimentation and was downgraded from a significant site. The site remains vulnerable to a similar event in the future.

Table 9. Assessment of anthropogenic impacts for Site 5.5 (Hitaua Bay head).

Original area of significant site (ha)	1.86 (2011)
Recommended area of site (ha)	1.96
Change to original site	Increase
Change (ha)	0.1
Percentage change from original (%)	5.4%
Human Use	Low (the site is seldom visited)
Vulnerability	High (cobble intertidal and soft sediment shallow subtidal habitats have been previously smothered by fine sediment from the adjacent catchment.)
Impact observed	Yes

4.5.5 Site 5.7 Deep Bay (subtidal cockles)

Deep Bay (40 ha) is located along the northern coastline of Tory Channel (Figure 7). The bay is approximately 1.2 km in length and up to 350 m wide. The bay is relatively shallow (< 7 m depth) with a shallow bank located at its entrance and a shallow area the head of the bay.

Davidson *et al*. (2011) ranked Deep Bay as a significant site (Figure 8). The authors stated "there is a cockle bed at the head of Deep Bay (Davidson and Richards, 2003a). It is low density compared to other areas in Tory Channel, but individual cockles are extremely large and therefore of scientific interest" (Figure 9, Plate 11).

Plate 10. Head of Deep Bay (12 March 2019).

In March 2019, the head of Deep Bay was resurveyed and the presence of large subtidal cockles was confirmed (Plate 10) (Davidson *et al*., 2019). The authors reported cockle density ranged from 0 to 4 individuals per core sample or 0 to 226 individuals per m^2 (Table 8). In the previous 2003 survey, cockle density ranged from 0 to 5 individuals per core sample or 0 to 283 individuals per m^2.

Mean density in 2003 was 63.7 individuals per m^2 compared to 74.3 individuals per m^2 in 2019 (Figure 8). This represented a small increase, but the increase was not significant (Mann-Whitney U statistic =169, P = 0.516).

Comparative densities from another bay in Tory Channel and several bays in Pelorus Sound showed Deep Bay supported a low density of cockles, however, all sites sampled in Pelorus were intertidal and the Hitaua Bay site was a combination of intertidal and shallow subtidal (Figure 10).

Cockle width in 2019 ranged from 46 to 69 mm compared to 45 to 65 mm in 2003 (Table 9, Plate 11). Mean cockle width was higher in 2019 with 59.2 mm compared to 59 mm width in

2003 (Figure 11). This increase was small and not statistically different (Mann-Whitney U statistic =305, P = 0.416).

Mean cockle size from another bay in Tory Channel and several bays in Pelorus Sound showed Deep Bay supported the largest cockles (Figure 11). No small cockles were recorded from cores collected in Deep Bay.

Plate 11. Large cockle from Deep Bay (March 2019).

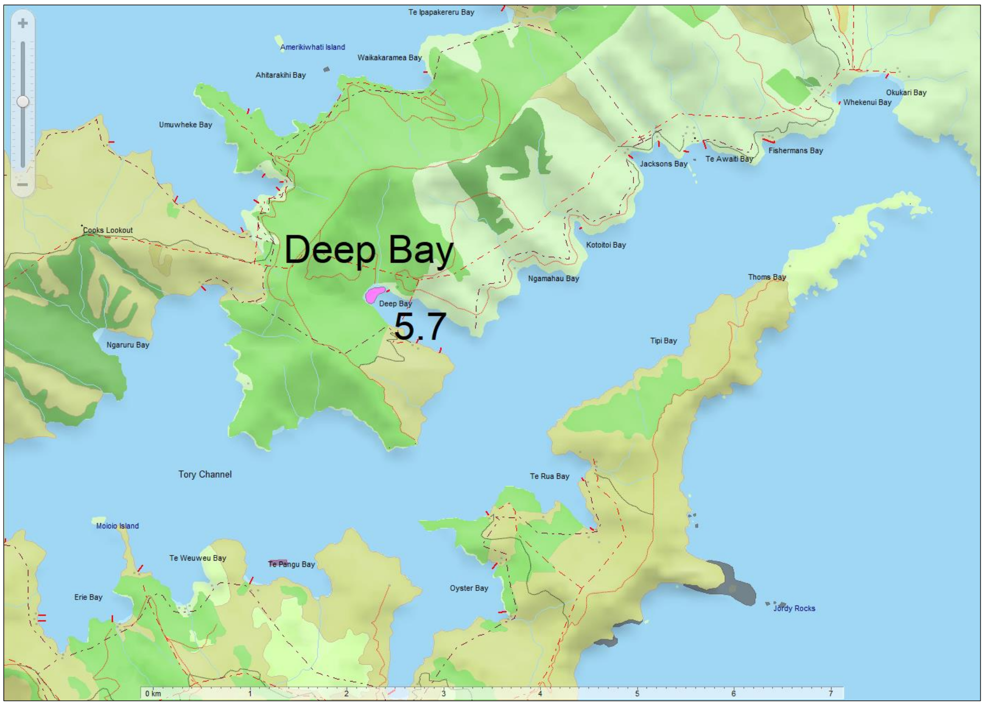

Figure 7. Location of Deep Bay significant site 5.7

Figure 8. Original significant sites from Davidson *et. al.* (2011) (red outline) versus suggested revised boundary (green shaded polygon).

Anthropogenic issues

Cockles are relatively resilient to sediment smothering as most cockles can excavate themselves to the surface if sediment increases (Barrett *et al*., 2017). The authors noted that cockles were slower to re-orientate following disturbance to their natural orientation (inverted at the time of burial) and, while able to resurface from an inverted position under low levels of deposited sediment, they were significantly impeded in their ability to resurface when buried under greater sediment loads (5 and 10 cm), with significantly fewer adults resurfacing than sub-adults.” This suggests they are likely to be impacted from activities such as dredging that disturbs sediment (Table 10).

Heavy rain events often result in very large fine sediment input into coastal environments (Davidson, 2018). Various authors have also documented smothering of bivalve beds due to sedimentation events (Stephenson, 1981; Morrison *et al*., 2009; Grange, 1996). Some estuaries that are now dominated by mud/silt have been found to have layers of dead cockle shell several feet below the surface, highlighting how vulnerable coastal populations can be to sedimentation events (Marsden and Adkins, 2010; Morrison *et al*., 2009).

During the 2019 survey, Davidson *et al*. (2019) stated:

"visual observations of the subtidal cores collected during the present investigation revealed what appeared to be terrestrially derived sediments at the surface. These sediment cores showed marine sediment were dominant (silts, clays and very fine sand). The surface layer was soft and fluffy in appearance suggesting recent deposition of very fine sediment. It is unknown how much of this terrestrial surface layer is brought into Tory Channel from the Wairau and Awatere catchments versus sediment deposited from the Deep Bay catchment. Cockle data collected in 2003 prior to logging and in 2019 after logging show cockle abundance and mean size have changed little over this period. Barrett *et al.* (2017) showed that cockles can move to the surface following sediment deposition. Sediment deposition from Tory Channel waters is likely to be at a low rate but relatively consistent throughout the year. Cockles are therefore likely to cope with this slow deposition. Sediment from the Deep Bay catchment is likely to be sporadic and highest after land clearance combined with heavy rain. The ability of cockles to cope with a pulse of fine sediment is a dependent on scale of rain events relative to cleared land. Once land cover re-establishes and the forest grows, sedimentation from the Deep Bay catchment is likely to return to and remain at low levels until future harvests. The survival of this cockle bed is therefore vulnerable to a combination of forest harvest and heavy rain events."

Table 10. Assessment of anthropogenic impacts for Site 5.7 (Deep Bay).

Original area of significant site (ha)	1.8
Recommended area of site (ha)	1.97
Change to original site	Increase
Change (ha)	0.170
Percentage change from original (%)	9.4%
Human Use	Low. Area seldom visited.
Vulnerability	Low-moderate (vulnerable to overfishing and physical disturbance. High sedimentation events likely cause cockle mortality)
Impact observed	Low-moderate (some terrestrially derived sediment observed on benthos).

Table 8. Sample event data in 2003 and 2019 from Deep Bay. Data are number of cockles per core and number of cockles per m^2 (from Davidson *et al*., 2019).

25-Nov-03

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Mean	SD	SE
Number of cockles (per core)	3	3	2	1	1	2	1	0	0	0	0	0	0	0	2	1	2	0	1	5	0	0	2	1	1.13	1.30	0.26
Number per m^2	169.8	169.8	113.2	56.6	56.6	113.2	56.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	113.2	56.6	113.2	0.0	56.6	282.9	0.0	0.0	113.2	56.6	63.66	73.33	14.97

05-Mar-19

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Mean	SD	SE
Depth (m)	2.7	2.3	1.7	1.2	1.2	1.6	1	3.2	4.5	5.6	4.6	3.5	2.6	2	2.5	4.7			
Number of cockles (per core)	1	0	0	3	1	3	3	1	2	0	4	1	0	0	1	1	1.31	1.30	0.27
Number per m^2	56.6	0.0	0.0	169.8	56.6	169.8	169.8	56.6	113.2	0.0	226.4	56.6	0.0	0.0	56.6	56.6	74.27	73.69	15.04

Table 9. Cockle width (mm) collected in 2013 and 2019 from Deep Bay.

	Deep Bay 25 November 2003	Deep Bay 05 March 2019
N	31	21
Mean length (mm)	59.00	59.24
SD	4.43	7.25
SE	0.80	1.58

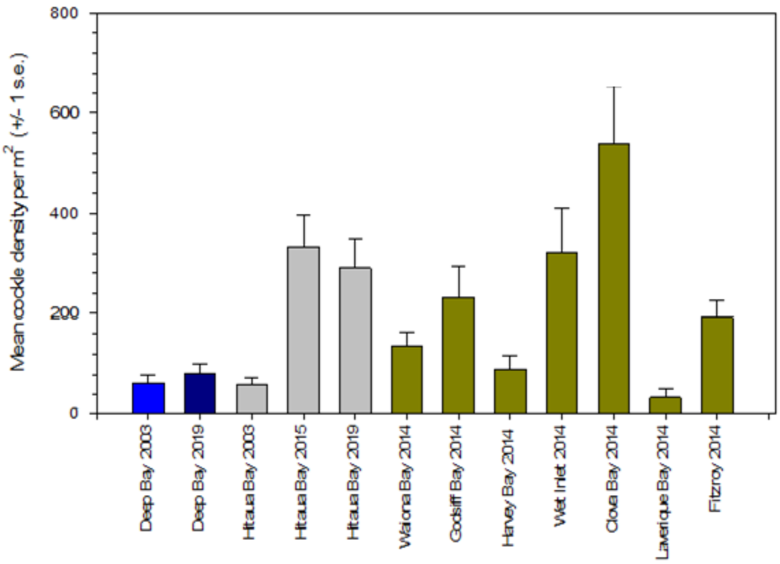

Figure 10. Mean cockle density (per m^2) from Deep Bay in 2003 and 2019, compared to other bays in the Marlborough Sounds.

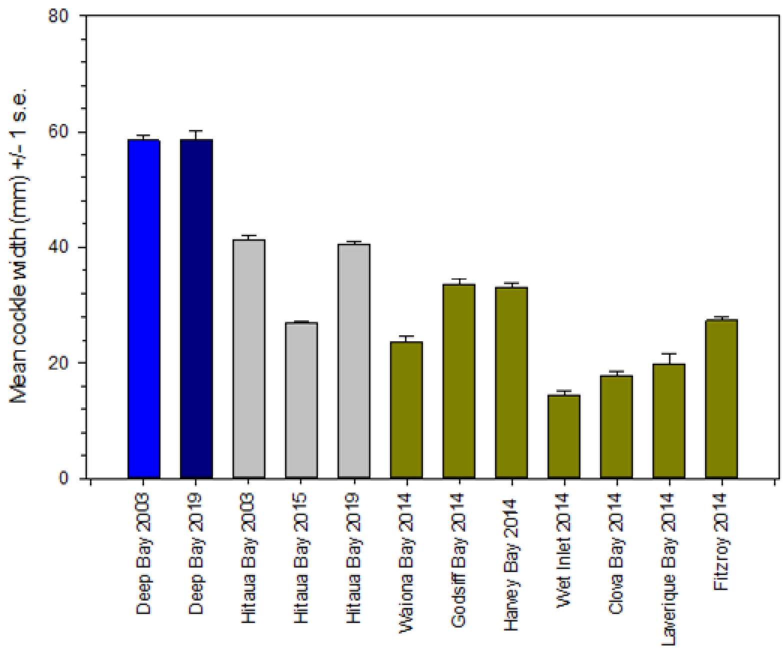

Figure 11. Mean cockle width (mm) from Deep Bay in 2003 and 2019, compared to other bays in the Marlborough Sounds.

4.5.6 Rat Point (reef)

Rat Point is located on the northern shoreline of Waitata Bay, near Waitata Reach, Pelorus Sound (Figure 12). A reef extends from the small promontory for some 270 m distance south-westwards from the tip of Rat Point. This is one of the largest reef structures known from inside Pelorus Sound and certainly the largest in Waitata Bay (Plate 12). Based on drop camera images, the reef supports numerous *Ancorina* sponges and patches of tubeworm mounds (*G. hystrix*).

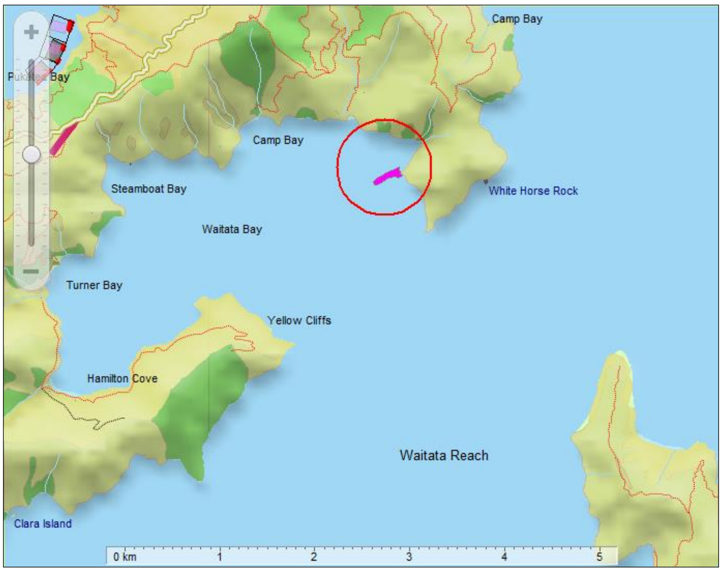

Figure 12. Location of Rat Point reef in Waitata Bay.

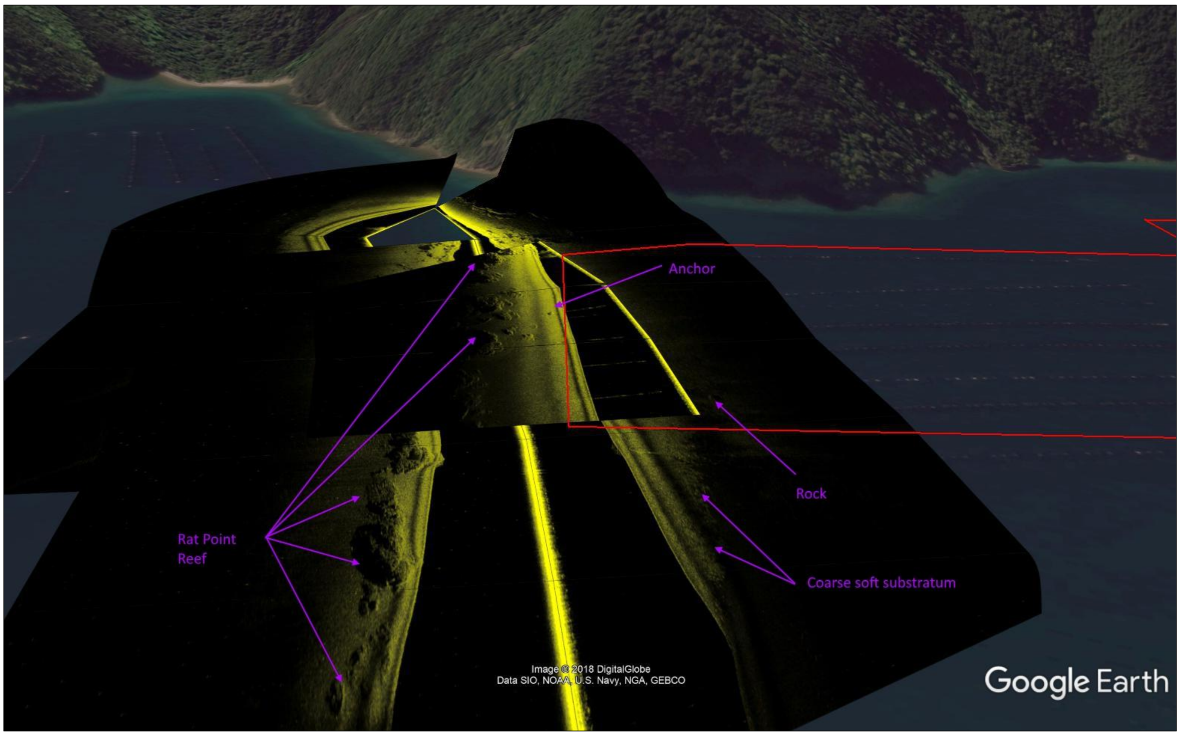

Plate 12. Sonar images from Rat Point reef.

Anthropogenic issues

The presence of rocky substratum reduces the risk of physical damage from dredging and trawling. Further, the site is likely swept by currents reducing sediment deposition. The site is occasionally used by recreational fishers. The impact of recreational fishing activity on this type of habitat is considered low compared to many other anthropogenic activities in the marine environment, however, anchoring would likely damage biogenic structures growing on the reef (Table 11). A marine farm is located both sides of this site. Potential impacts from mussel farms are minimised due to separation distances from production structures.

Table 11. Assessment of anthropogenic impacts for Rat Point Reef.

Original area of significant site (ha)	0
Recommended area of site (ha)	2.03
Change to original site	Increase
Change (ha)	2.03
Percentage change from original (%)	100%
Human Use	Low (the site is occasionally fished)
Vulnerability	Moderate (biogenic structures growing on reef vulnerable to physical damage from anchoring)
Impact observed	No

4.7.7 Nikau Bay outer coast (biogenic community)

This coast is located approximately 15 km north of Havelock. Areas surveyed were the coastline between Four Fathom Bay and Nikau Bay, between Nikau and Little Nikau Bays, and a small promontory south of Little Nikau Bay. A total of 73 drop camera stations were sampled along this stretch of eastern Hikapu Reach (Figure 13).

This coast was dominated by rocky substrata in the shallows, with coarser soft substrata between approximately 6-25 m depth. Below approximately 25 m depth, the substrata was dominated by silts and some shell. The coarse soft substrata were characterised by combinations of silt, fine sand and dead whole and broken shell. In places, shell was dominant and formed with hash (broken shell) or beds of whole and broken shell. Shallow coarse soft substratum was likely swept clear of fine substrata due to the moderate to strong currents that occur along this coast. Smothering by soft sediment with increasing depth was apparent.

Coarse substrata often supported a variety of current-loving species dominated by colonial ascidians (*Aplidium phortax; Didemnium vexillum*) and a hydroid (*Symplectoscyphus subarticulatus*) (Plate 13).

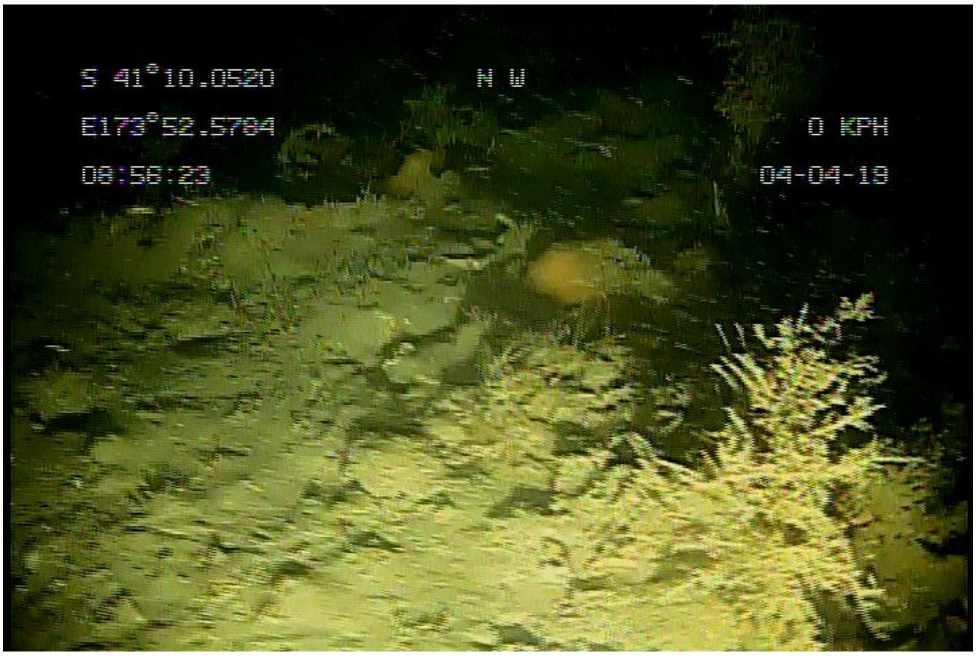

Plate 13. Silt and shell substrata with hydroids and colonial ascidians (photo 8, 24.7 m).

Anthropogenic issues

This section of Pelorus Sound is highly turbid with water clarity usually remaining very low for long periods. The source of turbid water is the Pelorus River (Plate 14). The edges of the Reach in this area are swept by currents that act to reduce sediment deposition, however, fine sediment has covered many of the organisms that inhabit this area (Plate 13).

These sites are occasionally used by recreational fishers. The impact of recreational fishing activity on this type of habitat is considered low compared to dredging and trawling, however, anchoring would likely damage biogenic structures growing on these current-swept soft substrata (Table 12).

Table 12. Assessment of anthropogenic impacts for Nikau Bay outer coast.

Original area of significant sites (ha)	0
Recommended area of sites (ha)	16.5
Change to original site	Increase
Change (ha)	16.5
Percentage change from original (%)	100%
Human Use	Low (the site is occasionally fished). No commercial fishing.
Vulnerability	Moderate-high (biogenic structures growing on soft substrata are vulnerable to physical damage from anchoring, biogenic habitats vulnerable to smothering).
Impact observed	Yes (occasional anchoring occurs, sediment smothering observed).

Plate 14. Inner Pelorus (centre) and Queen Charlotte Sound (bottom right). (Photo: L. Richards, 13-2-18).

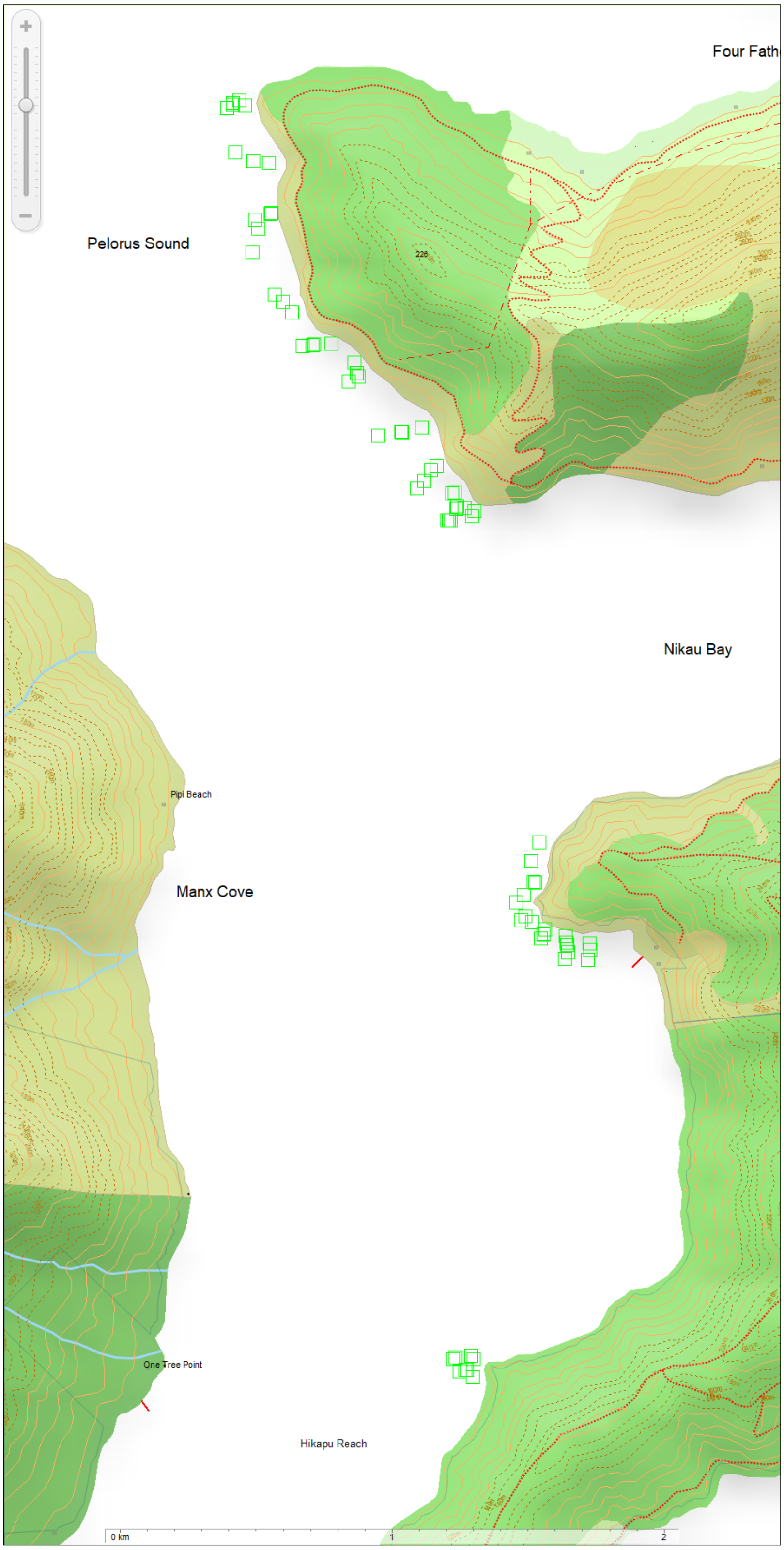

Figure 13. Location of drop camera stations along Hikapu Reach.

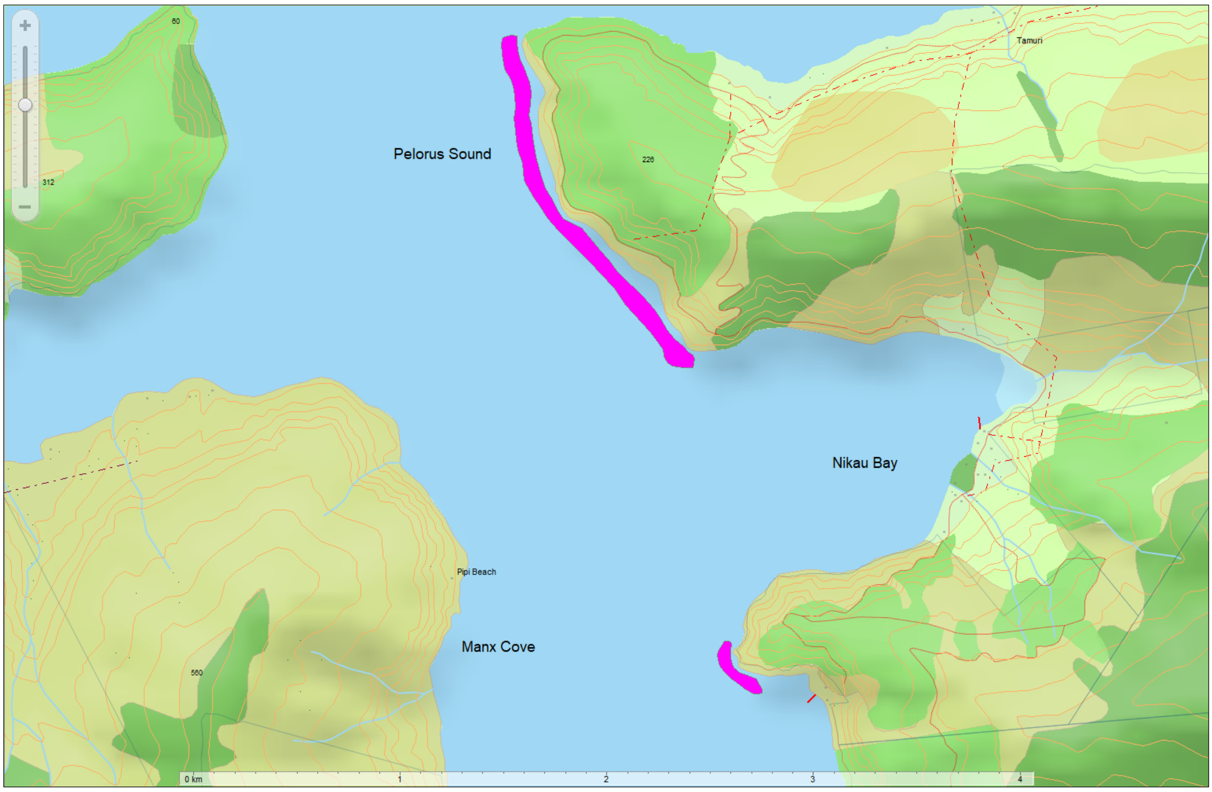

Figure 14. Suggested significant sites north and south of Nikau Bay.

4.5.8 Gold Reef Bay (west) (biogenic community)

The small bays to the west of Gold Reef Bay are one of three areas surveyed in central Kenepuru Sound (Figure 15).

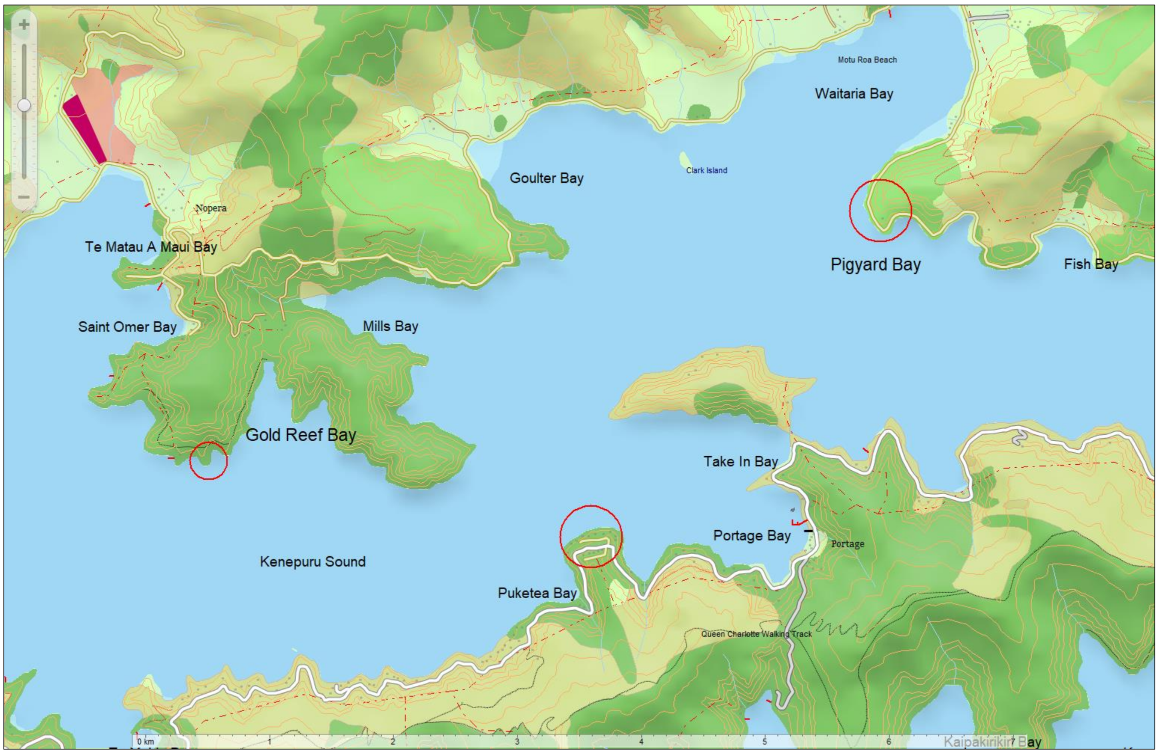

Figure 15. Location of three Kenepuru survey areas (red circles).

The Gold Bay (west) survey area is a 440 m stretch of coast located within and between two small bays along the northern coast of Kenepuru Sound, south-east of St Omer Bay (Figure 15, Plate 15). The benthos is relatively shallow and dominated by fine sediments. In the shallows, silt with a small component of natural shell dominates, with deeper areas dominated by silt and clays (mud).

Part of this area supports dense beds of the solitary ascidian (*Cnemidocarpa bicornuta*) and moderate number of horse mussels (*Atrina zelandica*) (Plate 16). The ascidian is often common in ports, harbours, and coastal environments (Page and Kelly, 2016). The authors state it may be locally abundant on shallow reefs and wharf piles and generally co-occurs with *Cnemidocarpa nisiotis*. This species of ascidian is widespread throughout New Zealand. Davidson et al. (2011) documented another high-density bed of these ascidians in inner Queen Charlotte Sound (site 4.2). This is the only high-density bed documented from Pelorus Sound.

Plate 15 Western small bay in the Gold Reef Bay (west) coast.

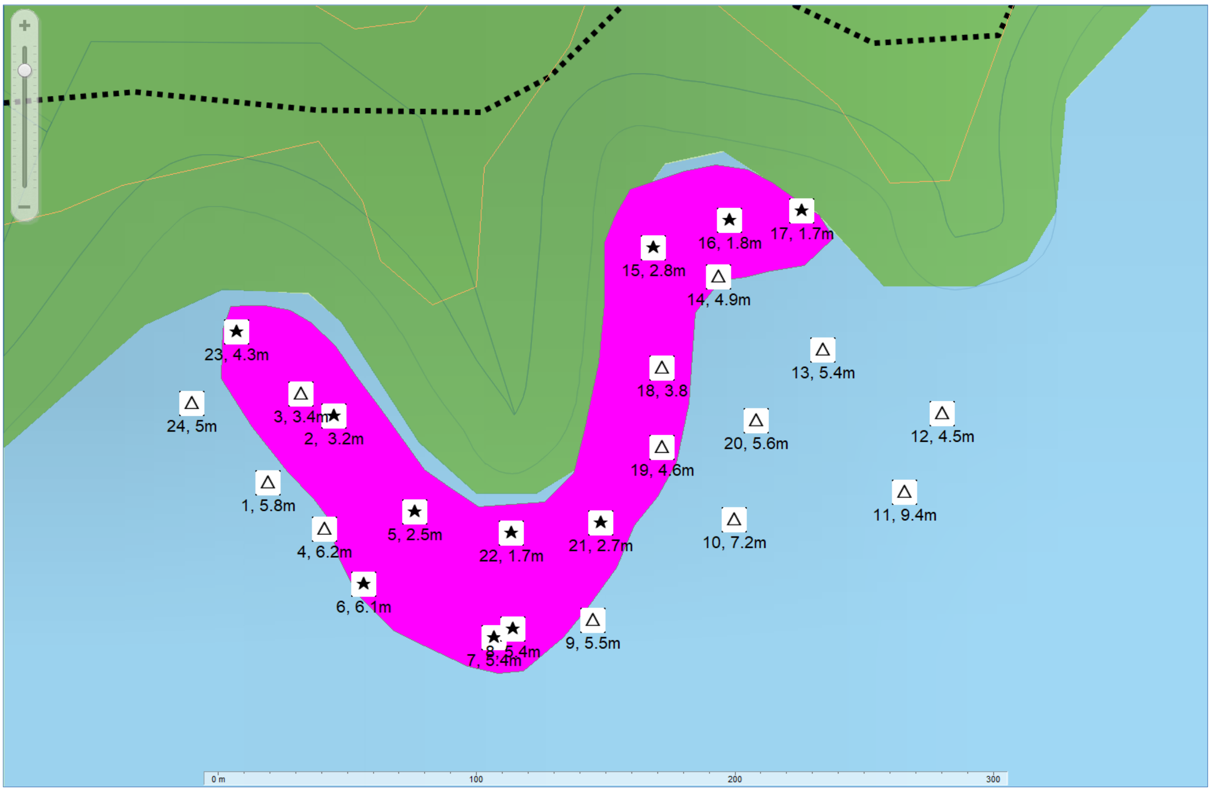

Figure 16. Location of Gold Reef Bay (west) site along the northern coastline of Kenepuru Sound. Stations are drop camera positions and depths. Stars indicate presence of ascidians and/or horse mussels.

Plate 16. High abundance of solitary ascidian (*Cnemidocarpa bicornuta*). Drop camera photo 3, 3.4 m depth).

Anthropogenic issues

The ascidians and horse mussels are located close to the edge of Kenepuru Sound and there are no scallops in this area. These factors mean it is unlikely the area would be recreationally dredged. Occasional anchoring occurs in the area, but this is mostly in central parts of these small bays outside the horse mussel and ascidian zone (Table 13). A mooring and a jetty are in the vicinity. These are also unlikely to have any impact on the biological features in this site.

Table 13. Assessment of anthropogenic impacts for Gold Reef Bay (west).

Original area of significant site (ha)	0
Recommended area of site (ha)	1.57
Change to original site	Increase
Change (ha)	1.57
Percentage change from original (%)	100%
Human Use	Low (the site is shallow, the area may be occasionally fished. Jetty and mooring in area unlikely to impact values).
Vulnerability	Moderate (biogenic structures are vulnerable to physical damage (e.g. anchoring)
Impact observed	No

4.5.9 Pukatea Bay (east)

Pukatea Bay (east) survey area was a 450 m stretch of coast located around a promontory east of Pukatea Bay and west of Portage, along the southern coast of Kenepuru Sound (Figure 15 & 17, Plate 17). The benthos is relatively shallow and dominated by fine sediments. In the shallows, silt with a small component of natural shell dominates, with deeper areas dominated by silt and clays (mud).

Patches of this area support dense beds of a solitary ascidian (*Cnemidocarpa bicornuta*) (Plate 18). Horse mussels (*A. zelandica*) are present but not in high numbers. The ascidian is often common in ports, harbours, and coastal environments (Page and Kelly, 2016). The authors state it may be locally abundant on shallow reefs and wharf piles and generally co-occurs with *Cnemidocarpa nisiotis*. The species is widespread throughout New Zealand. Davidson *et al*. (2011) documented another high-density bed of these ascidians in inner Queen Charlotte Sound (site 4.2). This area appears to support small shallow patches of ascidians in very shallow water (Figure 15). Most of the area does not support this community.

Plate 17. Coast east of Pukatea Bay.

Plate 18. High abundance of solitary ascidian (*Cnemidocarpa bicornuta*). Drop camera photo 14, 3.4 m depth.

Figure 17. Location of Pukatea Bay (east) survey area along the southern coastline of Kenepuru Sound. Stations are drop camera positions and depths. Stars indicate presence of abundant ascidians and/or horse mussels.

Anthropogenic issues

The ascidians and horse mussels are close to the shoreline and in shallow water. Further, there are no scallops in the area. These factors mean it is unlikely that the area would be dredged. Occasional anchoring occurs in the area (Table 14).

Table 14. Assessment of anthropogenic impacts for Gold Reef Bay (west).

Original area of significant site (ha)	0
Recommended area of site (ha)	0
Change to original site	NA
Change (ha)	0
Percentage change from original (%)	0%
Human Use	Low (the site is shallow, the area may be occasionally fished. Numerous holiday homes in area. Anchoring may occur).
Vulnerability	Moderate (biogenic structures are vulnerable to physical damage, e.g. anchoring)
Impact observed	No

5.9.10 Pigyard Bay (west)

The Pigyard (west) survey area was a 500 m stretch of coast located around a promontory west of Pigyard Bay, along the northern coast of Kenepuru Sound (Figure 18, Plate 19). The benthos is relatively shallow and dominated by fine sediments. In the shallows, silt with a small component of natural shell dominates, with deeper areas dominated by silt and clays (mud).

Patches of this area support dense beds of the solitary ascidian (*Cnemidocarpa bicornuta*). Horse mussels (*A. zelandica*) are present but not in high numbers. The ascidian is often common in ports, harbours, and coastal environments (Page and Kelly, 2016). The authors state it may be locally abundant on shallow reefs and wharf piles and generally co-occurs with *Cnemidocarpa nisiotis*. The species is widespread throughout New Zealand. Davidson *et al*. (2011) documented another high-density bed of these ascidians in inner Queen Charlotte Sound (site 4.2). This area appears to support high numbers of ascidians in isolated patches in the shallow subtidal (see stars in Figure 18). Most of the area does not support this community type.

Plate 19. Coast west of Pigyard Bay.

Figure 18. Location of Pigyard Bay (west) survey area along the northern coastline of Kenepuru Sound. Stations are drop camera positions and depths. Stars indicate presence of abundant ascidians and/or horse mussels.

Anthropogenic issues

The ascidians and horse mussels are close to shore in shallow water. Further, there are no scallops in the area. These factors mean it is unlikely that the area would be dredged. Occasional anchoring occurs in the area (Table 15).

Table 15. Assessment of anthropogenic impacts for coast west of Pigyard Bay.

Original area of significant site (ha)	0
Recommended area of site (ha)	0
Change to original site	NA
Change (ha)	0
Percentage change from original (%)	0%
Human Use	Low (the site is shallow), the area may be occasionally fished).
Vulnerability	Moderate (biogenic structures are vulnerable to physical damage,e.g. anchoring)
Impact observed	No

4.7.11 Catherine Cove (north)

A total of 18 drop camera images were collected from Rock Point, Catherine Cove (Figure 19). Depths where rhodoliths are traditionally found were targeted during the survey. No rhodoliths were observed from camera images.

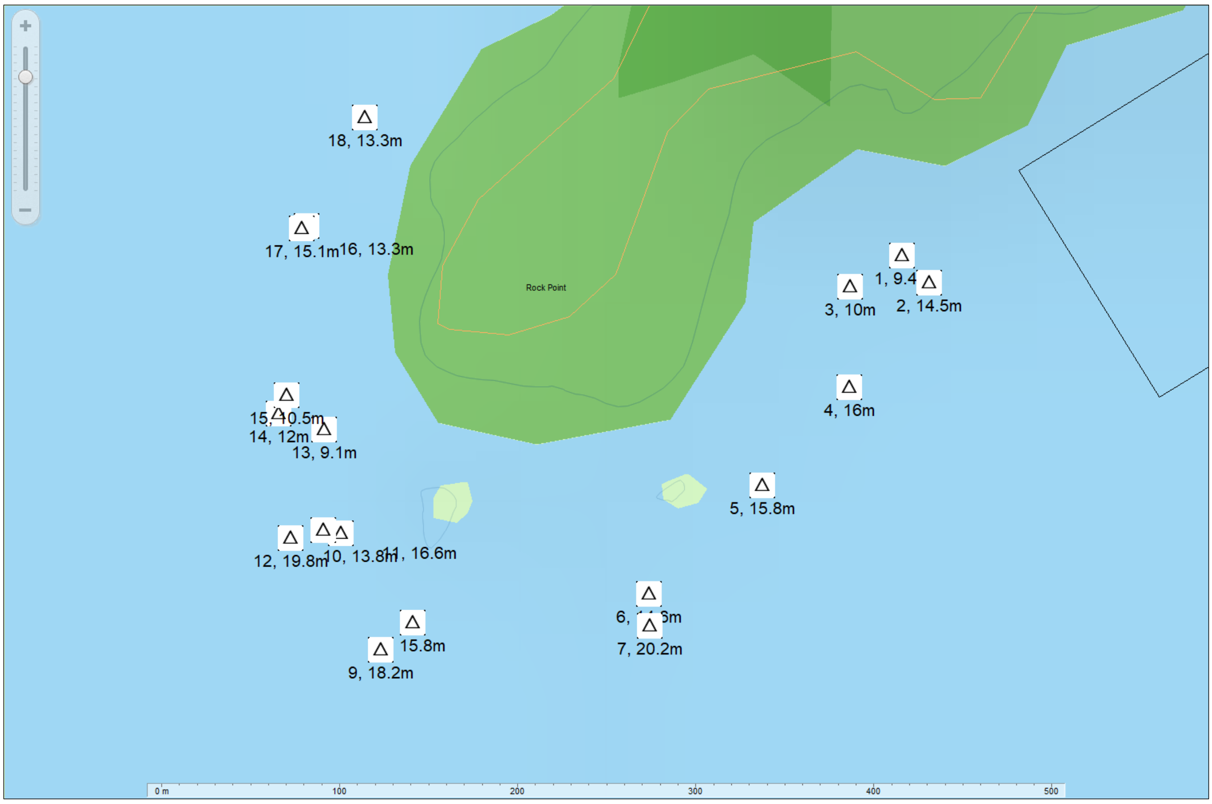

Figure 19. Location of drop camera stations around Rock Point in Catherine Cove.

5.0 Discussion

5.1 Changes in relation to significant sites

5.1.1 Reasons for change

Davidson and Richards (2015) stated change to significant marine sites and sub-sites can be due to:

(1) Discovery
A new site supports biological features with a medium or high ranking.

(2) Rejection
The site no longer supports biological features with a medium or high ranking.

(3) Reduction
Part of the significant site does not support biological features with a medium or high ranking.

(4) Addition
An area adjacent to or contiguous with an existing significant site supports the same or comparable biological features with medium or high ranking.

(5) Rehabilitation/recovery
Biological values increase to a medium or high-ranking due to recovery or rehabilitation of biological values.

Based on data in the present report, four new sites are proposed (**discovery**) with one of these sites being proposed due to **recovery** of biological attributes (Site 5.5 Hitaua Bay). Two existing sites have had new areas added (**addition**). No existing sites have had areas removed (**reduction**). No existing sites have been rejected. Two existing sites did not change in size, rather new data has been collected.

5.1.2 Confidence to make change

A change in significant site size must be based on data enabling reassessment of a site's biological ranking. It is noted, however, that because most significant sites are subtidal, temporal knowledge of biological value is usually patchy and infrequent leading to a degree of "uncertainty" regarding the level of change over time. Historically, this issue is almost always compounded by a complete lack of "before" data prior to the start of human activities.

For significant sites that have increased or decreased solely because of data quality, there is no need for "before" quantitative or qualitative data. The issue of change becomes more complex when a decline in size occurs wholly, or in part, due to anthropogenic activities (e.g. sediment smothering). Historically, scientists have collected little data on habitat extent and condition in New Zealand. When available, data are often poor quality or lacking good spatial resolution. Despite these issues, historic data can still indicate the presence of biological features of medium or high quality. These data are usually unsuitable to provide a scale or intensity of change; however, they can confirm a change from a previous state to a new state (e.g. rhodolith bed replaced by uniform mud).

A site's boundaries or significance may change based on: (1) published literature, (2) personal experience of researchers or the expert peer review panel, and/or (3) a comparison of before and after data. For example, Davidson and Richards (2015) surveyed an offshore soft bottom site in outer Queen Charlotte Sound and reported few horse mussels. Historically, this site was known to support horse mussels in densities that would have warranted classification as a "horse mussel bed" (Hay, 1990a; Davidson *et al*., 2011). No data exist to show an incremental loss over the intervening years, however, based on the literature, the most likely cause for the decline is physical damage from scallop dredging and trawling. Dredging occurs regularly in outer Queen Charlotte Sound and literature shows species like horse mussels can be significantly degraded by such activities (Thrush *et al*., 2001).

5.1.3 Site increases

Of the 11 sites presented in the present report, four were existing significant sites. Of these, two sites increased in size compared to the original significant area report (Davidson *et al.,* 2011) or subsequent annual significant site surveys. Three new sites were recommended and one site that was once a significant site was recommended (totalling 22.06 ha. Altogether, an increase of 693.6 ha was suggested in the present study. Apart from the new sites, increases to existing sites were due to improved coverage and data detail resulting in better confidence, resolution and precision.

5.1.4 Site decreases

Changes to benthic biological quality due to anthropogenic impacts has been documented elsewhere in and around the Marlborough Sounds (Stead, 1971; Handley 2015, 2016; Handley *et al*., 2017) and from the wider New Zealand environment (MacDiarmid *et al*., 2012; MFE, 2016) (see Section 5.4). In the present study, no sites declined in size.

5.2 Information issues (plan updates, data management)

5.2.1 Planning and Resource Consenting

The present study is the fifth MDC and DOC funded survey since Davidson *et al.* (2011). Like the previous surveys conducted by Davidson and Richards (2015, 2016) and Davidson *et al.* (2017, 2018), many existing sites surveyed changed in size, shape and/or attributes/values compared to original sites described by Davidson *et al.* (2011). In the present study, new quantitative data were collected from two existing sites. It is certain that further change will occur due to future surveys. An important issue is therefore how to integrate change into the Marlborough District Council planning and Resource Consent processes. It is recommended that a process enabling a regular update of significant site attributes in the Marlborough Environment Plan be implemented.

5.2.2 Data management and raw data

Survey data from the 2018-2019 survey are summarised in the present report. Detailed data (maps, photos, video, sonar) are either produced or listed in separate Excel spreadsheets. All media, raw data and spreadsheets have been stored in an MDC database. It is therefore recommended that the present document be treated as a summary with further additional detail provided by the raw data files.

5.3 Review and assessment of sites

Following approval and acceptance of the present report by the MDC Environment Committee, the significant site expert peer review panel will assess the new data and review and rank sites. A report like Davidson *et al*. (2015, 2016, 2017, 2018) outlining the expert peer review findings will be produced in due course.

Based on data collected during the present study, each site has a recommendation to the review panel. It is important to note that these are recommendations and may not necessarily be adopted by the expert panel (see Davidson *et al.,* 2013 for process).

5.4 Protection and protection initiatives

5.4.1 Anthropogenic impacts

Airoldi and Beck (2007) stated: "Nowadays less than 15% of the European coastline is considered in 'good' condition. Those fragments of native habitats that remain are under continued threat, and their management is not generally informed by adequate knowledge of their distribution and status". The authors stated for European "biogenic habitats, such as oyster reefs and maerls (rhodoliths), some of the greatest impacts have been from destructive fishing and overexploitation. Coastal development and defence have had the greatest known impacts on soft-sediment habitats with a high likelihood that trawling has affected vast areas. The concept of 'shifting baselines', which has been applied mostly to the inadequate historical perspective of fishery losses, is extremely relevant for habitat loss more generally. Most habitat loss estimates refer to a relatively short time span primarily within the last century. However, in some regions, most estuarine and near-shore coastal habitats were already severely degraded or driven to virtual extinction well before 1900."

The greatest sources of anthropogenic impacts in New Zealand's marine environment come from external sources (MacDiarmid *et al*., 2012; MFE, 2016). Climate change, ocean acidification and catchment inputs were considered the largest threats. MacDiarmid *et al.* (2012) ranked catchment effects, such as the introduction of sediment, as one of the most important local issues leading to serious impacts in the marine environment. The authors also reported that trawling and dredging were high on the list of sources of anthropogenic impacts.

In a recent study of sedimentation rates over the past 1,000 years in Pelorus Sound, Handley *et al*. (2017) stated: "*The results reflect the history of changing land-use from forest clearance in the 19th and early 20th centuries, followed by extensive sheep farming with regular burning of scrub and application of superphosphate through the middle years of the 20th century, widespread regeneration of native forest as pastures were abandoned over the last 30-40 years, and increasing areas and density of pine plantings from the turn of the 20th century to today*." Further, the authors state "*Prior to European settlement, time-averaged sediment accumulation rates were in the order of 0.2 to 1.2 mm/yr throughout the Kenepuru Sound. The main sources were the inflow from the Pelorus and Kaituna Rivers ('Havelock inflow'), subsoils from natural slips, and sediment generated from bracken, beech forest, and ponga/podocarp forest. The ecosystem had co-evolved with the fluctuations of sediment from periodic storms and episodic disturbances. Post-European settlement, sediment accumulation rates have increased to 1.8 to 4.6 mm/yr, with the contribution of the 'Havelock inflow' to the volumes of sediment deposited on the seabed increased well above historic levels, reflecting pastoral catchment practices as land was cleared and pastures maintained. This has continued to the present time. Slips associated with farming and roading also rose above historic levels. Pine-derived sediment was detected from the early 20th century, periodically was the dominant contaminant source, and has risen at most coring sites in both Kenepuru and Beatrix*

Bay since the 1990s. This is despite pine plantations representing less than 15% of the study region. Pine-derived sediment was also detected in samples taken from underneath mussel farms." The authors concluded, "*What has changed since European settlement has been the significant increase in annual or chronic sediment inputs, which have caused significant ecosystem effects and contributed to a decline in benthic biodiversity. This adds weight to the argument that an integrated range of improved land-use controls, particularly for forestry, in the Marlborough Sounds and the Pelorus and Kaituna River catchments, are required to mitigate chronic sediment inputs to benefit the health of the ecosystem and assist future restoration efforts*."

During the 2017-2018 season, two large cyclonic weather systems caused large rainfall events. The inner Pelorus Sound remained discoloured and turbid for most of this period. Further, water temperatures in Pelorus were 1-2 degrees higher than normal over the summers of 2018 and 2019 and this may have caused an extensive filamentous algae bloom on the shallow benthos at some sites. These phenomena may be related to global climate change with intense and sustained rainfall events exacerbating sedimentation rates from catchments.

As well as catchment effects, MacDiarmid *et al*. (2012) also ranked direct physical disturbance of the seafloor from activities such as the use of bottom-towed fishing gear as an important anthropogenic effect on marine environments. Cranfield *et al*. (2003) investigated the impacts of dredging on habitats in Foveaux Strait and reported that "*Initial dredging of a bryozoan biogenic reef destroys and/or removes much of the epifauna, and once the reef surface is broken up, loosened epifauna can be swept away by tidal currents and wave action. With the loss of the baffling effect of epifauna, fine sediments are then subject to transport and may be removed from the area entirely.*"

Davidson and Richards (2015) reported a decline in the area supporting significant sites particularly at offshore soft bottom areas in the Marlborough Sounds. For example, at Perano Shoal, the authors reported the presence of dense tubeworm mounds that are fragile and susceptible to physical damage from anchoring activities. They stated that 13% of the area sampled had been damaged by recreational fishers anchors. They argued that, if left unprotected, Perano Shoal would eventually lose status as a significant site. Some of the sites investigated during the present study supported biogenic habitats considered fragile and easily damaged or destroyed, notably those occurring on soft substrata. Like Europe, relatively little of Marlborough subtidal environment remains in a "good" state (Davidson and

Richards, 2015). Significant sites are often the last remaining areas of their type and therefore require immediate protection before they are degraded or lost.

5.4.2 Historic change and the need for protection

The amount of change that has occurred to New Zealand's subtidal marine environment since humans arrived is difficult to quantify due to a lack of before, during and after data. The scale of environmental change due to poor documentation, poor recollection, and consequently inter-generational loss of knowledge (i.e. shifting baseline) remains unquantified. Nevertheless, it is clear from historical accounts that large changes have occurred. Handley (2016) cited a statement calling for habitat protection from physical disturbance in the Sounds as early as 1939:

> Sir Harry Twyford, in 1939 on a return visit to New Zealand after a 35-year absence, lamented "a great deterioration of sea fishing at Cable Bay and in Queen Charlotte Sound" and the "loss of bush on the country that does not look good for grazing or anything else". Sir Harry Twyford also stated: "fishermen blamed trawlers for destroying breeding grounds" and suggested an exclusion of commercial trawlers from the Sounds.

Some early scientific publications investigated resources such as commercially viable intertidal mussel beds and subtidal scallop and horse mussel beds in the Pelorus Sound (Stead, 1991). Widespread subtidal mussel beds in the Firth of Thames also collapsed due to dredging by 1965 (Paul, 2012). Both Marlborough and Firth of Thames mussel beds have not recovered. Another indication of the effect of anthropogenic activities on the marine benthos can be derived from locations in New Zealand where biological values remain intact over widespread areas. Paterson Inlet in Stewart Island is a good example where the forest catchments are mostly intact and biological values on the soft bottom habitats of the Inlet are healthy, diverse and widespread (Smith *et al*., 2005; Willan, 1982).

There is evidence that historic human activities have had major and widespread effects on the New Zealand (and Marlborough) marine environment resulting in the loss of many areas with high biological value (Turner *et al*., 1999; Cranfield *et al.,* 2003; Morrison *et al*., 2009; NIWA, 2013; Morrison *et al*., 2014 A and B; Handley, 2015, 2016; MFE, 2016; Handley *et al*., 2017). Anthropogenic impacts in Marlborough's marine environment have resulted in ongoing biological loss, leaving only remnant areas of some particularly sensitive habitats.

Despite the intense and widespread human pressure and the knowledge that few significant sites remain, there is a poor record of marine protection in Marlborough. Davidson *et al.* (2011) reported that only one (non-terrestrial) significant site was fully protected (i.e. Long Island-Kokomohua Marine Reserve). This reserve represents approximately 0.1% of the Marlborough Sounds marine environment. In contrast, most of the terrestrial sites listed in Davidson *et al*. (2011) were protected under the Reserves or Wildlife Acts (e.g. site 2.6 Titi Island).

Since the previous significant site report was produced (Davidson *et al*., 2018), no new protected areas have been established in Marlborough. While there are a variety of partial protection mechanisms (notably fisheries regulations), these focus on the activity of fishing *per se* and do not provide comprehensive protection to vulnerable marine habitats.

The current draft Marlborough Environment Plan aims to provide a level of protection for significant sites under the RMA.

5.4.3 Protection of habitats

In terrestrial ecology, it is accepted that protection of a species cannot occur without protection of habitat. In the marine environment, this link is often ignored. A similar issue in relation to the lack of connection between habitat and fisheries management has been reported in Canada (McCain *et al*., 2016).

In Marlborough, for example, considerable attention has been given to blue cod stocks. Most focus has been on recreational fishing rules such as size limits, fishing seasons and bag limits. Little attention has been given to the protection of adult and juvenile blue cod habitat.

Blue cod regularly inhabit soft bottom biogenic habitats, with juveniles <10 cm often preferring sand with a strong component of dead whole shell (Cole *et al.,* 2000; Morrison *et al*., in prep.). Carbines *et al*. (2004) investigated growth rates of blue cod and stated: “Areas of recovering biogenic reef may, therefore, provide important habitat for the recruitment and early development of blue cod in Foveaux Strait.” The authors suggested that “remedial actions may be required to protect some areas of recovering biogenic reef from further damage, and to allow dredged areas sufficient time to recover if the blue cod fishery and related resources are to be managed effectively.”

In the present study, direct evidence of human damage to significant sites was observed. At Ouokaha Island, 11% of tubeworm mounds had been damaged presumably by recreational fisher boat anchors and anchor chains. Some significant sites have a level of natural protection due to the presence of physical structures such as rocks or reefs (e.g. parts of soft shores immediately adjacent to reef and boulder habitats). This does not, however, provide long term certainty from damage should human activities or behaviours change, nor from catchment effects such as sedimentation. Of note was the recovery of Hitaua Bay estuarine flats and shallow subtidal habitats from a large sedimentation event that reduced the areas values sufficiently to remove it from the list of significant sites in Marlborough. Data collected during the present study show the area has recovered, with eelgrass, cockles and intertidal invertebrates increasing in abundance and size. The threat of another sedimentation event does, however, remain at the future harvest event.

Some of the biological values found within significant sites are relatively rare. For example, *Galeolaria* tubeworms beds cover an area of 18.2 ha or 0.003% of the MDC marine area. Further, in the South Island, they are known from only five sites in Marlborough and one site in Big Glory Bay, Stewart Island. Similarly, rhodoliths are known from only 10 sites in Marlborough covering 31.5 ha or 0.0044 % of the marine area (Davidson et al., 2018). To date, these features remain unprotected despite their rarity.

Davidson *et al*. (2017) reported that in Australia, there exists a network of marine and freshwater protected areas. For example, the 98,000 ha Port Stephens-Great Lakes Marine Park (PSGLMP) was established in 2005 using the Marine Parks Act 1997 (now: Marine Estate Management Regulations 2014). The Act is administered by NSW Department of Primary Industries and Ministry for the Environment, with management oversight from the Marine Estate Management Authority (http://www.marine.nsw.gov.au/advisory-bodies/marine-estate-management-authority). The guideline document for the Park states: "*The PSGLMP zoning scheme enhances conservation of marine habitats and species by providing various levels of protection whilst allowing for multiple use. The four types of zones that are applied in NSW marine parks are sanctuary zones, habitat protection zones, general use zones and special purpose zones (**SANCTUARY ZONES; HABITAT PROTECTION ZONES; GENERAL USE ZONES, and SPECIAL PURPOSE ZONES)*** (http://www.dpi.nsw.gov.au/fishing/marine-protected-areas/marine-parks/port-stephens-marine-park).

Like similar habitats in Port Stephens-Great Lakes Marine Park in Australia, Marlborough's significant sites are important and worthy of protection. There are relatively few significant sites that remain and many are under threat.

It is strongly recommended their protection is urgently prioritised. Without protection, these habitats will continue to decline or be lost which will influence biodiversity, habitat values, and species (including fish) abundance, size, fecundity and recruitment.

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