Davidson Environmental Limited

Significant marine site survey and monitoring programme (survey 4): Summary report 2017-2018

Research, survey and monitoring report number 878

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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 was also used to collect HD media at selected sites.

A total of 14 sites are described in the present report. Six potential new significant sites (Woodlands west rhodoliths, Ouokaha Island coast, Tuhitarata Bay reef, Matai Bay tubeworms, Penzance Bay elephantfish spawning, Treble Tree coastline) were described. Matai Bay tubeworms and Penzance Bay elephantfish spawning 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. These 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 in 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.

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 that some of the remaining significant sites were being degraded or lost. The present study suggests that 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 remains a priority for coastal managers.

Exotic Chaetopterid tubeworms within significant site 3.8.

Note: Raw data collected during the 2017-2018 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) *	1592.14
Potential new sites*	6
Potential site removed*	0
Increase in area (ha) *	191.114
Decrease in area (ha) *	-112.68
Overall change (ha) *	78.434
Sites	Work conducted/recommendations
Site 3.7 Picnic Bay rhodoliths	Adjust boundaries, protect significant site from all forms of physical disturbance
Site 3.8 Fitzroy Bay elephantfish spawning	Adjust boundaries, protect significant site from all forms of physical disturbance
Site 3.9 Tennyson Inlet	Adjust boundaries, protect significant site from all forms of physical disturbance
Site 3.11 Tapapa coastline	Adjust boundaries, protect significant site from all forms of physical disturbance
Site 3.12 Piripaua reef	Adjust boundaries, protect significant site from all forms of physical disturbance
Site 3.15 Grant Bay reef	Adjust boundaries, protect significant site from all forms of physical disturbance
Site 3.22 Tawhitinui Bay king shag colony	Establish an approach distance guideline for colony, publicise
Site 3.23 Woodlands (west) rhodoliths *	Establish significant site and protect from all forms of disturbance
Site 3.24 Tuhitarata Bay reef	Establish significant site and protect from physical disturbance
Site 3.25 Kauauroa coast	Adjust boundaries, protect significant site from all forms of physical disturbance
Site 3.26 Ouokaha Island (west coast) *	Establish significant site and protect from physical disturbance
Site 3.27 Matai Bay tubeworms *	Establish significant site and protect from physical disturbance
Site 3.28 Penzance Bay elephantfish spawning *	Establish significant site and protect from physical disturbance, low impact moorings
Site 3.29 Treble Tree coastline *	Establish significant site and protect from physical disturbance, collect more data

*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 in 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). These increases were due to an improvement in the level of 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.

2.0 Study sites (present study)

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

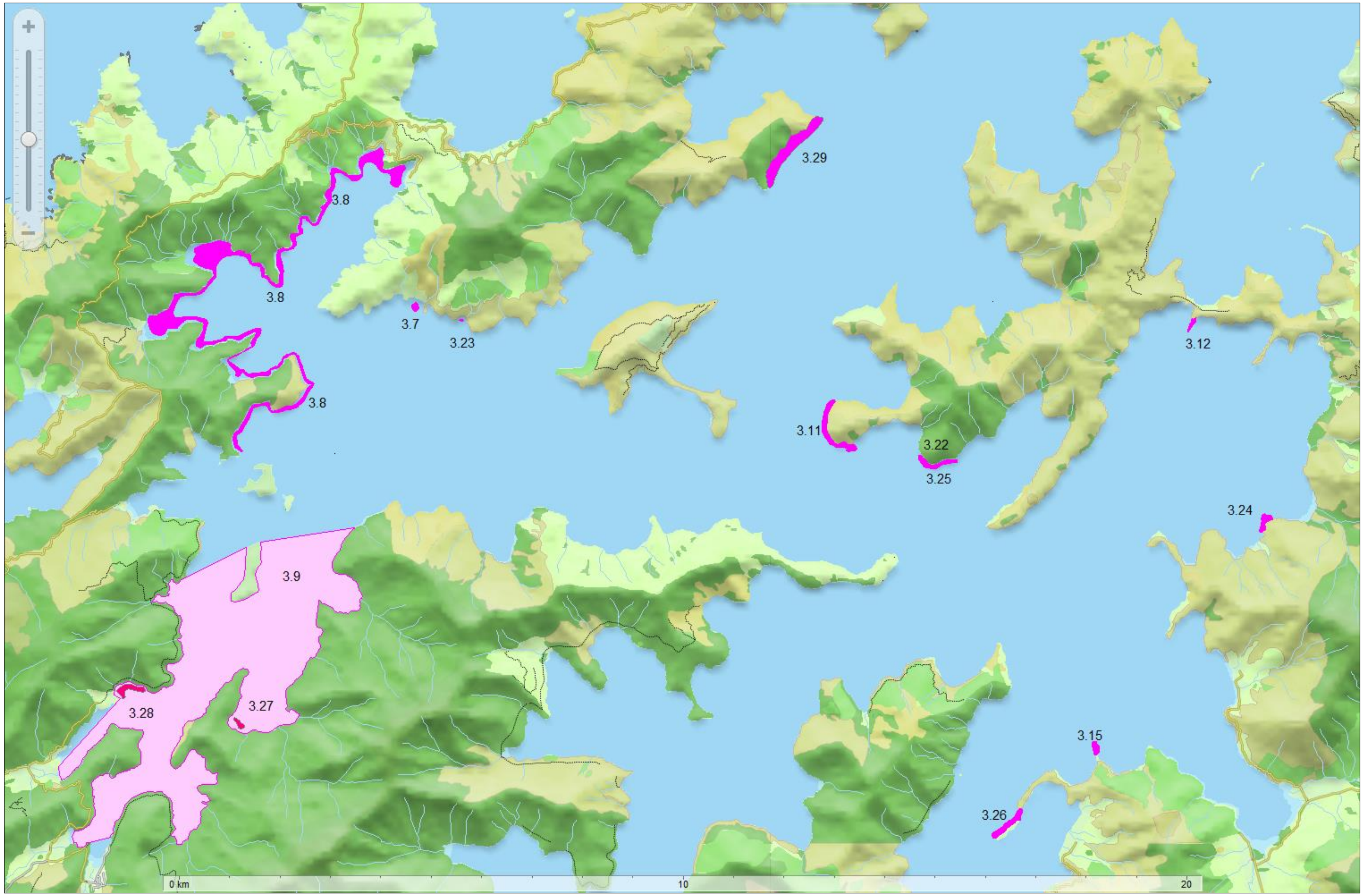

Figure 1. Location of the 14 recommended significant sites from the present 2018 study (survey sites = pink and red polygons).

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).

3.1 Sonar imaging

Sonar investigations were conducted using a Lowrance HDS-12 Gen 2 and HDS-8 Gen2 linked with a Lowrance StructureScan™ Sonar Imaging LSS-1 Module. These units provide right and left side imaging as well as DownScan Imaging™ and were linked to a Point 1 Lowrance GPS Receiver. The unit also allows real time plotting of StructureMap™ 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 low-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). 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 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 S6 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

Divers collected samples of tubeworms from Fitzroy Bay for identification. Samples were placed in a plastic bag, chilled and later preserved for ID.

3.7 Excel site sheets and data

Data collected from each site during the present study were entered into 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).

3.8 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.

4.0 Results and recommended changes

Survey data from the 2016-2017 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 supplied to MDC to be stored in an MDC database. The present report should therefore be regarded as a summary or overview of all the raw data.

4.1 Site changes

Fourteen sites are included in this report (Table 3) and are discussed in section 4.5. Two sites were located within the boundaries of the large Tennyson Inlet site (3.9). No sub-sites were described (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, it is recommended to:

1. Site 3.7 Picnic Bay rhodoliths: update boundary to encompass rhodoliths.
2. Site 3.8 Fitzroy elephantfish spawning: update boundary to spawning habitat.
3. Site 3.9 Tennyson Inlet: update boundary to encompass increased area surrounded by stable protected catchment.
4. Site 3.11 Tapapa coast: update boundaries to encompass current swept habitats and biogenic communities.
5. Site 3.12 Piripaua reef: update boundary to encompass reef.
6. Site 3.15 Grant Bay reef: update boundary to encompass reef.
7. Site 3.22 Tawhitinui Bay king shag colony: update Excel data.
8. Site 3.23 (new site) Woodlands (west) rhodoliths: establish a new site to encompass rhodoliths.
9. Site 3.24 (new site) Tuhitarata Bay reef: establish new site to encompass reef habitat.
10. Site 3.25 Kauauroa coast: update boundaries to encompass current swept habitats and biogenic communities.
11. Site 3.26 (new site) Ouokaha Island western coast: establish new site to encompass inshore habitats and tubeworm mounds.

12. Site 3.27 (new site) Matai Bay tubeworms: establish a new site to encompass tubeworm bed.
13. Site 3.28 (new site) Penzance Bay elephantfish spawning: establish a new site to encompass spawning site.
14. Site 3.29 (new site) Treble Tree coastline: establish a new site to encompass current swept recovering habitats.

4.2 Size change since 2011

Six new candidate or potential significant sites were described during the present study totalling 51.6 ha (Table 3). Three existing significant sites increased in size by a total of 146.2 ha due to either improvements in data (Sites 3.12 and 3.15) or additional area applied based on assessment criteria (i.e. site 3.9 boundaries increased to reflect DOC managed land). Four sites declined in size by a total of 112.68 ha (Sites 3.7, 3.8, 3.11, 3.25). Declines were mostly due to an improved level of information, however, a small area of site 3.8 (Fitzroy elephantfish egg-laying habitat) was impacted by marine farms and no longer supported spawning habitat (Table 3). One site was a terrestrial seabird nesting site and did not change in size or location (Site 3.22).

4.3 Substratum and habitats

Five sites were totally located on soft substratum, while all but one of the remainder were combinations of soft and rocky substratum (Table 3). Significant sites located on soft substratum are considered the most vulnerable and threatened type of site as they can be damaged or destroyed by anthropogenic physical damage and are also vulnerable to sediment smothering as they are often offshore 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 dominated by soft sediment and combined soft sediment and rocky communities. Some sites supported biogenic community types (e.g. tubeworms, bryozoans, sponges, ascidians, hydroids). This community type is often fragile, slow growing, and has 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 3.27 tubeworms) or the species present (Site 3.28 elephantfish spawning).

Biogenic mounds

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. DeSmet *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 spawning

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 spawning 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 spawning sites in the Marlborough Sounds are of scientific interest as they represent sites where egg cases can be reliably collected using SCUBA.

Dredge and trawl free habitats

Current swept soft bottom habitats are often dredged and trawled in the Marlborough Sounds. These habitats usually gain refuge when they are located immediately adjacent to rocky shores. One current swept soft bottom area in Waitata Reach has limited dredging since 1997 due to the presence of three research marine farm sites. It is noted, however, that fishers have attempted to dredge parts of this area on occasion (N. Keeley, pers. comm.) Marine research activities occurring at these sites have had no impact on the benthos (Battershill, 1987; DuFresne and Richards, 2006).

Table 3. Summary of sites and sub-sites surveyed in 2018 including recommended changes and the suggested reason for site changes.

Site	First described as signficant site	Original area (ha)	Recommended area (ha)	Change (ha)	Change %	Benthos type	Reason for change	Notes
Site 3.7 Picnic Bay rhodoliths	2011	1.9	1.1	0.8	-42.1	Soft	Improved detail of survey	
Site 3.8 Fitzroy Bay elephantfish spawning	2011	252.6	160.4	92.2	-36.5	Soft	Improved detail of survey, marine farm impact	
Site 3.9 Tennyson Inlet	2011	1211.68	1354.8	143.12	11.8	Rocky and soft	Reassessment of boundary	Survey incomplete
Site 3.11 Tapapa coastline	2011	24.11	13.03	11.08	-46.0	Rocky & soft	Improved detail of survey	
Site 3.12 Piripaua reef	2011	0.685	1.86	1.175	171.5	Rocky & soft	Improved detail of survey	
Site 3.15 Grant Bay reef	2011	0.987	2.92	1.933	100.0	Rocky & soft	Improved detail of survey	
Site 3.22 Tawhitinui Bay king shag colony	2017	0.16	0.16	0	0.0	Terrestrial	New data	
Site 3.23 Woodlands (west) rhodoliths	2018		0.188	0.188	100.0	Soft	New site	
Site 3.24 Tuhitarata Bay reef	2018		3.398	3.398	100.0	Rocky & soft	New site	
Site 3.25 Kauauroa coast	2011	14.9	6.3	8.6	-57.7	Rocky & soft	Improved detail of survey	
Site 3.26 Ouokaha Island (west coast)	2018		6.5	6.5	100.0	Rocky and soft	New site	
Site 3.27 Matai Bay tubeworms	2018		2.23	2.23	100.0	Soft	New site	
Site 3.28 Penzance Bay elephantfish spawning	2018		6.68	6.68	100.0	Soft	New site	
Site 3.29 Treble Tree coastline	2018		32.57	32.57	100.0	Soft & rocky	New site	Survey required
Total			**1592.14**					
Increase to significant sites				191.114				
Decrease to significant sites				-112.68				

New sites =	

4.5 Significant sites

4.5.1 Site 3.7 Picnic Bay rhodoliths

Picnic Bay is on the northern shoreline of Tawhitinui Reach. The rhodolith bed was re-surveyed using drop camera technology and the site boundaries altered based on this new data. This alteration was not due to a change in rhodolith distribution or abundance, rather the increased intensity of drop camera stations.

Figure 2. Boundary of original site (red polygon) and suggested new site (green polygon) in Picnic Bay.

During the present 2018 survey, 19 stations that had been sampled in September 2008 were resampled to investigate if percentage cover had changed (Table 4, Figure 3). The mean percentage cover from all 19 stations declined by approximately 9%, however, it is likely this was due to a high cover of filamentous algae present during the 2018 survey (Plate 1). This alga was recorded from other shallow sites in central Pelorus Sound and may have been due to the higher than normal water temperatures in the summer of 2017-2018.

Table 4. Drop camera station data from the same 19 stations sampled in 2008 and in the present study.

No. & Depth (m)	Coordinates	Substratum	Feature	% cover Sept 2008	% cover Feb 2018
1, 22.7m	1670327.4,5458824.6	Silt & shell hash		0	0
2, 23.5m	1670306.1,5458832.6	Silt, fine sand, shell		0	0
3, 23.5m	1670290.8,5458840.4	Silt, fine sand, shell		0	0
4, 8.1m	1670417.3,5458846.9	cobbles, sand, shell		0	0
5, 15.8m	1670386.6,5458860.0	Silt, fine sand, shell		0	0
6, 18.1m	1670358.2,5458879.1	Sorted shell and sand		0	0
7, 18.2m	1670350.6,5458885.7	Silt, fine sand, shell, rhodoliths	Rhodoliths	55	40
8, 17.8m	1670343.6,5458895.2	Silt, fine sand, shell, rhodoliths	Rhodoliths	40	70
9, 17.8m	1670343.6,5458895.2	Silt, fine sand, shell, rhodoliths	Rhodoliths	60	80
10, 17.7m	1670336.9,5458902.2	Silt, fine sand, shell, rhodoliths	Rhodoliths	80	90
11, 17.7m	1670336.9,5458902.2	Silt, fine sand, shell, rhodoliths	Rhodoliths	85	95
12, 17.2m	1670300.4,5458941.6	Silt, fine sand, shell, rhodoliths	Rhodoliths	90	70
13, 17.2m	1670300.4,5458941.6	Silt, fine sand, shell, rhodoliths	Rhodoliths	60	30
14, 14.5m	1670313.9,5458989.2	Silt, shell		0	5
15/16, 10.2m	1670412.5,5458929.6	Fine sand, shell hash		0	0
17, 15.5m	1670366.6,5458914.0	Silt, fine sand, shell, rhodoliths	Rhodoliths	75	0
18, 15.5m	1670366.6,5458914.0	Silt, fine sand, shell, rhodoliths	Rhodoliths	95	60
19, 15.5m	1670366.6,5458914.0	Silt, fine sand, shell, rhodoliths	Rhodoliths	90	20
Mean				40.56	31.11
SD				39.63	36.32
SE				9.34	8.56

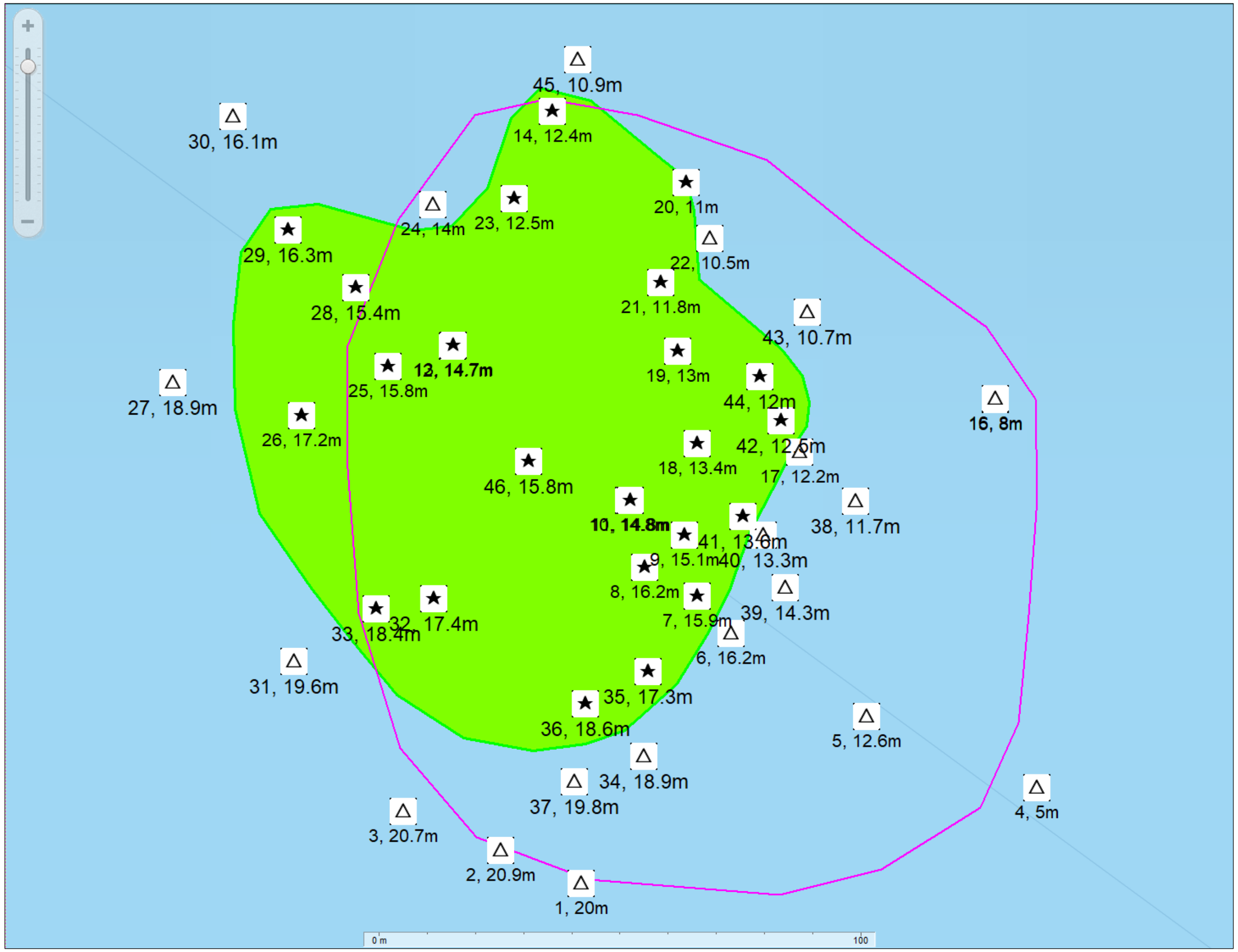

Figure 3. Drop camera stations and depths (stars = rhodoliths, triangles = no rhodoliths). Pink line = 2008 boundary, green = 2018 boundary.

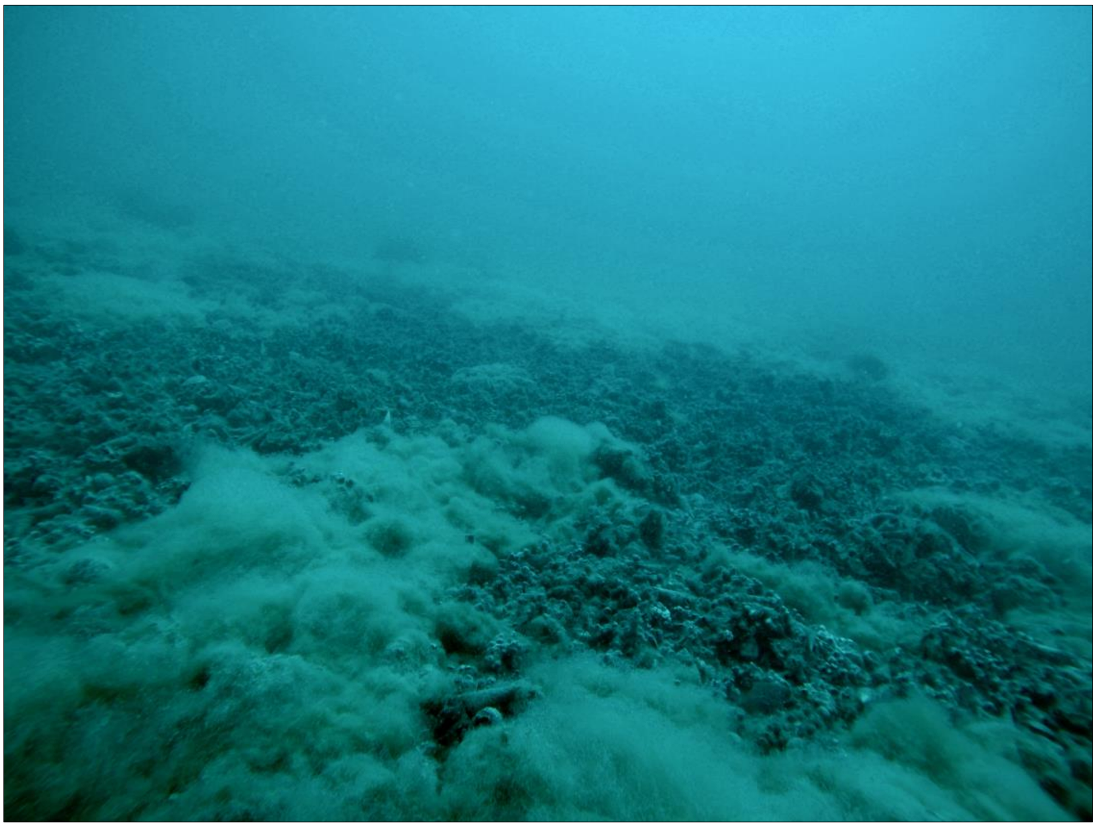

Plate 1. Rhodoliths with patchy cover of filamentous algae in 2018.

Of the 46 drop camera stations sampled in 2018, 25 supported rhodoliths ranging from 2% to 95% cover. The overall mean percentage cover from stations with rhodoliths was 47.7%. This value was considerably lower than beds located in the D'Urville Island and Croisilles Harbour where mean cover is above 79% (Catherine Cove = 79.6%; Lone Rock (Croisilles) = 81.9%; Coppermine-Ponganui Bays = 82.5%; Bonne Point = 86%). The reason for this difference is unknown but may be related to environmental conditions.

Anthropogenic issues

Rhodoliths are long-lived, slow growing and fragile (Nelson *et al*., 2012). No anthropogenic impacts were observed or are known from the rhodolith bed in Picnic Bay (Table 5). Rhodoliths at this site are located on soft substrata and are therefore vulnerable to physical disturbance and sediment smothering. They are afforded a good level of protection from dredging due to the proximity of the adjacent headland and a marine farm to the west. Due to their location on soft substratum and the small size of the bed, they should be considered highly vulnerable. A forestry block is located high on the adjacent hillside. It is recommended that considerable care be exercised to minimise sediment runoff during future logging operations.

Table 5. Assessment of anthropogenic impacts for Site 3.7 (Picnic Bay rhodoliths).

Original area of significant site (ha)	1.9
Recommended area of site (ha)	1.1
Change to original site	Decrease
Change (ha)	0.8
Percentage change from original (%)	42.1%
Human Use	Low (dredging limited by adjacent headland and marine farms).
Vulnerability	High (rhodoliths are long-lived, fragile species living on soft substratum).
Impact observed	None.

4.5.2 Site 3.8 Fitzroy Bay (elephantfish spawning)

Fitzroy Bay complex, including Hallam Cove, Garne, Savill, Canoe Bays and the Camel Point coast, are situated at the western end of Tawhitinui Reach. The Garne and Savill Bay Scenic Reserves cover much of the catchment of these bays. Areas of private land and many marine farms exist along this coast.

The shallow edges of these bays are used as spawning grounds by elephantfish, *Callorhinchus milii* (Plate 2). This is one of two regularly used spawning areas in the Marlborough Sounds (Davidson *et al*., 2011).

Based on the present study, the area supporting suitable benthic spawning habitat in Fitroy Bay complex was reduced in size by 160 ha compared with the area described in Davidson *et al*. (2011) (Figure 4). Deep and shallow areas that did not support suitable habitat were removed from the significant site polygon.

In addition, divers collected elephantfish egg case density from 12 replicate 10m^2 quadrats in each of Garne and Savill Bays. The density of live and dead cases was compared with data collected by Davidson Environmental Ltd. in 1996. Overall, the density of both live and dead cases was lower in 2018 compared to the previous sample. Divers observed only three live cases in Garne Bay quadrats and only one live egg case in Savill Bay quadrats.

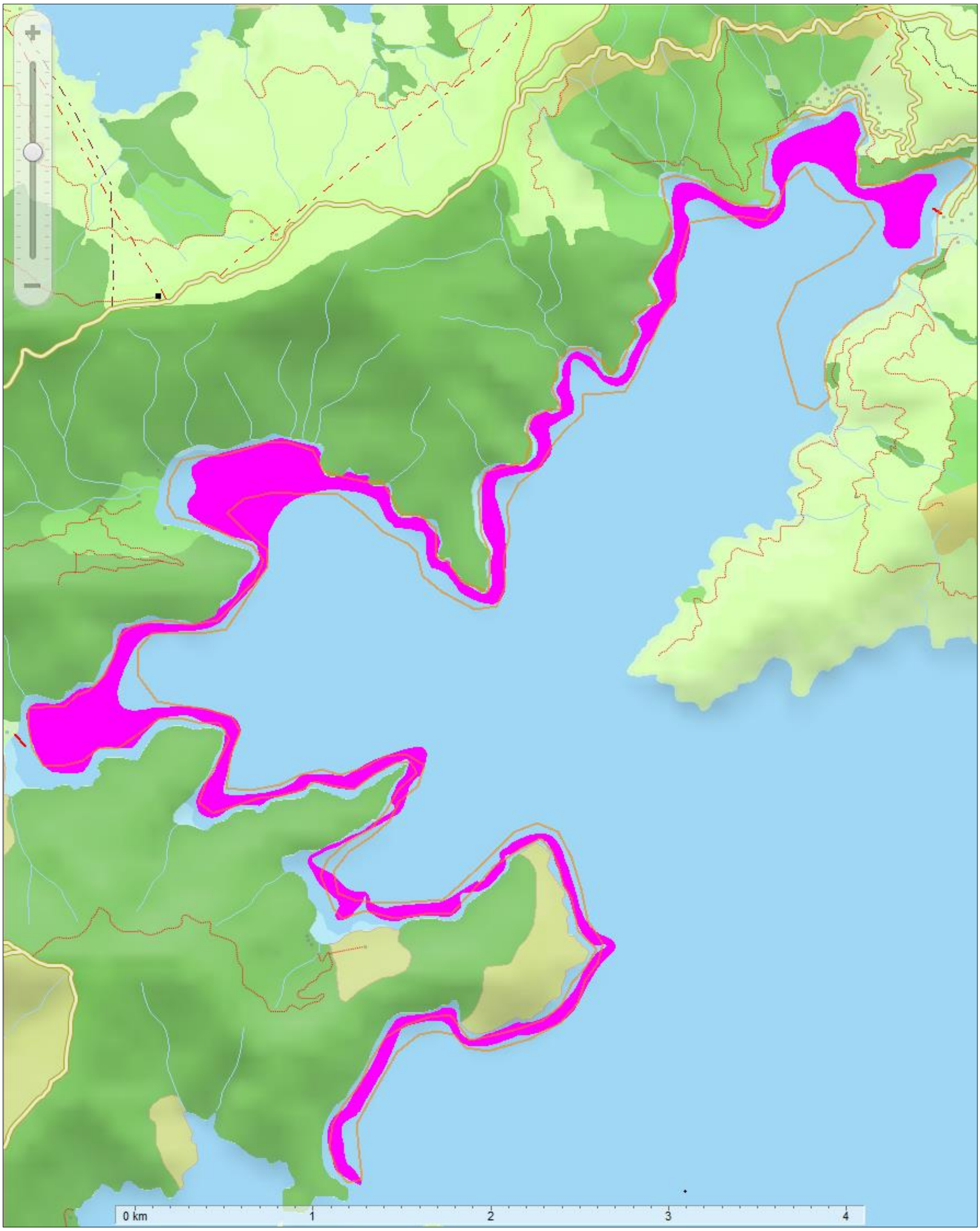

Figure 4. Boundaries of the recommended elephantfish spawning area (pink filled polygon) compared to the 2011 boundary (orange polygon).

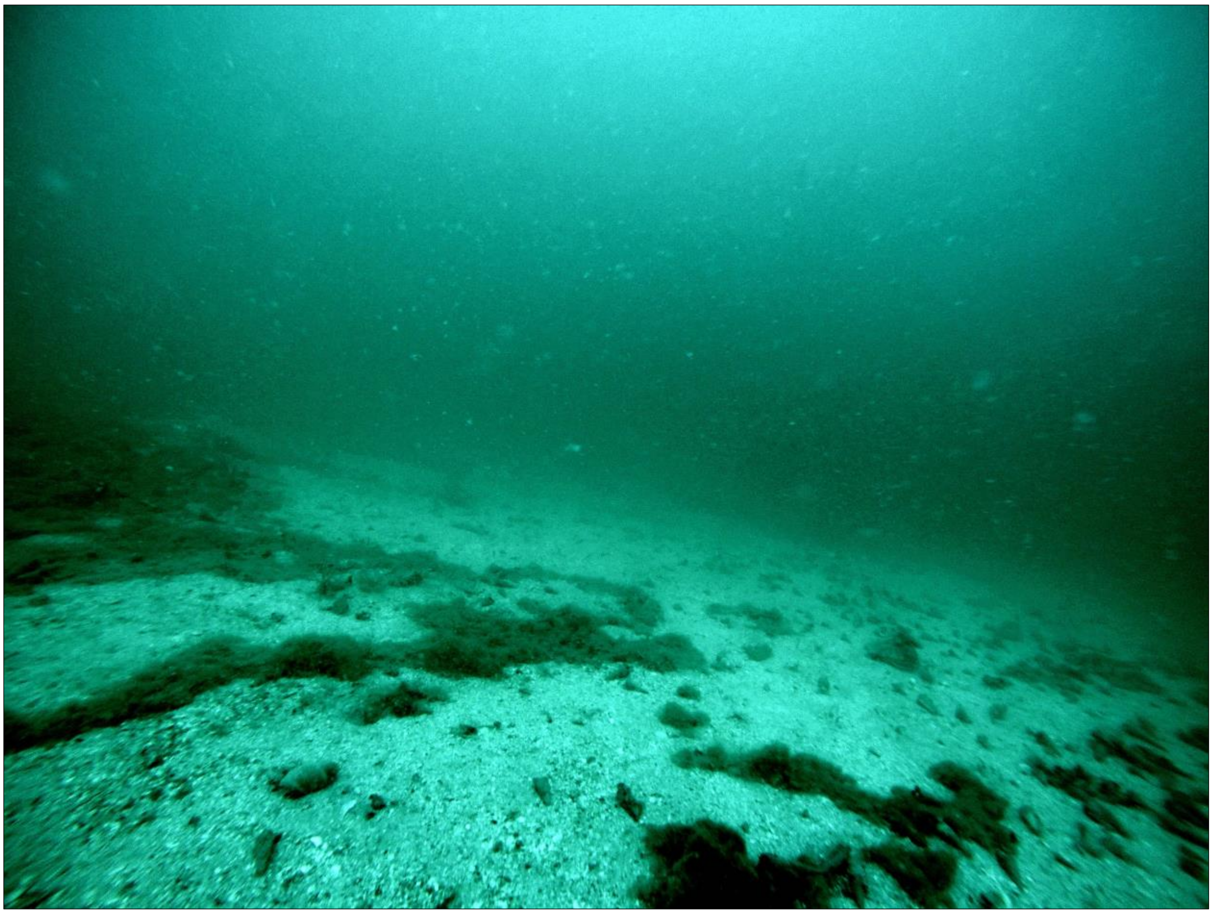

Plate 2. Typical elephantfish spawning habitat in the Fitzroy Bay area.

Anthropogenic issues

Elephantfish usually choose to lay their egg cases on certain substratum types. Substratum is almost always dominated by sand and shelly substratum with a low proportion of silts and clays. As such, these sites are usually located around coastal edges (5-18m depth) or in shallow bays.

Elevated sedimentation levels can alter subtidal substratum (MacDiarmid *et al*., 2012; Handley *et al*., 2017) and therefore has the potential to impact on elephantfish. Most of the catchment surrounding this significant site is clad in native forest or regenerating scrub. However, a large block of forestry is located at the western head of Hallam Cove. Further, most of the catchment supports no or low levels of housing and related infrastructure. The exception is the head of Hallam Cove (Cissy Bay) where a settlement exists. Future logging and activities that disturb land in the settlement have the potential to alter spawning habitats if conducted poorly.

Commercial and recreational dredging and trawling does not occur along the inshore area (authors, pers. obs.). Marine farms are located along this coast and several moorings are located at the head of Hallam Cove (Table 6). Approximately 2.3 ha of existing marine farms overlap with spawning habitat in the Fitzroy Bay complex. Mussel shell deposition occurs where mussel droppers are placed above spawning areas and it acts to smother spawning substratum. It is recommended that these farms be shifted further from shore or a no dropper structure zone be established where overlap occurs. Approximately 17 moorings have been approved in the Cissy Bay area. Most of these overlap with the spawning habitat. It is recommended that low impact moorings replace traditional block and chain structures in this area as these may damage egg cases when chain is dragged across the sea floor.

Two exotic species of note were recorded during the present study. The exotic algae *Asperococcus bullosus* (Nelson and Knight, 1995) was present in Garne and Savill Bays and the exotic tubeworm (Chaetopteridea) were sometimes abundant around coastal edges. 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 areas have been invaded by the worm, believed to be *C. variopedatus*. Since about 1995, divers reported seeing whole areas of the sea bed covered in parchment-like tubes (http://www.seafriends.org.nz/indepth/invasion.htm). Both species, especially *Asperococcus bullosus*, have the potential to impact elephantfish spawning by modifying the benthos in the Fitzroy Bay complex.

Table 6. Assessment of anthropogenic impacts for site 3.8 (Fitzroy Bay).

Original area of significant site (ha)	252.6
Recommended area of site (ha)	160.4
Change to original site	Decrease
Change (ha)	92.2
Percentage change from original (%)	-36.5%
Human Use	Moderate -high (mussel farms, moorings, settlement, forestry).
Vulnerability	Moderate (biogenic communities are fragile and slow to recover from physical disturbance)
Impact observed	A small number of mussel farms have consent space that overlaps with spawning habitat. Where this occurs, the benthos has been modified making it unsuitable for spawning. Mooring overlap with spawning habitat. Two exotic species have modified the benthos at several locations.

4.5.3 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. 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) (Plates 3a 3b). 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 3a. Ngawakawhiti Bay in inner Tennyson Inlet.

During the present survey, 221 drop camera stations were collected from the eastern shoreline and the western shore as far north as Penzance Bay. The eastern shoreline was also sampled using sonar. Two features of special interest were recorded at Matai and Penzance Bays (Plate 5) and have been described as separate significant sites in the present report. Apart from these new sites, the remainder of the Inlet supported habitats and species that appeared typical of central Pelorus Sound. The influence of stable forested catchments is apparent in the estuaries, however, the effect on marine communities may only become apparent with quantitative epifaunal and infaunal sampling.

Plate 3b. Tawa Bay fringing vegetation and alluvial coastal forest.

Plate 4a. Cobble, boulder, sand and natural shell substratum around the edges of Tennyson Inlet.

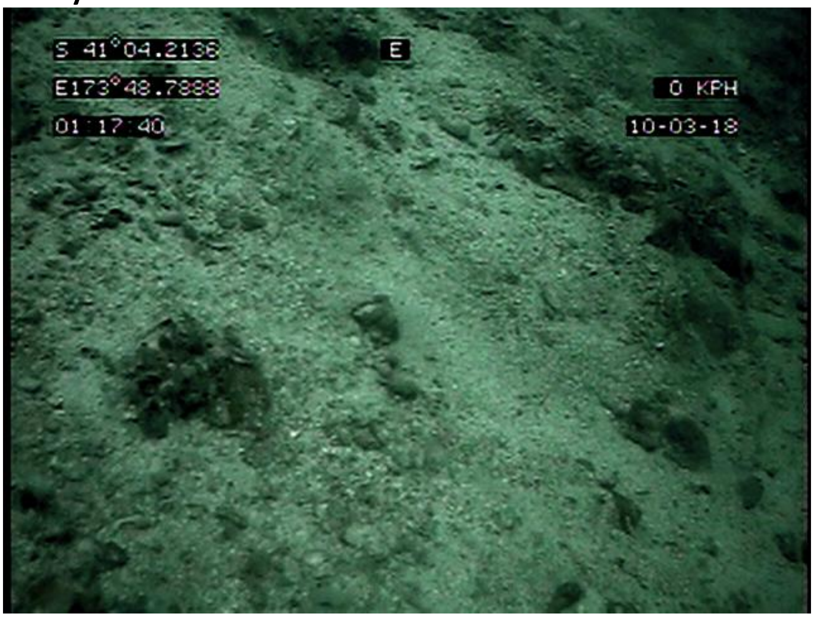

Plate 4b. Coarse soft substratum composed of combinations of sand, natural broken and whole shell and silt from around the lower shore edges of Tennyson Inlet.

Anthropogenic issues

Two areas within the Inlet are sensitive to anthropogenic disturbance. These are discussed separately as Matai Bay tubeworms (3.27) and Penzance elephantfish spawning (3.28). Apart from candidate sites 3.27 and 3.28, Tennyson Inlet is comprised of habitats and a community type 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 impacts sources in New Zealand (MacDiarmid *et al*., 2012; MFE, 2016). As such, the marine habitats of Tennyson Inlet represent an area in a relatively natural, pre-human "natural" state.

Human impacts and use are relatively low in Tennyson Inlet compared to much of Pelorus Sound (Table 7). Bray and Stuick (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 and Penzance Bays, but most of the site has little or no terrestrial habitation. A DOC hut is situated on the coast in Matai Bay. People transiting between the hut and mooring (3524) has caused a localised impact on estuarine vegetation (i.e. trampling). Forestry blocks exist on private land in the Tennyson Inlet catchment. Replanting of existing and planting of new forestry blocks require careful consideration to ensure the low sedimentation properties of this area are maintained.

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

Table 7. Assessment of anthropogenic impacts for Site 3.9 (Tennyson Inlet).

Original area of significant site (ha)	1211.68
Recommended area of site (ha)	1345.9
Change to original site	Increase
Change (ha)	134.2
Percentage change from original (%)	11.1%
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.

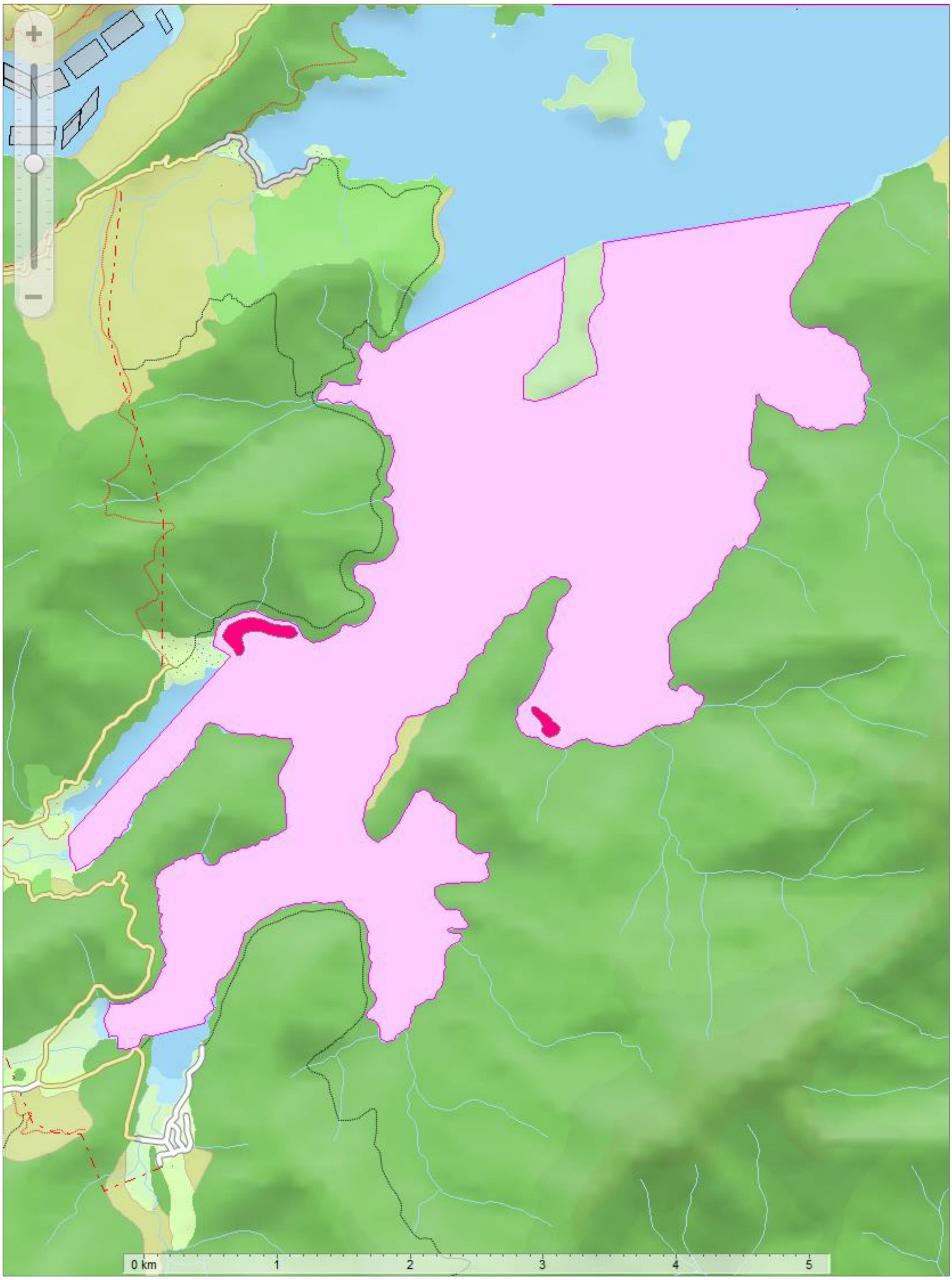

Figure 5. Tennyson Inlet significant site (pink polygon), with two small new candidate significant sites located in Penzance and Matai Bays (small red polygons).

4.5.4 Site 3.11 Tapapa coastline (current community)

This short stretch of coast is located east of Maud Island at the confluence of Waitata and Tawhitinui Reaches (Plate 5). The fringing subtidal shores shelves steeply and are swept by moderate to strong tidal currents (Davidson *et al*., 2011). At this site, there is a wide variety of filter feeding organisms including biogenic habitat formers of sponges, ascidians and hydroids. Fish, particularly blue cod, are common and the benthic biogenic communities also provide habitat for juvenile blue cod. This site is regarded as one of the best examples of tidally swept habitats within the Pelorus Sound biogeographic area (Davidson *et al*., 2011).

The present survey confirmed the presence of a range of current swept habitats with a variety of species including sponges, anemones, bryozoans, hydroids and ascidians (Plate 6). Adult and juvenile blue cod were numerous, especially in current-swept locations. The present survey provided improved resolution of biogenic habitats and resulted in amended boundaries (Figure 6).

Plate 5. Tapapa coastline looking northwards into Waitata Reach.

Plate 6. Current-swept cobbles supporting biogenic communities dominated by large sponges, ascidians and hydroids.

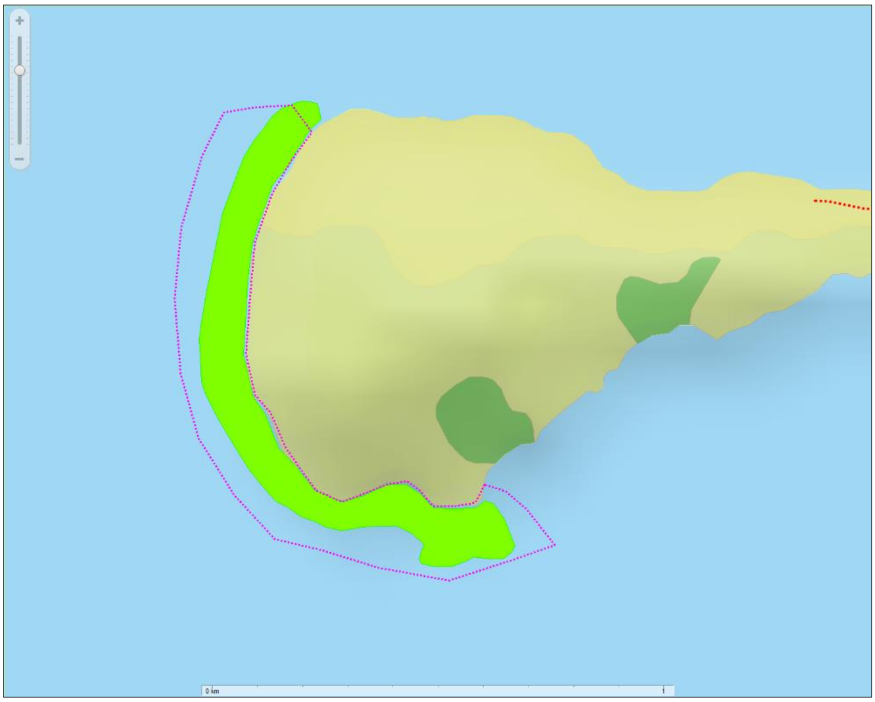

Figure 6. Original site 3.11 described in Davidson *et al.* (2011) (red open polygon) and suggested revised site boundaries (green polygon).

Anthropogenic issues

The presence of rocky substratum along this site reduces the risk of physical damage from dredging and trawling. Further, the current-swept position reduces sediment deposition. The site is a popular location for recreational fishers with two recreational fishers observed in the area during the survey (Plate 5). The impact of recreational fishing activity on this type of habitat is considered low compared to many other anthropogenic activities in the marine environment (Table 8). A marine farm is located at the south-eastern edge of this site. Due to the high currents in this area, potential impacts from the mussel farm are minimised and appear restricted to under the production droppers.

Table 8. Assessment of anthropogenic impacts for Site 3.11 (Tapapa coastline).

Original area of significant site (ha)	24.11
Recommended area of site (ha)	13.03
Change to original site	Decrease
Change (ha)	11.08
Percentage change from original (%)	-45.9%
Human Use	Low (the site is a popular site for recreational fishers, the impact of this activity on habitats is likely low). Dredging occurs offshore but is unlikely to occur within the site.
Vulnerability	Low (rocky reef habitats deter dredging and trawling activities). Sedimentation levels are likely to be low.
Impact observed	No.

4.5.5 Site 3.12 Piripaua (reef)

Piripaua is located at the northern end of Beatrix Bay (Figure 7, Plate 7). Davidson *et al*. (2011) stated this reef was one of the better examples of a reef system in central Pelorus Sound.

Plate 7. Piripaua taken from a position offshore and looking northwards.

The present survey confirms the presence of the reef and identifies the existence of a greater area of deep reef habitat than previously known (Plates 8 and 9). The reef appears to support a range of species typical of low current reef systems in central Pelorus Sound from Tawero Point northwards (Stewart, 2014) (Plate 8). A narrow and shallow fringe of sparse macroalgae (*C. flexuosum, C. maschalocarpum*) is present in low abundance near low water (Chadderton and Davidson, 2001). Chadderton and Davidson (2001) showed the abundance of macroalgae were comparable to Maud Island (south).

Figure 7. Original site 3.12 (red open polygon) described in Davidson *et. al.* (2011) and the suggested revised boundary (green polygon).

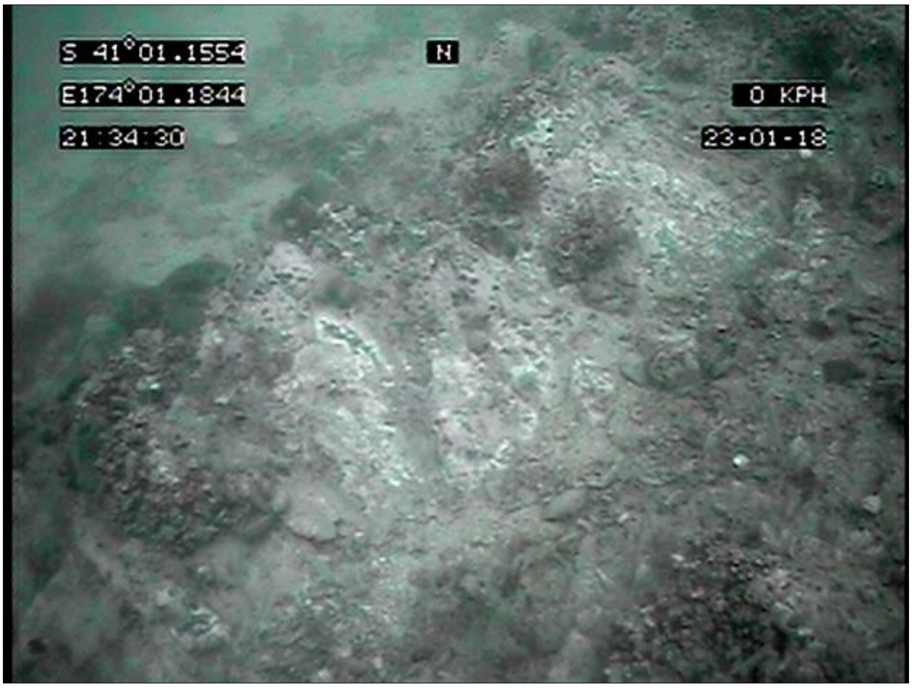

Plate 8. Rocky reef habitat at 18 m depth (Photo 11).

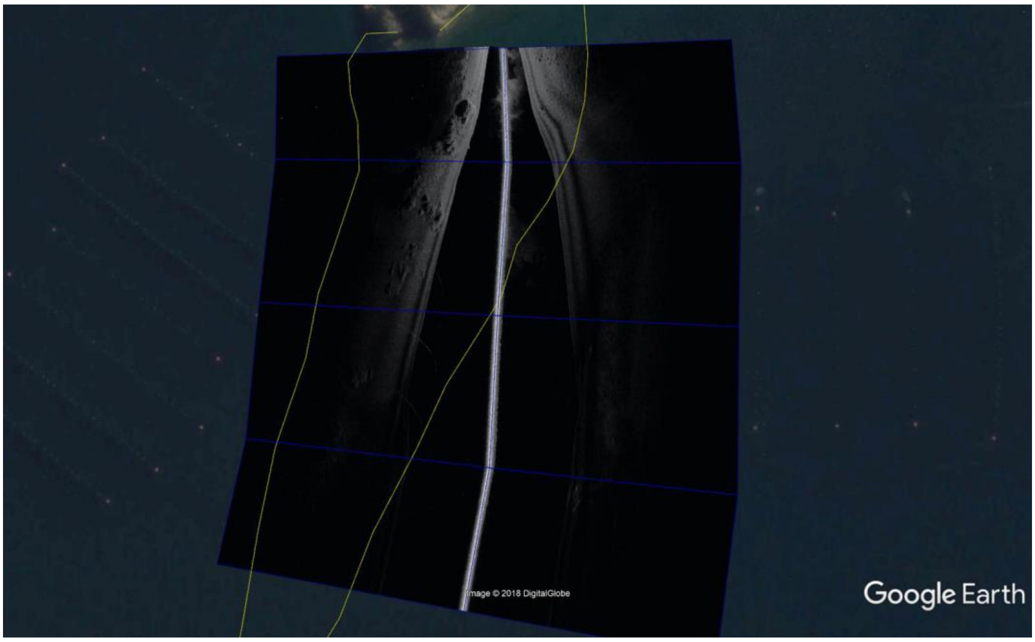

Plate 9. Sonar data collected along the reef at Piripaua.

Anthropogenic issues

The presence of rocky substratum and two mussel farms reduce the chance of physical damage from dredging and trawling. The site is occasionally used by recreational fishers. The impact of recreational fishing on rocky habitat integrity is low (Table 9). Mussel shell was observed on the soft bottom substrata adjacent to the reef and within the farm consent. The rocky reef did not appear to be impacted by mussel farms. It is recommended that no marine farm growing structures (i.e. droppers) are placed over the reef.

Table 9. Assessment of anthropogenic impacts for Site 3.12 (Piripaua).

Original area of significant site (ha)	0.685
Recommended area of site (ha)	1.86
Change to original site	Increase
Change (ha)	1.17
Percentage change from original (%)	160%
Human Use	Moderate (marine farms are located on both sides of the reef)
Vulnerability	Low-moderate (the rocky reef and marine farms deters dredging and trawling activities. Mussel shell from farms tends to fall off upright reef structures, but low-lying reef may be impacted by shell smothering).
Impact observed	Low-moderate (mussel shell was observed on soft bottoms adjacent to the reef).

4.5.6 Site 3.15 Grant Bay (reef)

Grant Bay is a small bay east of Crail Bay and approximately 39 km by sea from Havelock. A large reef approximately 200 m in length extends from a small headland (Figure 8, Plates 10, 12).

Blue maomao have been recorded on this reef (Davidson, 2000). This fish is near its southern New Zealand limit in the Marlborough Sounds and is therefore of scientific interest. This is one of the largest reef systems inside the sheltered waters of Pelorus Sound and is a representative example of large reef structure inside the Pelorus Sound.

The reef appears to support a range of species typical of low current reef systems in central Pelorus Sound (Plate 11). A narrow and shallow fringe of sparse macroalgae was present.

Plate 10. Base of Grant Bay reef.

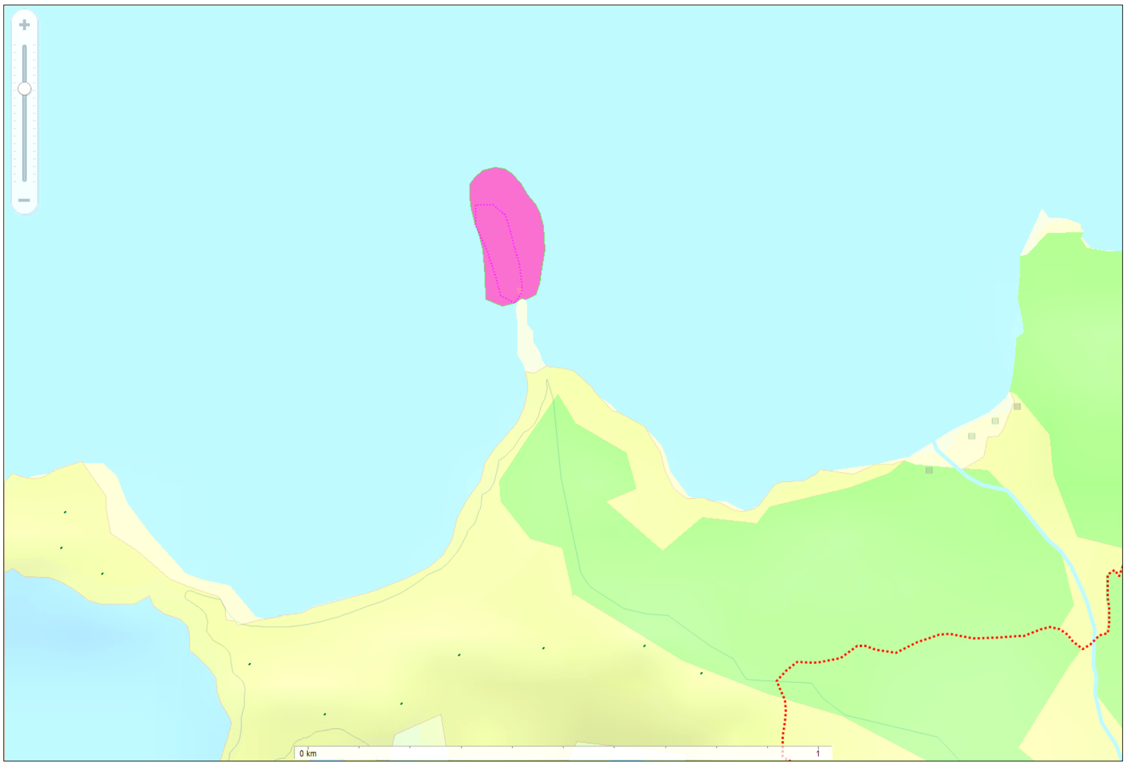

Figure 8. Original site 3.15 (red dotted polygon) described in Davidson *et. al.* (2011) and the suggested revised boundary (red shaded polygon).

Plate 11. Rocky reef habitat at 5 m depth. (Photo station 3).

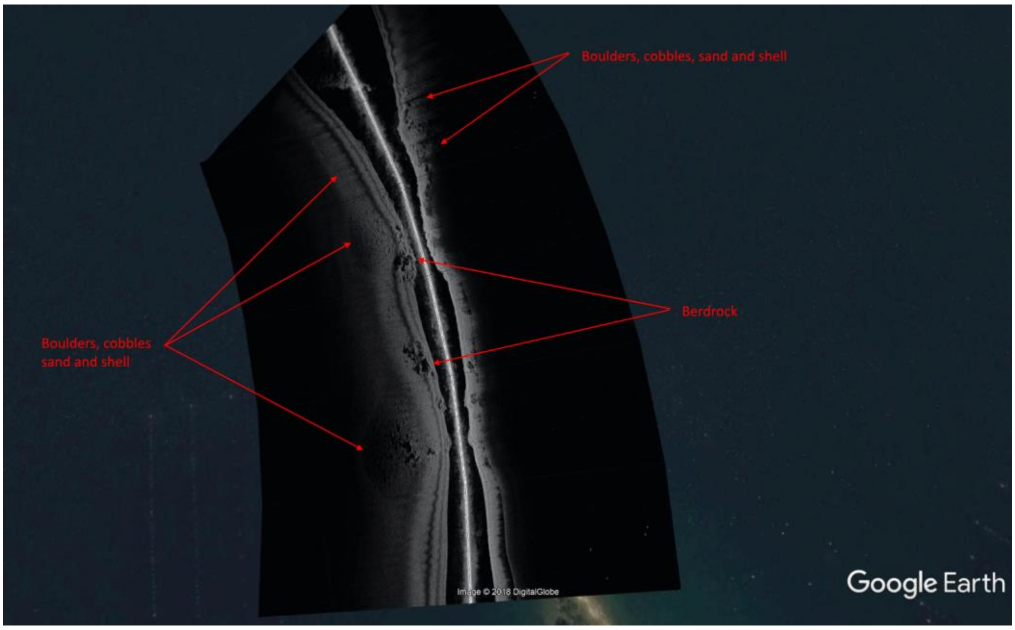

Plate 12. Sonar data collected from along the reef.

Anthropogenic issues

The presence of rocky substratum and mussel farms near the base of the reef reduces the chance of physical damage from dredging and trawling. The site is occasionally used by recreational fishers. The impact of recreational fishing activity on rocky habitat integrity is considered low (Table 10). No impacts have been recorded on the reef during the present brief investigation or marine farm related investigations at the adjacent farms (Davidson and Richards, 2017a). It is recommended that no marine farm growing structures (i.e. droppers) are placed closer to the reef than at present.

Table 10. Assessment of anthropogenic impacts for Site 3.15 (Grant Bay reef).

Original area of significant site (ha)	0.987
Recommended area of site (ha)	2.92
Change to original site	Increase
Change (ha)	1.933
Percentage change from original (%)	196%
Human Use	Low (marine farms are located at and south of the reef base, recreational fishing occurs)
Vulnerability	Low (the rocky reef and marine farms deters dredging and trawling activities. Mussel farms are located at and further south of the reef base and are unlikely to impact the reef).
Impact observed	None.

4.5.7 Site 3.22 Tawhitinui Bay (king shag colony)

Tawhitinui Bay is a small bay at the eastern end of Tawhitinui Reach, Pelorus Sound, and approximately 36.5 km by sea from Havelock. It has a coastline length of approximately 2.9 km and covers about 80 ha. The 0.16 ha king shag site is located around the eastern coastline of outer Tawhitinui Bay (Figure 9, Plate 13). The establishment of this site has expanded the feeding range of birds as far as Kenepuru Sound (author, pers. obs.). Diet studies show that king shags feed on a variety of benthic and pelagic species (Lalas and Brown, 1998).

Previously, this site was briefly visited on August 2016 and January 2017 and photos were collected. On those occasions, a total of 19 adults and chicks on nests were counted in August 2016, while only 7 birds were observed in January 2017. Both visits were conducted through the middle of the day. Prior to those visits, an aerial survey funded by New Zealand King Salmon, counted 43 birds and 16 active nests (Schuckard *et al*., 2015). In a more recent study of nesting numbers were counted for the entire Sounds by Schuckard *et al*. (2018). The authors stated that nest surveys were carried on 6th June (89 active nests) and 1 July 2016 (117 active nests) and 1st July 2017 (153 nests) and previously 2015 (187 nests). Authors suggested that some of this variation was due to the timing with lower nesting in June compared to July, however, overall variation was within historic variation. Authors noted no nests were observed at the Trio site in 2017 compared to 34 and 29 nests in previous surveys.

During the present survey, the site a Tawhitinui Bay was visited on 4 September 2017 and 25 January 2018. A total of 19 adults and one juvenile bird was observed in September 2017, while 55 adults were observed in January 2018. Both visits were conducted during the day and therefore should not be regarded as representing the total numbers of birds as individuals may have been away feeding.

The New Zealand king shag is endemic to New Zealand, only occurring in the Marlborough Sounds. Subfossil bone deposits indicate two regional haplogroups, from the Cook Strait region and northern North Island. However, king shags have been confined to the outer Marlborough Sounds for at least 240 years (NZ birds online). King shags are restricted to the outer Marlborough Sounds, from the west coast of D'Urville Island east to where Queen Charlotte Sound and Cook Strait meet. About 85% of all existing birds are located at five colonies: Rahuinui Island, Duffers Reef, Trio Islands, Sentinel Rock and White Rocks. The shags feed up to 25 km distance in a predominantly southwest direction from the main colonies, mainly in waters up to 50 m deep (diving in deeper waters has been recorded). The foraging area of king shag is estimated to be 1300 km^2. Away from the Marlborough Sounds, there are records of single king shags from Wellington Harbour (July 2002) and Kaikoura (October 2011). In 2015 and 2016, seven individual king shags, mostly 1st and 2nd year birds, were recorded from Abel Tasman National Park.

The International Union for Conservation of Nature threat classification is "Vulnerable to extinction" and, under the New Zealand Threat Classification System, the species has the status "Nationally Endangered". This means the species is considered threatened with extinction due to its low population numbers, the limited area of occupancy (usually considered to be the nesting habitat of seabirds), and limited extent of occurrence (foraging range at sea). The total population of king shags is likely to be less than 1000 birds. The most recent published full population censuses were: (1) February 2015, 839 birds (Schuckard *et al*., 2015), and (2) February 2018, 634 birds (A. Baxter, pers. comm.).

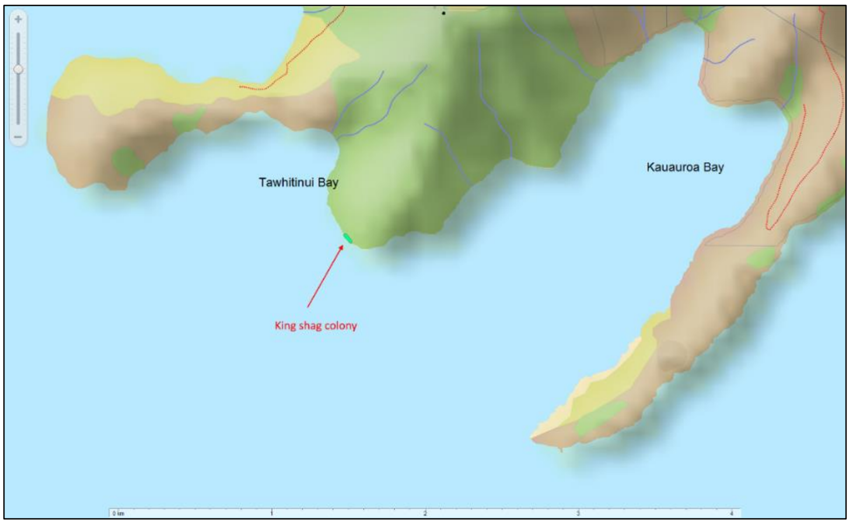

Figure 9. Location of king shag site at Tawhitinui Bay (green polygon with red arrow).

Plate 13. King shag colony at Tawhitinui Bay (Photo: 25/01/2018). Adult birds = 55.

Anthropogenic issues

The king shag colony at Tawhitinui Bay is located centrally in Pelorus Sound. The coastline between Tawhitinui and Kauauroa Bays is regularly visited by recreational fishers (Plate 14). Vessels also transit along this coast when heading from Waitata Reach to Kauauroa and Beatrix Bays. When transiting vessels that remain well distant from the coast do not appear to disturb king shags (authors, pers. obs.).

The colony is vulnerable to disturbance from humans that approach close and cause birds to panic. This can occur when recreational fishers drift and anchor along this coast (Plate 14). Panic can cause chick mortalities during the breeding season due to predation from black-backed gulls (Table 11). A protocol outlining a minimum recommended approach distance to king shag colonies is recommended plus ongoing public education. Other management actions could include construction of a pig proof fence or encouraging birds to nest on predator-free Maud Island.

Plate 14. Recreational fisher activity along the coast immediately adjacent to the king shag colony at Tawhitinui Bay.

Table 11. Assessment of anthropogenic impacts for Tawhitinui Bay king shag colony.

Original area of significant site (ha)	0.16
Recommended area of site (ha)	0.16
Change to original site	No change
Change (ha)	0
Percentage change from original (%)	0
Human Use	Moderate (the area is often visited recreational fishers)
Vulnerability	High (king shags are easily disturbed, and this can result in chick and egg mortalities).
Impact observed	Disturbance by recreational fishers.

4.5.8 Site 3.23 Woodlands (west) (rhodolith bed)

This rhodolith bed is in a small unnamed bay west of Woodlands, along the northern coastline of Tawhitinui Reach (Figure 10, Plate 15). The bay is approximately 4.1 ha in size and the entrance to the bay is approximately 400 m in width.

This site was surveyed as part of a monitoring programme by the adjacent marine farm owner and has been investigated on two occasions (Davidson and Richards, 2016; Davidson *et al.*, 2018). The rhodolith bed is small compared to other beds known from Marlborough measuring 0.2 ha or approximately 79 m in length and between 18 m to 38 m in width.

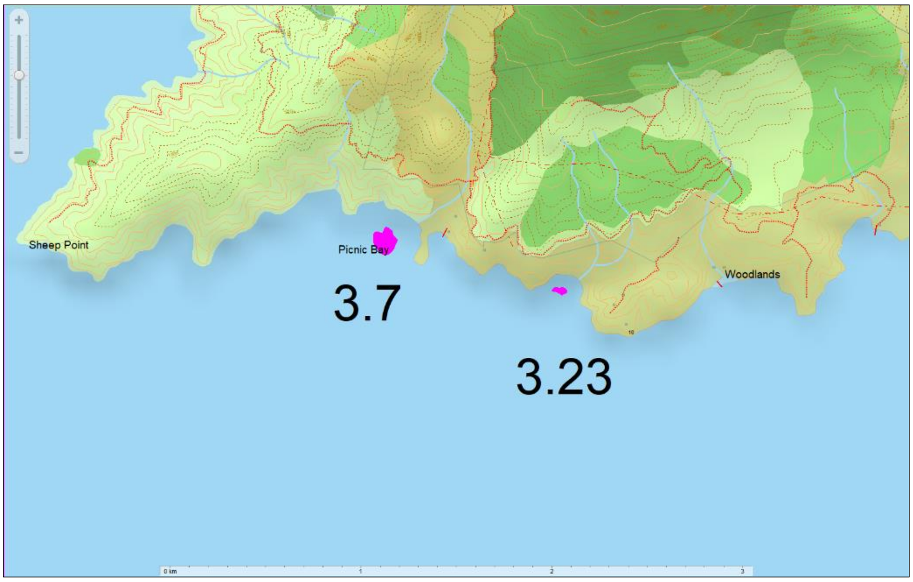

Figure 10. New significant site 3.23 west of Woodlands Bay and existing rhodolith site in Picnic Bay.

The mean percentage cover from the same 27 stations increased between sample events (Table 12). Davidson *et al*. (2018) stated this was unlikely due to the adjacent marine farm being moved further away and was instead may have been due to improved water visibility in the 2018 sample making estimates of percentage cover more accurate.

Table 12. Drop camera station data from the same 27 stations sampled in 2016 and in the 2018 study (from Davidson *et al*., 2018).

Station (depth)	Coordinates	2016 A	2016 B	2018 field	2018 A	2018 B
1, 15m	1671248.7,5458652.4	40	40	90	95	85
2, 15.2m	1671236.3,5458642.3			40	30	40
3, 17.6m	1671228.8,5458653.7	25	20	70	70	70
4, 13m	1671251.2,5458663.4	60	55	90	95	90
5, 16.1m	1671237.0,5458669.4	60	55	60	70	50
6, 18m	1671213.0,5458669.0	15	10	40	30	35
7, 19.6m	1671200.6,5458653.2					
8, 20.7m	1671187.8,5458660.3			10	10	25
9, 17.8m	1671193.2,5458673.5	10	10			
10, 15m	1671210.2,5458694.0					
11, 16.6m	1671180.1,5458680.9					
12, 16.2m	1671212.9,5458678.5	5	5			
13, 17.3m	1671224.7,5458663.9	30	20	80	80	70
14, 14.3m	1671247.4,5458685.6					
15, 15.9m	1671239.1,5458679.9					
16, 15.8m	1671227.3,5458675.8			10	15	20
17, 20.4m	1671216.6,5458645.9				1	1
18, 18.5m	1671203.6,5458661.8	20	15	30	30	25
19, 14.7m	1671221.2,5458684.9					
20, 14.1m	1671262.1,5458638.9					
21, 14.8m	1671258.4,5458651.2	40	30	80	80	70
22, 12.3m	1671285.1,5458646.5					
23, 12.3m	1671270.3,5458655.6					
24, 12.4m	1671258.4,5458673.1			80	70	70
25, 14m	1671258.1,5458665.7	50	40	90	90	85
26, 12.8m	1671265.2,5458663.2	1	1	40	25	15
27, 13.8m	1671252.0,5458671.6	10	10	90	95	85
Mean		28.15	23.92	60.00	55.38	52.25
N		13	13	15	16	16
SD		20.35	18.40	29.28	33.93	29.32
95% confidence		11.06	10.00	14.82	16.62	14.37

Station (depth)	Coordinates	2018 field	2018 A	2018 B
28, 12.5m	1671269.9,5458676.6	0	0	0
29, 12m	1671254.2,5458680.1	0	0	0
30, 16.5m	1671241.1,5458629.0	0	0	0
31, 15.3m	1671249.6,5458639.2	0	0	0
32, 16.6m	1671227.5,5458640.0	0	0	0
33, 18.8m	1671214.5,5458655.1	0	0	0

Plate 15. Rhodoliths with cover of filamentous algae sampled in 2018.

Of the 33 drop camera stations sampled in the 2018 study, 16 supported rhodoliths ranging in percentage cover from 2% to 95%. The overall mean percentage cover from sites with rhodoliths was 52 to 55%. This value was considerably lower than beds located in the D'Urville Island and Croisilles Harbour where mean cover is above 79% (Catherine Cove = 79.6%; Lone Rock (Croisilles) = 81.9%; Coppermine-Ponganui Bays = 82.5%; Bonne Point = 86%), but comparable to the nearby Picnic Bay bed (47.7%). The reason for this difference is unknown but may be related to environmental differences between Pelorus Sound compared to the outer Sounds.

Anthropogenic issues

Rhodoliths are long-lived, slow growing and fragile (Nelson *et al*., 2012). The bed at Woodlands (west) has been impacted by historic marine farm effects. Davidson *et al*. (2018) reported at least two strips where anchor blocks had dragged through the bed (Plate 16). It is unclear if this occurred during a storm event causing lines to drag or during relocation of the farm. Rhodoliths at this site are located on soft substrata and are therefore vulnerable to physical disturbance and sediment smothering (Table 13). They are afforded a good level of protection from dredging due to the proximity of the adjacent headland and a marine farm to the west and south. Due to their location on soft substratum and the small size of the bed, they should be considered highly vulnerable. A forestry block is located high on the adjacent hillside. It is recommended that considerable care be exercised during future logging operations to minimise sedimentation effects.

Plate 16. Anchor block drag track through the Woodland (west) rhodolith bed.

Table 13. Assessment of anthropogenic impacts for Site 3.22 (Woodlands west rhodoliths).

Original area of significant site (ha)	
Recommended area of site (ha)	0.2
Change to original site	
Change (ha)	
Percentage change from original (%)	
Human Use	Low (dredging limited by adjacent headland and marine farms).
Vulnerability	High (rhodoliths are long-lived, fragile species living on soft substratum).
Impact observed	Anchor block drag track.

4.5.9 Site 3.24 Tuhitarata Bay (shallow reef)

Tuhitarata Bay is a small bay located at the south end of Beatrix Bay, approximately 40 km by sea from Havelock. Tuhitarata Bay has a coastline length of approximately 1.9 km and covers an area of sea of approximately 37 ha. The mouth of the Bay is approximately 950 m wide.

A large reef is located on the eastern side of Tuhitarata Bay (Davidson and Richards, 2011) (Figures 11 and 12). This reef is approximately 3.4 ha is size and as such is one of the largest single reef structures within Pelorus Sound. The reef is unusual in the respect that it is shallow and wide rather than thin and long which is more typical of Sounds reef structures. Based on data collected from the reef by Davidson and Richards (2011), it supports a typical range of rock dwelling species from central Pelorus Sound (Plate 17).

Approximately 10 ha of inshore areas adjacent and southwards to the reef have been colonised by a Chaetopteridae tubeworm (Figure 13). It is probable this species is exotic and arrived in the Sounds in the mid to late 1990's. In high densities, this species forms a low relief biogenic structure.

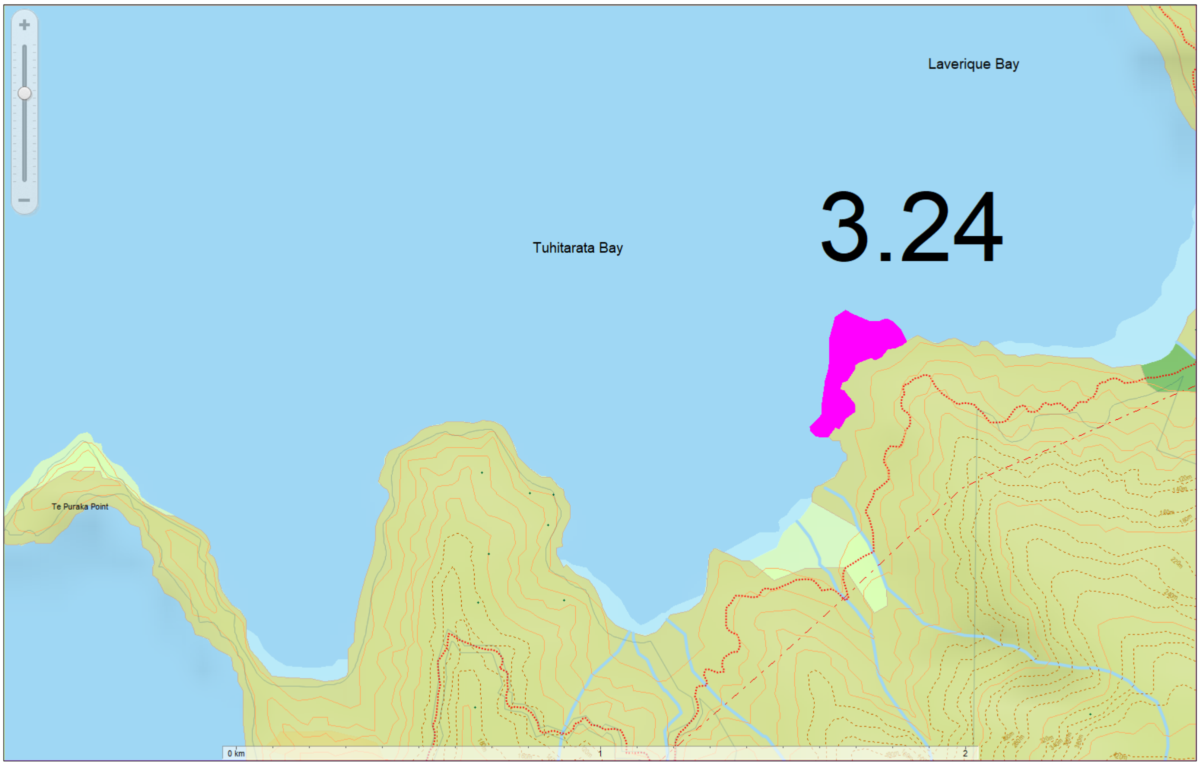

Figure 11. Location of Tuhitarata Reef (pink polygon).

Plate 17. Reef fringe with large *Ancorina* sponges. Exotic tubeworms present in foreground.

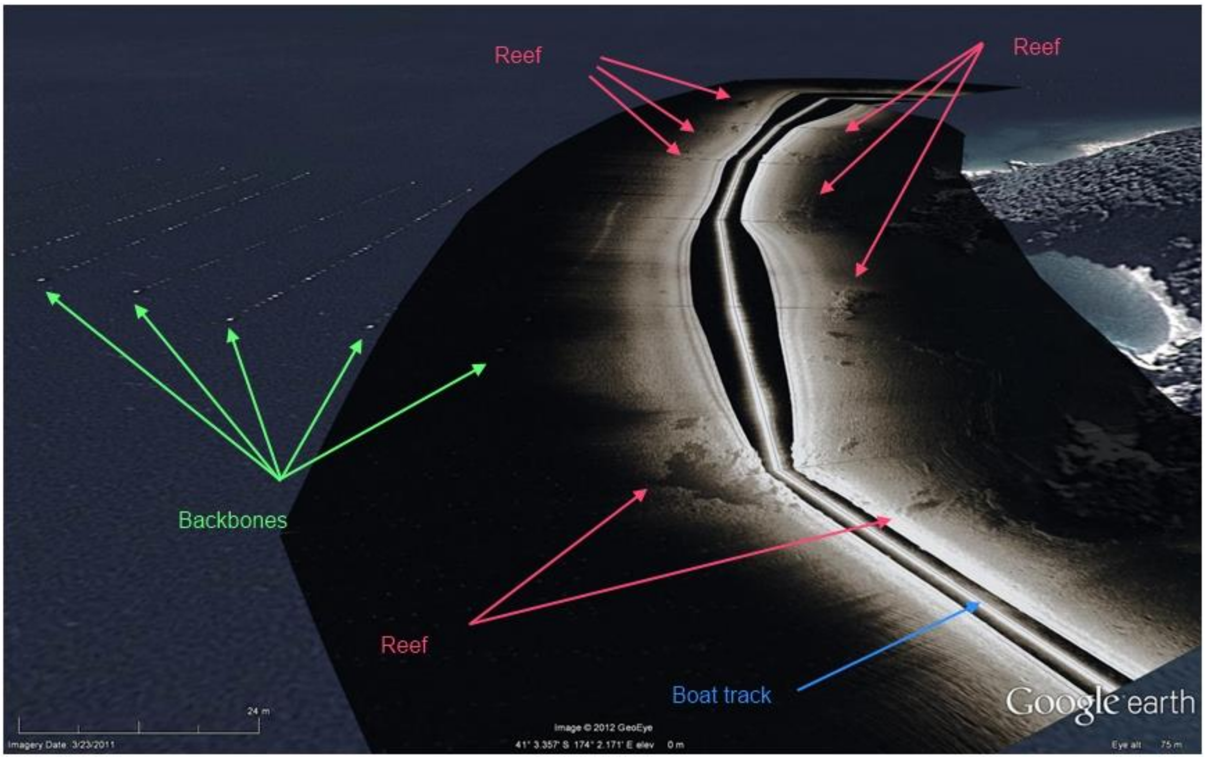

Figure 12. Sonar run showing reef in Tuhitarata Bay.

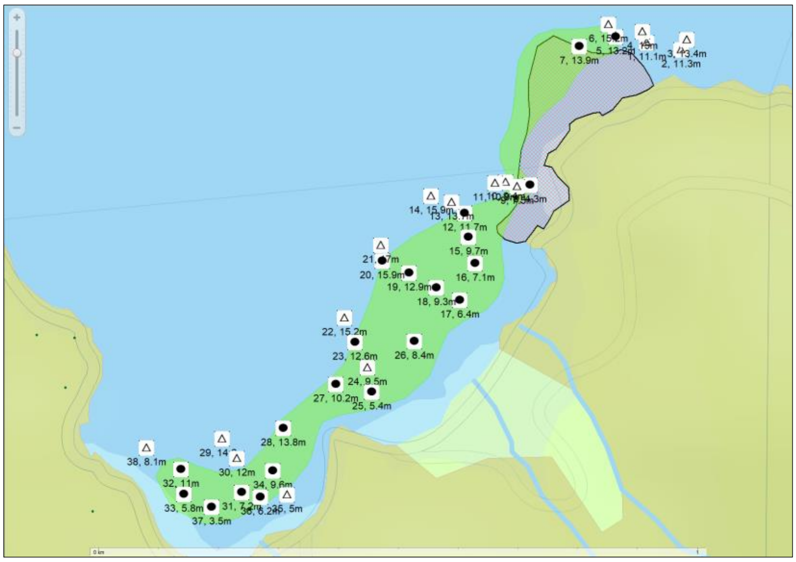

Figure 13. Location of exotic tubeworms bed (green polygon relative to Tuhitarata reef, grey/hatched polygon).

Anthropogenic issues

No human impacts were observed from photos collected from the reef by Davidson and Richards (2011) (Table 14). The reef structures provide protection from commercial dredging and trawling. Occasional anchoring occurs in this area by recreational fishers. Most people, however, anchor further north near the edge of the main reef.

Table 14. Assessment of anthropogenic impacts for Tuhitarata Bay reef.

Original area of significant site (ha)	NA
Recommended area of site (ha)	3.4
Change to original site	NA
Change (ha)	NA
Percentage change from original (%)	NA
Human Use	Low (recreational fishers occasionally anchor in this area)
Vulnerability	Low (reef structures are resilient but vulnerable to smothering by sediment)
Impact observed	Low (exotic tubeworm present around reef fringes)

4.5.10 Site 3.25 Kauauroa coastline

This stretch of coast is located near the western entrance to Kauauroa Bay in eastern Tawhitinui Reach (Figure 14). The subtidal sea floor shelves steeply and is swept by light to moderate tidal currents (Davidson *et al*., 2011). There is a wide variety of filter feeding organisms including biogenic habitat formers such as sponges, ascidians, and hydroids present at this site. Fish, particularly spotty, are common, however, these biogenic communities also provide habitat for juvenile blue cod (Davidson *et al*., 2011).

This coast is a good example of tidally swept habitat adjacent to a stable protected catchment within the Pelorus biogeographic area. The present survey confirmed the presence of a range of current swept habitats with a variety of species including sponges, anemones, hydroids and ascidians (Plate 18). Adult and juvenile blue cod were common, especially in current-swept locations. The present survey provided improved resolution of biogenic habitats and amended boundaries for the significant site are suggested (Figure 14).

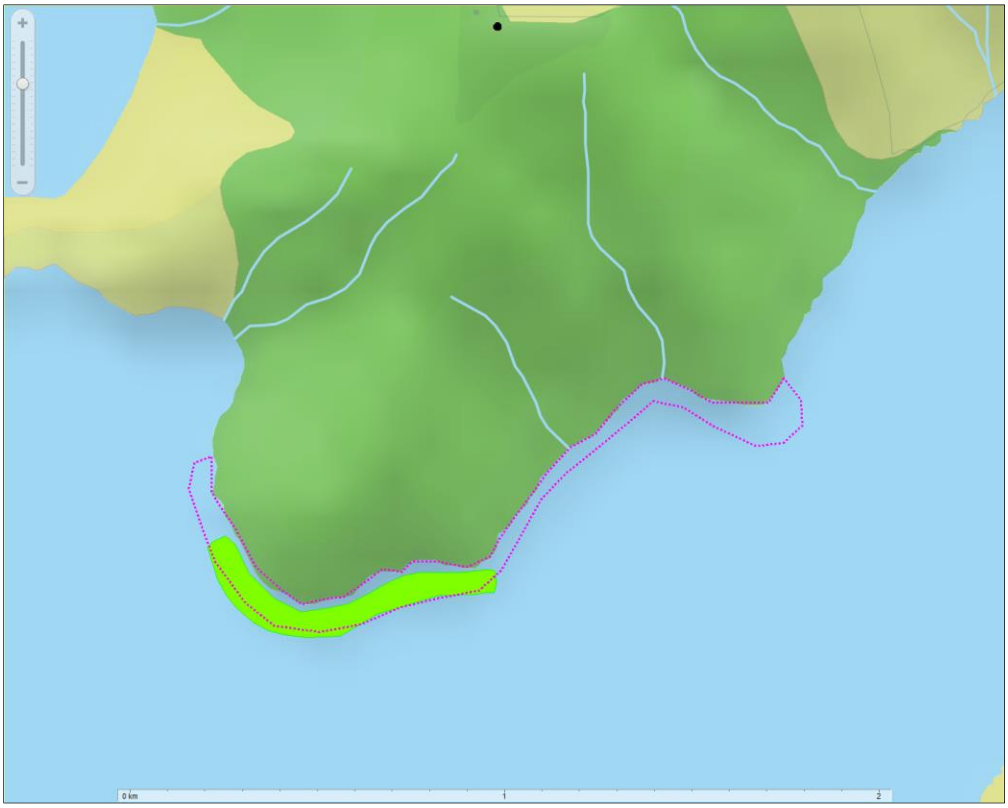

Figure 14. Original site 3.25 described in Davidson *et al*. (2011) (red line) and suggested revised site boundaries (green polygon).

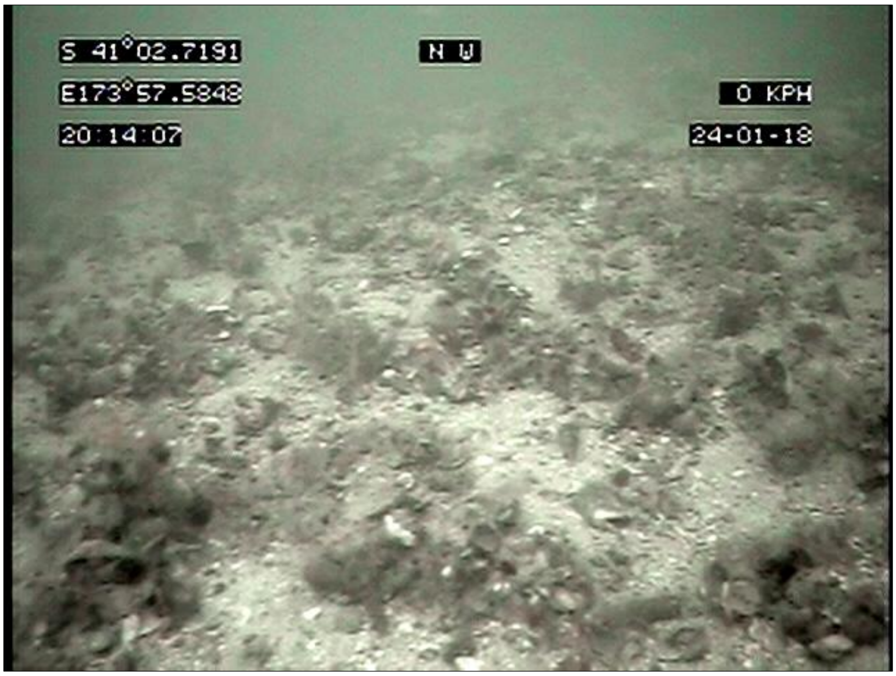

Plate 18. Current-swept sand and shell benthos supporting ascidians and hydroids.

Anthropogenic issues

The presence of rocky substratum along this site reduces the chance of physical damage from dredging and trawling. Being in a current-swept location, lower sediment deposition rates are likely to occur compared to sheltered locations. The site is a popular location for recreational fishers (Plate 14). The impact of recreational fishing activity on habitat integrity is considered low compared to many other anthropogenic activities in the marine environment (Table 15).

Table 15. Assessment of anthropogenic impacts for Site 3.25 (Kauauroa coastline).

Original area of significant site (ha)	14.9
Recommended area of site (ha)	6.3
Change to original site	Decrease
Change (ha)	8.6
Percentage change from original (%)	-57.7%
Human Use	Low (popular site for recreational fishers, the impact of this activity on habitats is likely low). Dredging occurs offshore but is unlikely to occur within the site.
Vulnerability	Low (rocky reef habitats deter dredging and trawling activities). Sedimentation levels are likely to be low.
Impact observed	None

4.5.11 Site 3.26 Ouokaha Island (western coast)

Ouokaha Island is an approximately 4.02 ha island located at the southern tip of Hopai Peninsula, Crail Bay (Plate 19). The candidate significant site is located along the western side and the channel between the island and Hopai Peninsula (Figure 15).

Plate 19. Northern and western shoreline of Ouokaha Island.

Hay (1990b) stated " From the low water mark to about 3 metres depth there is a fairly thick band of seaweed comprising *Cystophora torulosa, C. retroflexa, Carpophyllum flexuosum* and *Sargassum sinclairii*. Occasionally there are small clumps of *Hormosira* - an unusual feature since the plant is usually confined to the intertidal zone. Sponges were recorded, especially the sulphur sponge *Aplysilla sulfurea*. 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. Fish seen included the spotty, triplefin, blue cod, kahawhai, stargazer and eagle rays."

During the present study (2018), large tubeworm mounds (*Galeolaria hystrix*) were detected on the sonar and confirmed by drop camera images (Plate 20). 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. The presence of horse mussels, brachiopods and the epibiota associated with horse mussels as described by Hay (1990b) were not observed during the present investigation along the western side of the island.

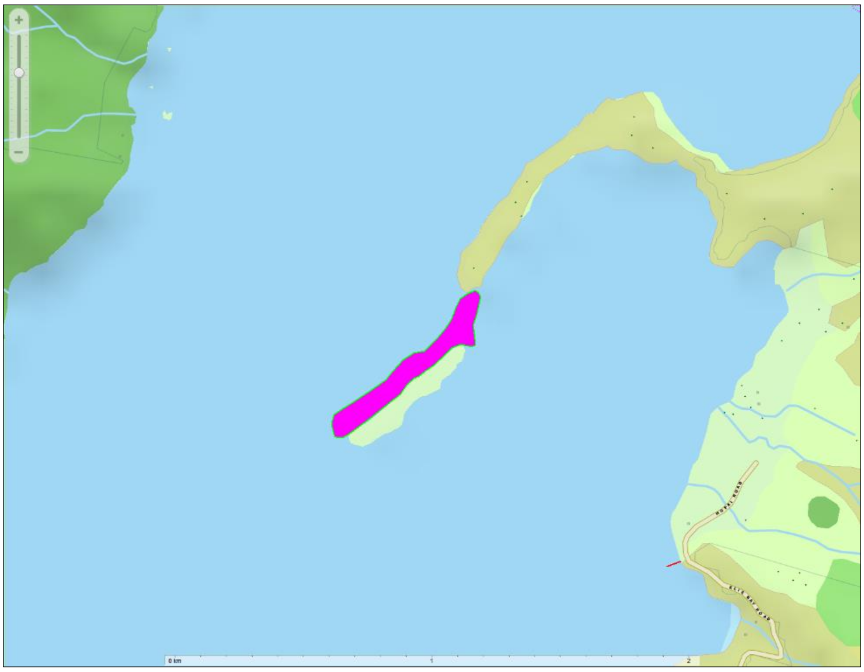

Figure 15. Suggested significant site (red polygon) along the western shores of Ouokaha Island.

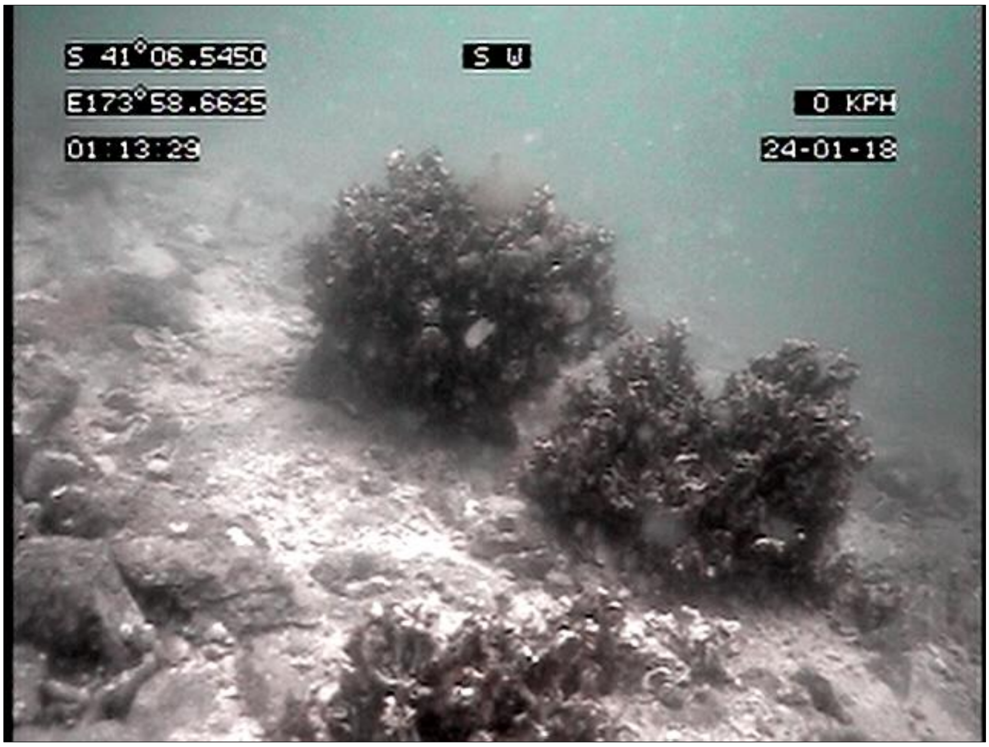

Plate 20. *Galeolaria hystrix* tubeworm mounds at Ouokaha Island.

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 often deploy anchors that damage tubeworm mounds (Plate 21, Table 16). The reason for the disappearance of horse mussels described by Hay (1990a) is unknown.

Plate 21. Damaged tubeworm mounds at Ouokaha Iasland.

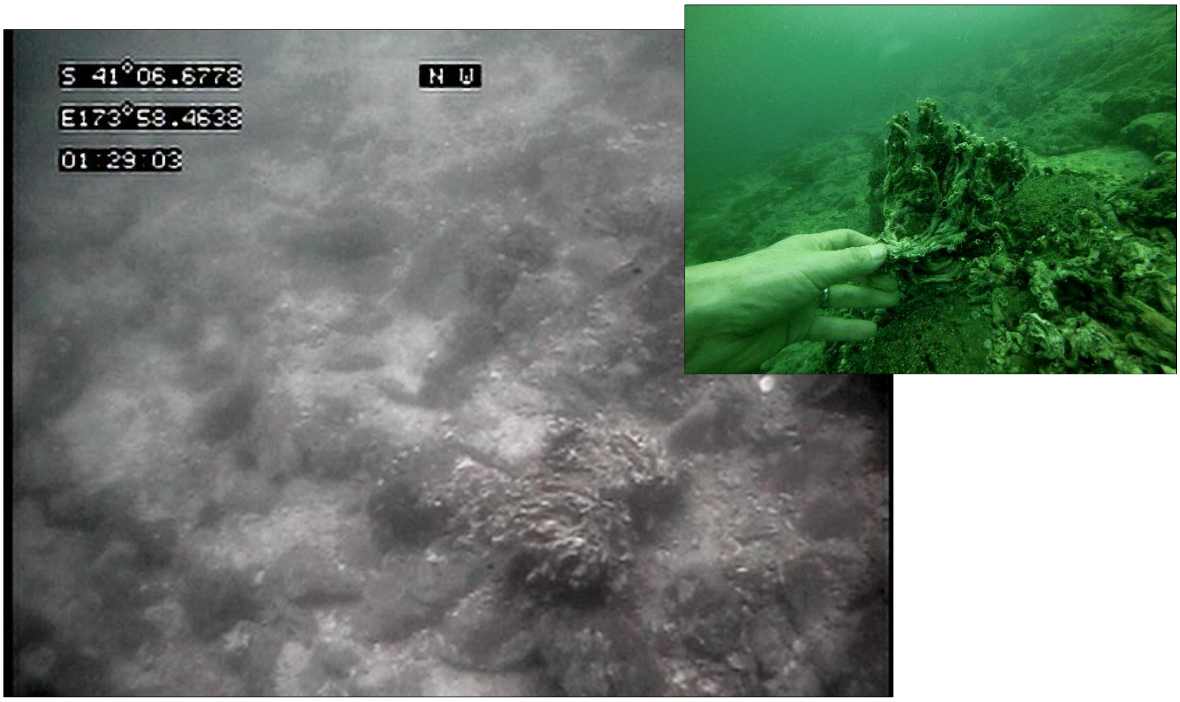

Table 16. Assessment of anthropogenic impacts for Site 3.26 (Ouokaha Island coastline).

Original area of significant site (ha)	
Recommended area of site (ha)	6.5
Change to original site	
Change (ha)	
Percentage change from original (%)	
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 divers

4.5.12 Site 3.27 Matai Bay (tubeworms)

Matai Bay (Godsiff Bay) is located within Tennyson Inlet (western end of Tawhitinui Reach), 22 km north of Havelock. The Inlet is well separated from the rest of the Sounds due to its geographic location; as a result, water residency time are likely to be some of the longest in the Sounds. There is relatively low variety of subtidal habitats and species compared to other areas in the Marlborough Sounds (Davidson *et al*., 2011).

Plate 22. Matai Bay (tubeworm site to right of photo).

During the present study a dense bed of tubeworms *Bispira bispira* SpA. were found in Matai Bay (Figure 16, Plate 23). This is the third known aggregation bed and largest site (2.23 ha) in the Sounds and the only known site in Pelorus Sound that supports sufficient numbers of this species to form a bed. It is unclear if this species is native or introduced or invasive. At present it is being treated as cryptogenic as there is not enough data to know if it is native or exotic (Barrie Forest, pers.comm.).

This species was previously recorded from Blow Hole Point, Pelorus Sound, the northern shore of Waikawa Bay, Wellington Harbour, Whangarei Harbour, Mount Manganui, Houhora Harbour in Northland (Geoff Read, NIWA, pers. comm.).

More recently, dense beds of this tubeworm have been described from a small site in Bobs Bay (0.363 ha) in Picton Harbour (Davidson *et al.,* 2011; Davidson and Richards, 2015) and a very small site in Port Underwood (author, pers. obs.). The site in Matai Bay is the third known and largest bed of this species (2.23 ha) in the Sounds and the only known site in Pelorus Sound that supports sufficient densities to form a bed.

It is recommended that this site be approved as a significant marine site but should be reassessed if the status for this species changes to introduced or invasive.

Figure 16. Suggested 2.23 ha tubeworm significant site in Matai Bay (red polygon).

Plate 23. Tubeworm bed in Matai Bay.

Anthropogenic Issues

Tubeworms are located on soft substrata and are therefore vulnerable to sediment smothering and physical disturbance from dredging and trawling. They are however, located in a shallow bay that is unlikely to be recreationally dredged (note: Tennyson Inlet is closed to commercial trawling and or dredging).

Table 17. Assessment of anthropogenic impacts for Site 3.27 (Matai Bay tubeworms).

Original area of significant site (ha)	
Recommended area of site (ha)	2.232
Change to original site	
Change (ha)	
Percentage change from original (%)	
Human Use	Low (area seldom visited).
Vulnerability	High (tubeworms are fragile and easily damaged).
Impact observed	None

4.5.13 Site 3.28 Penzance Bay (elephantfish spawning)

Penzance Bay is located along the northern shores of Tennyson Inlet (Figure 17). The Bay supports a small settlement of mostly holiday homes, a jetty and launching ramp. The site is located inside the larger Tennyson Inlet significant site (Davidson *et al*., 2011). The Inlet is well separated from the rest of the Sounds due to its geographic location; as a result, water residency time are likely to be some of the longest in the Sounds. There is relatively low variety of subtidal habitats and species compared to other areas in the Marlborough Sounds (Davidson *et al*., 2011).

Dr. Ken Grange (NIWA) reported elephantfish egg cases in Penzance Bay. During the present survey of Penzance Bay, it was confirmed that the bay supported good numbers of live and dead egg cases (Figure 17, Plate 23). Based on qualitative observations, this site presently supports the highest abundance of egg cases for any known egg laying area in the Sounds. The survey of Tennyson Inlet has not been completed, therefore future surveys may lead to the discovery of more spawning sites.

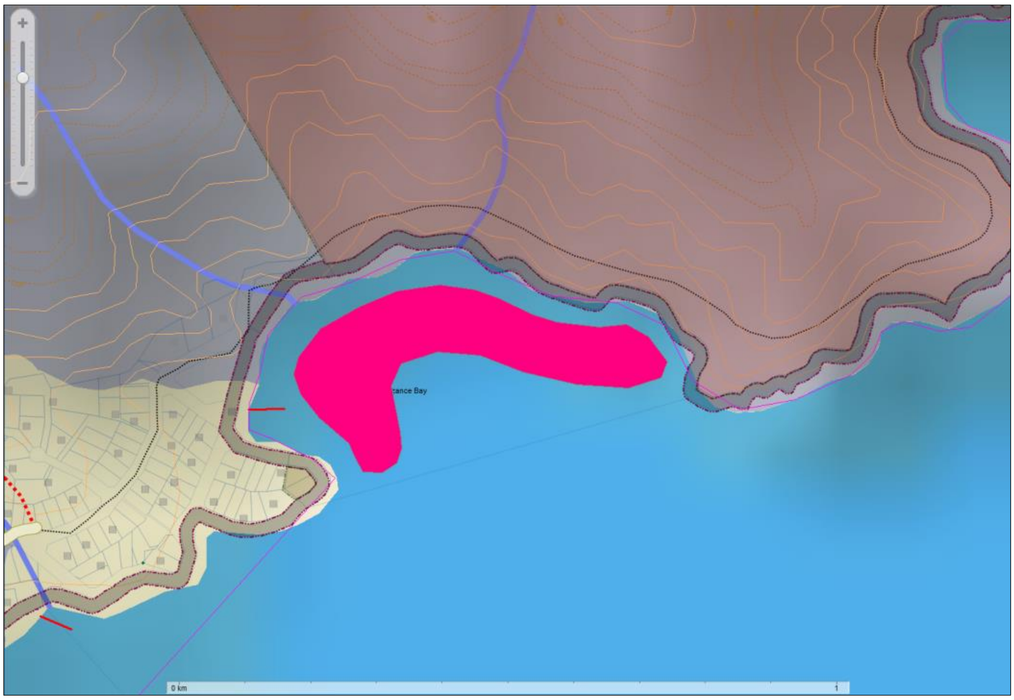

Figure 17. Suggested new elephantfish spawning significant site in Penzance Bay (red polygon).

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Plate 23. Two hatched elephantfish egg cases in Penzance Bay.

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 this occurs are the Fitzroy Bay complex and inner Queen Charlotte Sound. Egg cases are protected from dredging and trawling in this location by the moorings, however, traditional block and chain mooring may damage egg cases. Sedimentation is also a concern as smothering by mud would likely make this bay unsuitable.

Table 18. Assessment of anthropogenic impacts for Site 3.28 (Penzance Bay elephantfish spawning).

Original area of significant site (ha)	
Recommended area of site (ha)	6.68
Change to original site	
Change (ha)	
Percentage change from original (%)	
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

4.5.14 Site 3.29 Treble Tree coastline

The Treble Tree coastline is located along the western shores of Waitata Reach immediately south of Waitata Bay.

Plate 24. Treble Tree coast viewed from its northern end.

The Treble Tree coast had three 3 ha research marine farms installed in 1997. The research farms were in a moderate to strong tidal flow environment and have been only used for sponge research and juvenile mussel spat experiments. These experiments have not impacted the seabed (Battershill, 1998), however the presence of farm structures (i.e. surface or anchors) over a period of 20 years has limited, but not eliminated scallop dredging. In contrast, adjacent soft bottom habitats in Waitata Reach have been intensively dredged during scallop seasons. The Treble Tree coast therefore represents an area in a state of recovery and heading towards the pre-dredge state.

DuFresne and Richards (2006) recommended that the three research marine farm sites be relocated further from shore to avoid benthic habitats (Plate 25). These habitats were mostly soft bottom biogenic communities. Since that time, 12 years have passed allowing further recovery of the benthos.

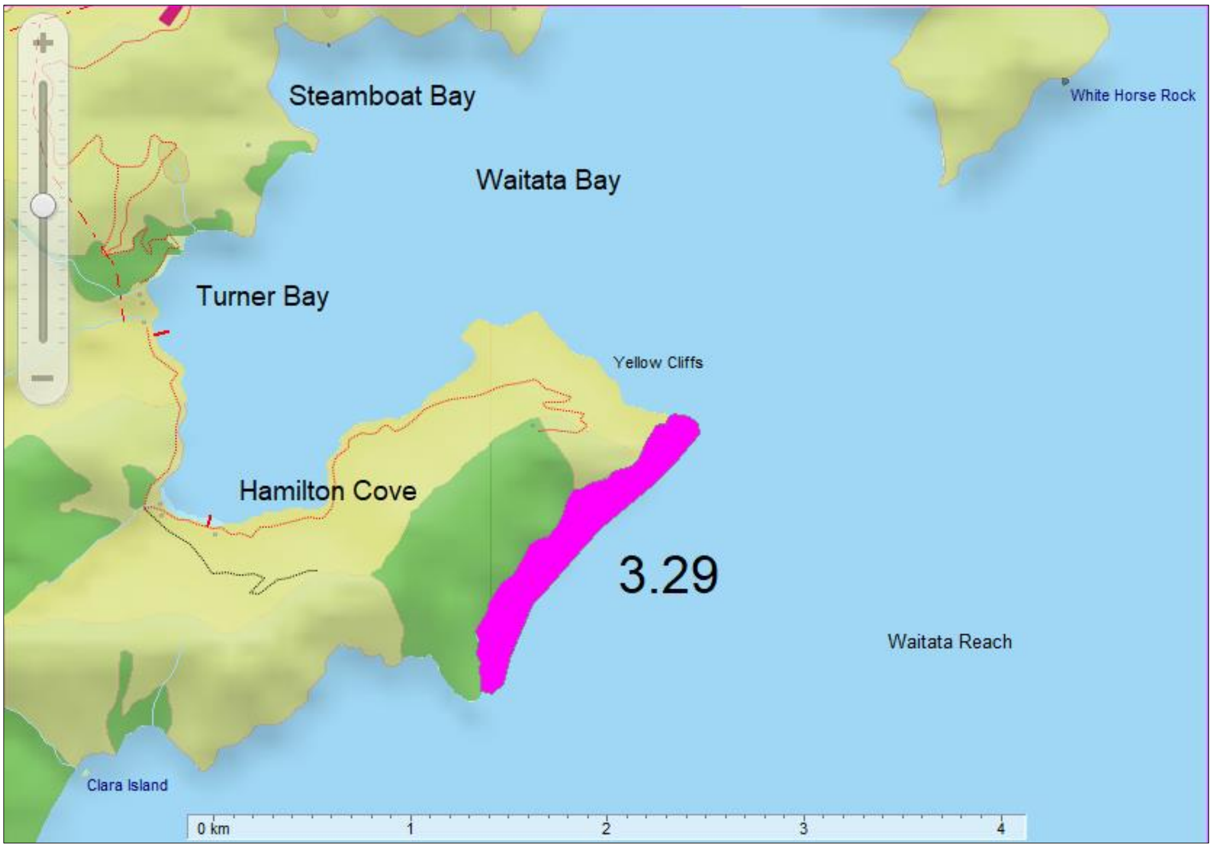

Figure 17. Suggested new significant site at Treble Tree coastline (red polygon).

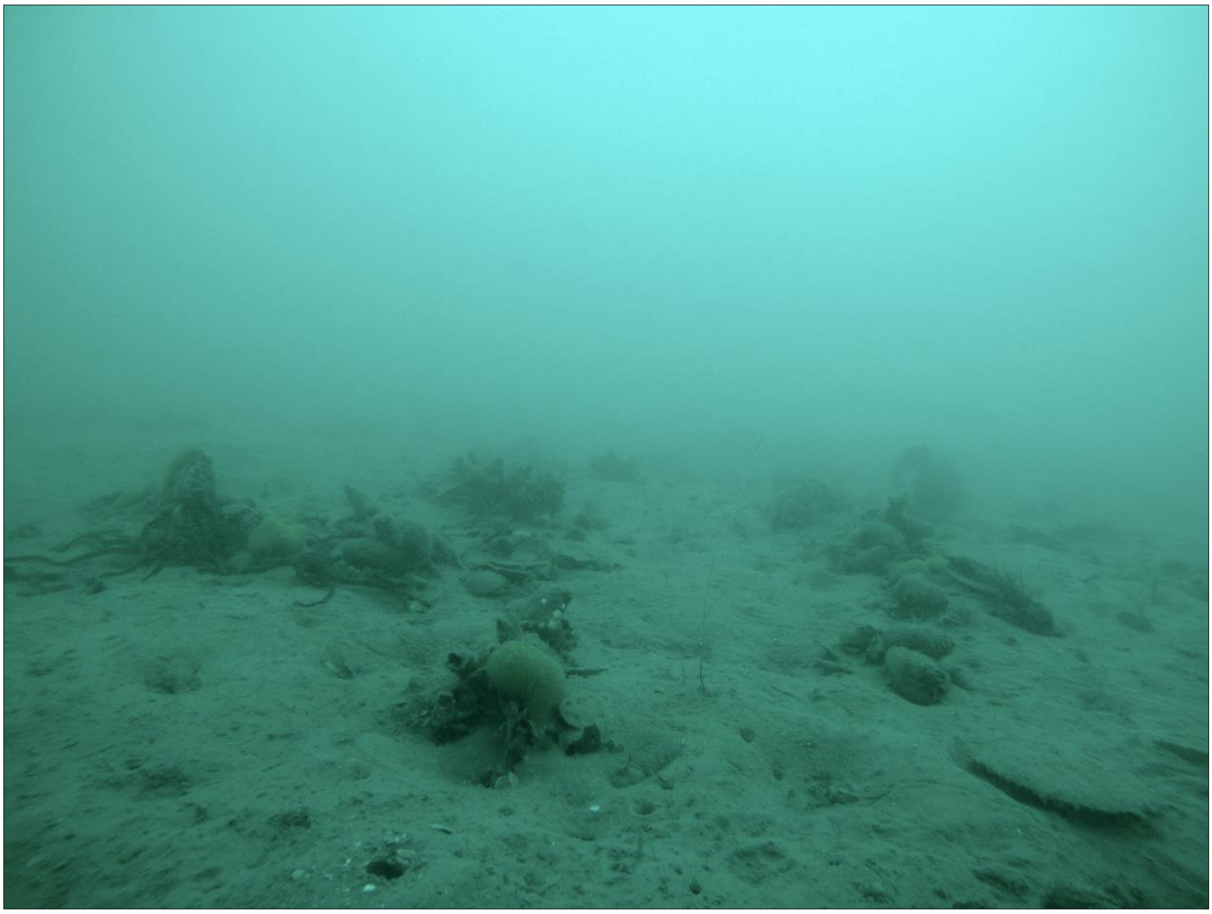

Plate 25. Biogenic community dominated by horse mussels, hydroids and ascidians on soft bottom shores along the Treble Tree coast.

Anthropogenic Issues

Waitata Reach is swept by moderate to strong tidal currents (Broekhuizen *et al.,* 2015). These tidal currents facilitate the establishment and growth of biogenic communities on both rocky and soft shores. Significant rocky shore sites have been identified in the Reach at Tapapa (Significant site 3.11). To date, no soft bottom significant sites have been identified in the Reach.

The intensity of historic dredging in Waitata Reach is very high during open scallop season. The Treble Tree site is likely the only large soft bottom habitat < 35 m depth in Waitata Reach that has been available to intense dredging over the last 20 years. AS such the site represents a rare scientific opportunity to investigate the difference between tidally swept dredged and non-dredged habitats.

Table 19. Assessment of anthropogenic impacts for Site 3.29 (Treble Tree coastline).

Original area of significant site (ha)	
Recommended area of site (ha)	32.57
Change to original site	
Change (ha)	
Percentage change from original (%)	
Human Use	Low (the coast has been retired form dredging and trawling due to the presence of marine farm structures).
Vulnerability	High (soft bottom biogenic communities are very vulnerable to physical damage from dredging and trawling).
Impact observed	Yes (historical dredge tracks along outer boundaries of the site in 2010) (Plate 26)

Plate 26. Dredge track in an offshore location along the Treble Tree coast (30 m depth) (Photo: Nigel Keeley, Cawthron).

5.0 Discussion

5.1 Significant site changes (2011 to 2018)

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 presented in the present report, six new sites are proposed (**discovery**) with one new site being proposed due to **recovery** of attributes compared to adjacent areas. Three existing sites have had new areas added (**addition**) and four existing sites have had areas removed (**reduction**). No existing sites have been rejected.

One site in the present study did not change; however, new data were collected (Site 3.22 Tawhitinui king shag colony).

5.1.2 Confidence around change and the reasons for loss of biological values

Changes to a significant site must be based on good quality 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 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 biological natural history 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 has been regularly observed in outer Queen Charlotte Sound and the literature shows species like horse mussels can be significantly degraded by such activities (Thrush *et al*., 2001).

5.1.3 Area increases

Of the 14 sites presented in the present report, eight were existing significant sites. Three sites increased in size compared to the previous area reported in Davidson *et al.* (2011) or subsequent annual significant site surveys. A further six new sites were recommended, totalling 51.57 ha. Altogether, an increase of 191.1 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 Area 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 (MacDiarmid *et al*., 2012; MFE, 2016) (see Section 5.4).

In the present study, four sites declined in size (total reduction of 112.7 ha). Davidson and Richards (2015) considered declines to offshore soft substratum sites were often due to physical damage, primarily trawling and dredging. During the present study, declines were due to improved data.

5.2 Information issues (plan updates, data management)

5.2.1 Planning and Resource Consenting

The present study is the fourth 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), most sites changed in size, shape and/or attributes/values compared to original sites described by Davidson *et al.* (2011). It is certain that further change will occur in 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 2017-2018 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) 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 present 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 summer 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 (e.g. Plate 27). 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.

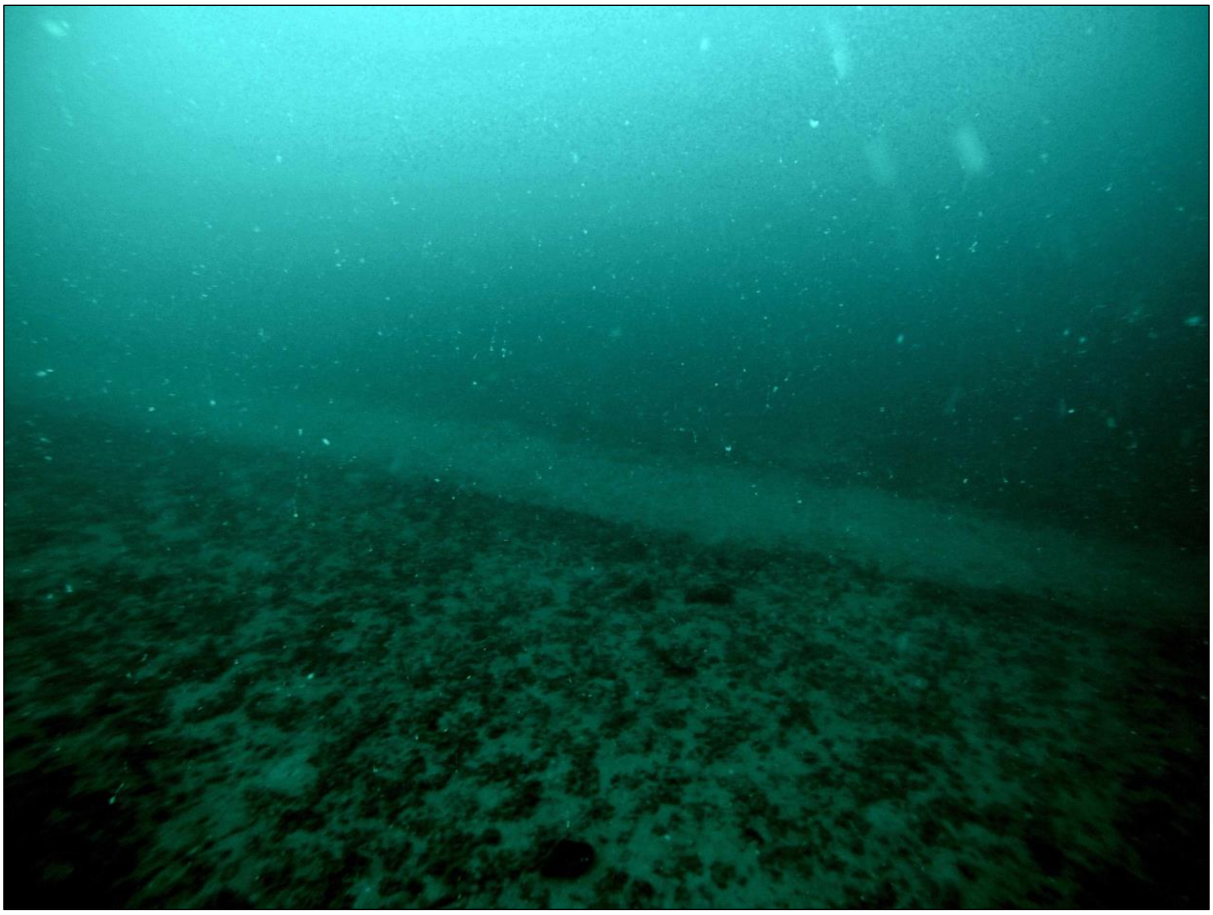

Plate 27. Anchor block drag track through rhodolith bed.

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., 2017), 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 tubeworm mounds had been damaged presumably by recreational fisher boat anchors and anchor chains, while parts of Marlborough’s smallest rhodolith bed at Woodlands (west) had been lost from anchor block drag. An exotic species of algae may also have reduced the quality of elephantfish spawning habitat in Garne and Savill Bays. 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.

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. 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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