



Biological report for an extension to marine farm 8164 in Hikoekoea Bay, Guards Bay, outer Pelorus Sound

Survey and monitoring report number 1103

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1.0 Preface

The present report provides biological information for a proposed 28.8 ha offshore extension to existing marine farm 8548 located in Hikoekoea Bay (Guards Bay), outer Pelorus Sound. The existing 12 ha marine farm is owned by P. H. Redwood & Company Limited.

2.0 Background information

2.1 Guards Bay

Hikoekoea Bay is located along the eastern shore of Guards Bay; a large bay complex east of Forsyth Island, approximately 61 km by sea from Havelock. Hikoekoea Bay has a coastline length of approximately 2.3 km and covers an area of sea of approximately 55.3 ha. Hikoekoea Bay is approximately 1.1 km wide (Figure 1).



Figure 1. Location of Guards Bay, Pelorus Sound, Marlborough Sounds.

2.2 Marine farming

There is one marine farm in Guards Bay complex (Figure 2). This marine farm is used for production mussel farming.

Numerous marine farms are located throughout Anakoha Bay, west of Guards Bay.

Figure 2. Marine farm located in Guards Bay complex.



2.3 Catchments

The adjacent land and catchment of Guards Bay are mostly areas of pasture and with fringes of regenerating native vegetation. The adjacent landowner has been and is presently planting native vegetation around the coastal edges. Reserves are located at Tawaroa Point, Puzzle Peak, Tahuakai and Titi Island. Titirangi Farm Park is located at the head of Titirangi Bay.

Overall, the present land use and vegetation cover in the area means sediment runoff into the marine environment will likely be at the lower end of the range known from the Marlborough Sounds.

2.4 Fishing

Commercial trawling occurs in the outer waters of Guards Bay (Figure 3a). Commercial scallop dredging historically occurred when the season was open (Figure 3b). Recreational fishing is less common than outer Pelorus and Kenepuru Sounds locations (Figure 3c).

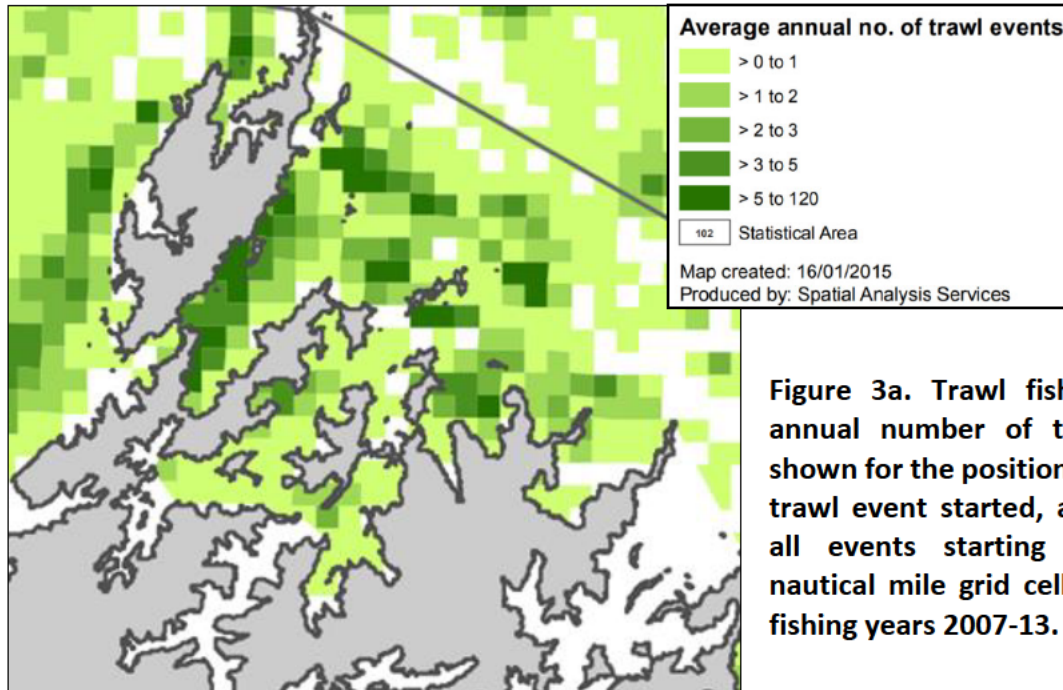


Figure 3a. Trawl fishing events: annual number of trawl events shown for the position where each trawl event started, averaged for all events starting in each 1 nautical mile grid cell and for six fishing years 2007-13.

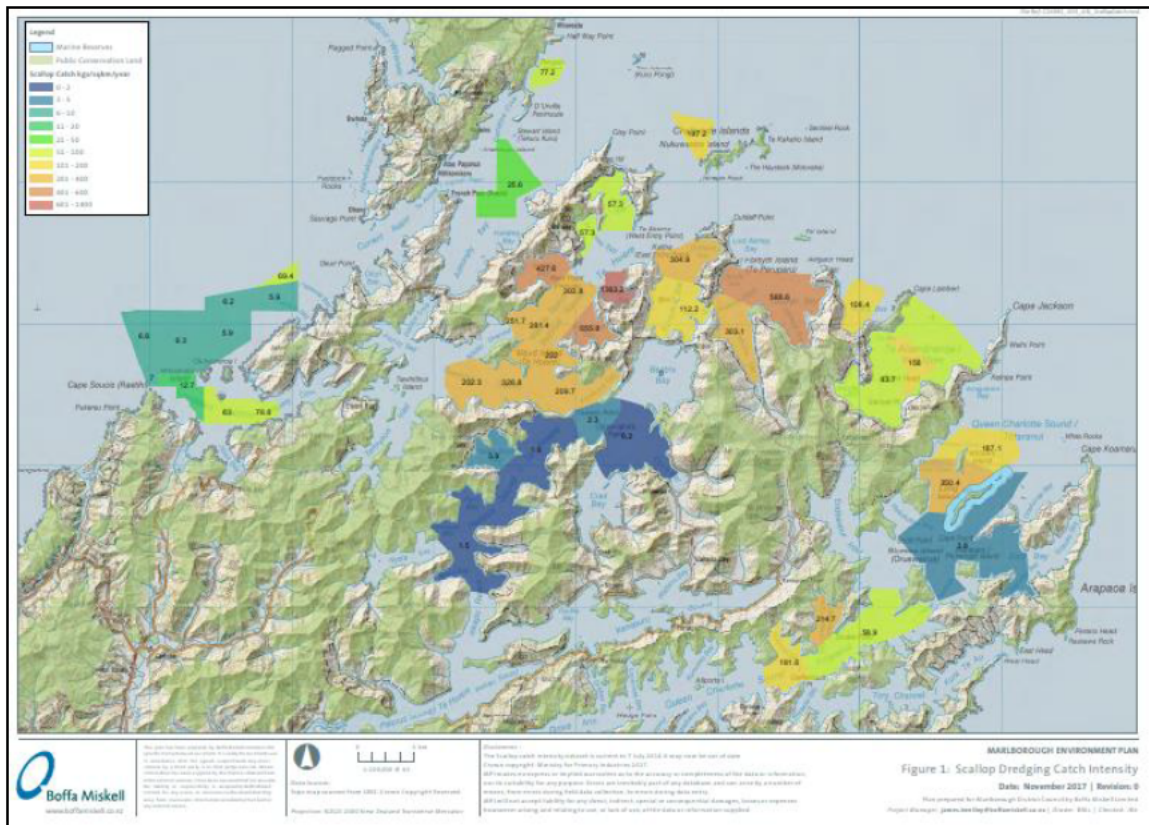


Figure 3b. Scallop catch data to July 2014 (from Boffa Miskell maps produced for MDC Coastal Plan).

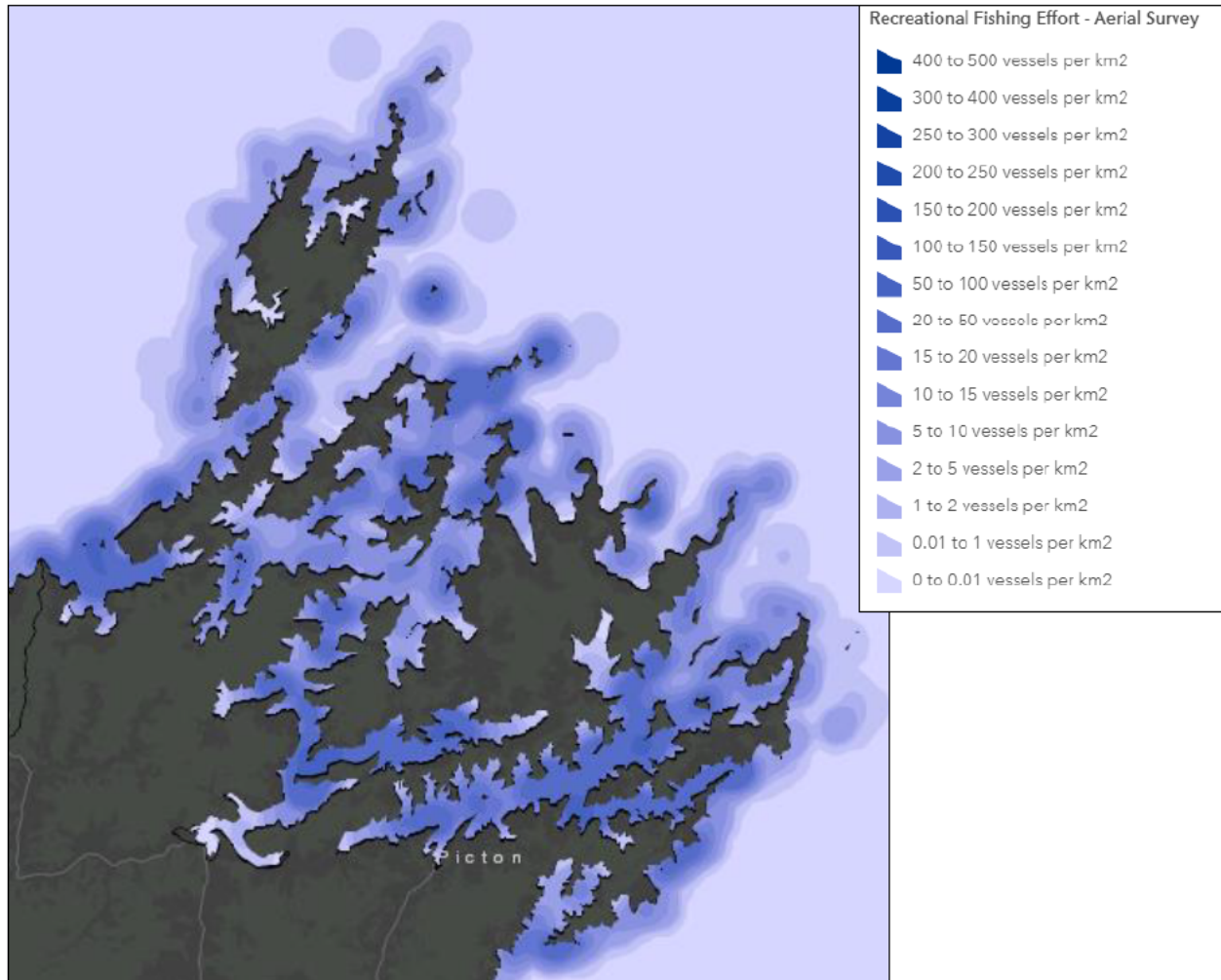


Figure 3c. Aerial survey of recreational fishing effort. Map created by NIWA for MPI, October 2016.

2.5 Existing biological studies and data

Some marine-based studies have occurred in Guards Bay complex (Figure 4). Most data points relate to species, habitat or community-based studies. A few studies have been commissioned by the marine farm industry.

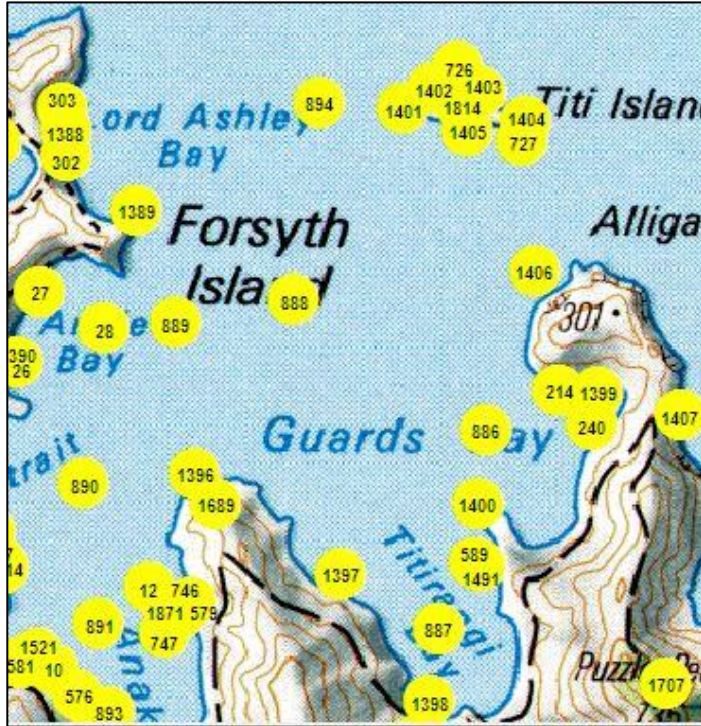


Figure 4. Summary of existing studies from Guards Bay complex (yellow dots).

2.6 Significant sites (ESMS)

There are no known significant sites located in Hikoekoea Bay or Guards Bay proper. All known significant sites are well distant to Hikoekoea Bay (Figure 5).



Figure 5. Known significant sites close to Guards Bay (pink polygons).

Allen Strait bryozoans (7km distance)

Davidson *et al.* (2011) described this site as “a narrow body of water that separates Forsyth Island from the mainland and connects Forsyth Bay to Anakoha Bay in the east. Strong tidal currents sweep through this 260m gap which is shallower than the bays east and west. This site is the best example in Marlborough of an area dominated by the habitat-forming bryozoan, *Galeopsis porcellanicus*. it is also important for the variety of current dwelling species including anemones, hydroids, nesting mussels and colonial ascidians. Mats of living barnacles are found in the deeper and central parts of the Strait. The robust triplefin is a distinctive element of the fishlife.”

Titi Island (3.7km distance)

Davidson *et al.* (2017) surveyed the area and suggested three ESMS sites (2.27a = 4.3ha, 2.27b = 13.5ha, 2.27c = 20.3ha). The authors stated “the present survey confirmed the presence of a range of biogenic habitats including sponges, anemones, bryozoans, hydroid gardens and ascidians. Site 2.27a is centred around a current-swept reef supporting biogenic communities. Dense gardens of hydroid trees were observed in areas around the rocky substrata. Site 2.27b is a current-swept area at the western end of Titi Island and is dominated by cobbles and boulders encrusted with biogenic communities. Isolated rock outcrops also occur in the area. Site 2.27c is a large rocky reef located at the eastern end of Titi Island. Biogenic communities including hydroid gardens are located along its deeper slopes and edges.”

2.7 Marine mammals

The Marlborough Sounds and wider Cook Strait region is an area of high diversity for marine mammals. Recent reviews (e.g. Douglas *et al.*, 2018, Clement & Elvines, 2019) of marine mammals have confirmed that at least 22 species of marine mammals have been reported (e.g. sightings, strandings, bycatch, etc.) from the region. For the 22 species reported in the wider region, their presence varies from the resident (e.g. Hector’s and bottlenose dolphins), semi-resident (e.g. dusky and common dolphins), regular visitor (e.g. orca), migratory (e.g. humpback whales) to vagrant (e.g. leopard seals), depending on their exact relationship with the region (see Slooten *et al.*, 2002; Markowitz *et al.*, 2004; Merriman *et al.*, 2009; Clement and Halliday, 2014; Cross, 2019). Low numbers of New Zealand fur seals (status = not threatened) can be observed year-round within Pelorus Sound, Queen Charlotte Sound and Tory Channel.

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Bottlenose dolphins (status = Nationally endangered: Baker *et al.*, 2019) is the species most consistently observed within the Marlborough Sounds (Authors, pers. obs.). An open, yet semi-residential population of approximately 385 bottlenose dolphins ranges throughout the Marlborough Sounds (Merriman *et al.*, 2009), generally in groups of 30–40 animals (Cross, 2019). These animals use the entire Sounds region year-round, regularly and systematically moving from one end of the Sounds to another, while additional animals migrate in and out of the region at the same time (Merriman *et al.*, 2009). A long-term sighting database from Dolphin Watch Marlborough (now known as E-Ko Tours) starting in 1995 suggests that bottlenose dolphins have been frequently found within inner and mid-QCS and are commonly seen around the wider Picton Bays region (Slooten *et al.*, 2002; Cross, 2019). Recent research surveys found while sighting rates are fairly consistent across seasons, group sizes are slightly larger in autumn accounting for greater densities of bottlenose reported within QCS during these months (Cross, 2019).

Bottlenose dolphins within the Sounds represent one of three isolated subpopulations around New Zealand's coastline; the others are found along the northeast coast of the North Island and within Fiordland in the south-west of the South Island. This species nationally endangered status is due to their restricted ranges and the fact that the other two sub-populations have reported general population declines over the last decade. Such factors make this species potentially more vulnerable to disturbance or changes within their distribution range (D. Clement, pers. comm.). International studies investigating the interaction between bottlenose and marine farms have shown that this species can target aquaculture facilities where they forage for fish (Lopez, 2012; Diaz Lopez and Methion, 2017; Methion and Lopez, 2019).

Starting in 1998, Markowitz *et al.* (2004) studied dusky dolphin (status – not threatened) presence within the Marlborough Sounds, and in particular Admiralty Bay. The authors found that the number of dusky dolphins increased significantly over the winter months and are periodically present throughout the outer Sounds east of D'Urville to Rarangi. No studies have focused specifically on the presence of common dolphins (status = not threatened) in the Sounds.

Clement and Halliday (2014) suggest that outer Sounds bays, such as Admiralty, may serve as important habitat for at least a proportion of the common dolphin population found around New Zealand. Common dolphins appear most abundant in the outer Sounds bays during mid-to late winter and early spring, often coinciding with dusky dolphins while in the region (Clement and Halliday, 2014). Seasonal trends and the high re-sighting rates of identified

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individuals within the area over consecutive seasons and years indicates that common dolphins are either seasonally migrating to this region (i.e. like dusky dolphins) or use it as part of a large home range, like bottlenose dolphins (D. Clement, pers. comm.).

Several studies have aimed at investigating marine mammal interactions with aquaculture in New Zealand and internationally (Markowitz *et al.*, 2004; Merriman, 2007; Vaughn *et al.*, 2007; Pearson *et al.*, 2012; Díaz López, 2012; Clement and Halliday, 2014; Methion *et al.*, 2019).

Some species such as NZ fur seals, may be attracted to mussel farms as hauling outs (Clement and Halliday, 2014; Davidson and Richards, 2017). Farm structures may also attract bottlenose dolphin and possibly killer whales, due to these species' curious natures and the associated aggregations of possible prey species under and near farms. Bottlenose dolphins have been frequently recorded 'sweeping' through mussel farms in the Sounds (D. Clement, pers. comm; Authors, pers. obs.).

Guards Bay

Guards Bay has not been ranked as a significant site for marine mammals. Bottlenose, common and dusky dolphins are intermittently seen in this area and orca are periodically observed.

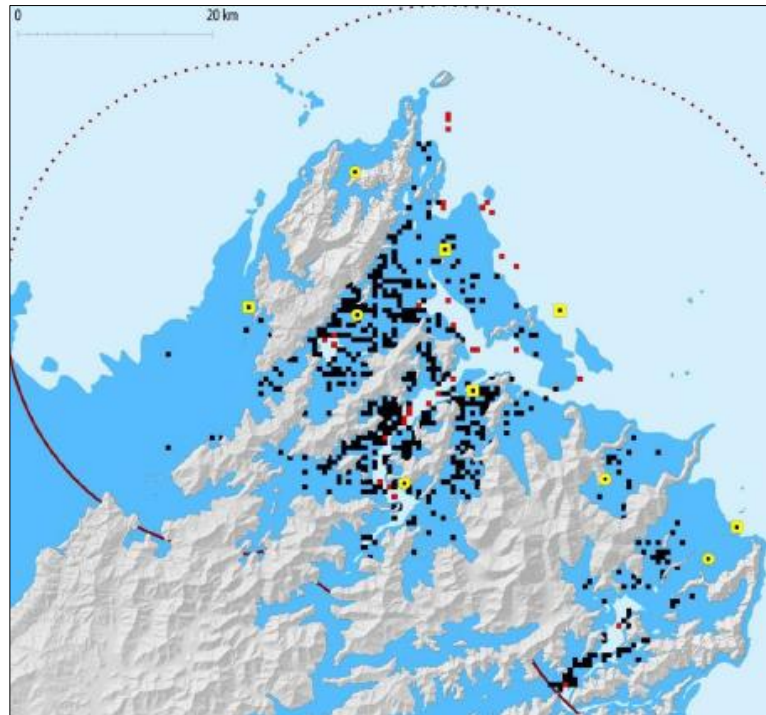
2.8 King shag

King shag (*Leucocarbo carunculatus*) is one of the world's rarest seabird species. The species is endemic to the Marlborough Sounds and is seldom observed outside of this region. The species nests at a small number of colonies, usually on rock stacks that are separate from the mainland, however, there are two mainland colonies presently used by birds (Hunia and Tawhitinui Bay). Historical counts have usually been undertaken by boats; however, most recent surveys have been aerially surveyed and photographed during the breeding seasons of 2016 (2 surveys), 2017 and 2018 (Schuckard *et al.*, 2015; 2018). The latter count showed a 24% decline in the number of adult birds (Schuckard, 2018). The total number of nests range from 187 in 2015 to 89 (June 2016), 117 (July 2016), 153 nests June 2017 (Schuckard, 2018) and 274 active nests in 2019 (Bell, 2019). Roost counts also showed a decline in 2018 (633 birds) compared to 834 (2015), 789 (2019) and 815 birds in the most recent survey by Bell *et al.* (2020).

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Schuckard (2017) did not identify any feeding activity within Hikapu Reach (Figure 6). However, birds do feed as far south as the confluence with Kenepuru Sound (Bell, 2021; Authors, pers. obs.).

Figure 6. Distribution of foraging by king shags in Marlborough Sounds. Figure from Schuckard (unpublished evidence, 2017).



Diet studies have shown king shags feed on a variety of fish at a wide variety of locations in the Marlborough Sounds. Lalas and Brown (1998) recorded 683 prey items, of which flatfish accounted for 90% of items.

Two scientists have recently been working on king shag, funded by the MFA and Seafoods Innovations Limited. In the study by Bell (2019a), GPS transmitters were placed on birds from two Pelorus colonies. GPS data revealed birds have individual foraging preferences. Some birds foraged outside marine farms while some foraged within marine farms. McClellan *et al.* (2020) conducted a pilot study comparing king shag (and seabird) use at paired sites with and without mussel farms. McClellan *et al.* (2020) found that king shags were present at five of the eight study farms and four of the control sites. Birds were not observed at two of her eight paired sites. King shag roosted only at two farms and roosted and foraged at three farms. Preliminary data show that some king shag chose to forage in mussel farms and in some instances for prolonged periods.

Guards Bay

Foraging king shags were not recorded by Schuckard (2017) in Guards Bay (Figure 6).

2.9 Benthic

Duffy et al. (in prep) qualitatively described the biota from 360 sites around the Marlborough Sounds. The authors found most sample sites in Guards and Forsyth Bay were grouped into Rocky groups 1, 2 and 4 and Soft groups 4 and 7.

Rocky Site Group 1

This was the largest of the 11 sub-groups. Sites in this group were representative of much of the sheltered inner Sounds. They were located in Queen Charlotte (34 sites) and Pelorus (31) Sounds, Port Hardy (2), Admiralty Bay (8), Cherry Bay at D'Urville Island (1), Squally Cove in Croisilles Harbour (1), Catherine Cove (2), Guards Bay (2), Anakoha Bay (2) and Forsyth Bay/Island (5).

Distance to open water was high and fetch is low. It was the deepest of the inner sounds site groups and contained a high proportion of rocky outcrops when compared with the other inner sounds site groups. The most common habitat type was cobble banks. Although it had few indicator species, it was the most species-rich of the inner sounds site groups (average 31 species per site). The best indicator species were *Maoricolpus roseus*, *Galeolaria hystrix* and *Forsterygion lapillum*.

Rocky Site Group 2

The majority of these sites were located in Tasman Bay, between Croisilles and Greville Harbours (20 sites). Additional sites were located in Port Hardy (3), Alligator Head (1), Forsyth Bay (2), Port Gore (1) and Queen Charlotte Sound (3). Fetch was variable, DTOW was low and species richness was relatively high (average 48 species per site). The substratum was one, or a combination of rocky outcrops, boulders and cobbles. One site had rock wall and one was a pinnacle. The best indicator species for this group were the inflated cushion star (*Stegnaster inflatus*) and the reef star (*Stichaster australis*).

Rocky Site Group 4

Sites in this group were located around north-east (12 sites) and western D'Urville Island (3), Motuanauru Island in Croisilles Harbour (1), the Chetwode Islands and the mouth of Pelorus Sound (6), Guards Bay (2), Port Gore and Waitui Bay (7), Long Island (5), Motungarara Island

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(1), Motuara Island and the adjacent mainland (3), and Tory Channel (2). A high proportion contained boulder habitat. Rock outcrops and cobbles were also common. Two sites had rock wall and one was a pinnacle. Indicator species were queen paua (*Haliotis australis*), blueeye triplefin (*Notoclinops segmentatus*) and the brown alga *Glossophora kunthii*. Indicator values were low for *H. australis* and *G. kunthii*. *H. australis* was also found in groups 10 and 11 and it had a high indicator value (IndVal = 44) when all three groups were combined.

Soft Site Group 4

Sites in this group were located in Queen Charlotte Sound (8), Pelorus Sound (6), outer sounds (9), and Croisilles Harbour (2). Most of the sites had a shallow minimum depth (median = 4.5 metres) and variable maximum depth. This was the most species rich of the soft sediment site groups (average 20 species per site). On average, sites in this group spanned a larger depth range than sites in all other groups. Although they are not particularly strong, the best indicator species for this group are the scallop (*Pecten novaezelandiae*) and the sunset shell (*Gari stangeri*). *Macomona liliana* was only recorded from this group.

Soft Site Group 7

Thirteen of these sites were located in inner and outer Pelorus Sound, with the other three located in Admiralty Bay (1 site) and East Bay, Queen Charlotte Sound (2). The sites were relatively deep, had a high DTOW and medium species richness (average 13 species per site). The predominant substratum was shelly mud or shelly sandy mud. The brachiopod *Terebratella* sp. occurred at all sites and was the best indicator species for the group. The opal fish (*Hemerocoetes monopterygius*) was also a good indicator.

3.0 Marine farm 8164

Hikoekoea Bay is a small bay situated in eastern Guards Bay, outer Pelorus Sound. Guards Bay also includes Titirangi Bay to the southwest of Hikoekoea Bay. The present report provides biological information relating to a proposed offshore extension to marine farm 8164 located north of Hikoekoea Bay (Figure 7, Plate 1).

The adjacent hillside along this coast of Guards Bay are pasture and a fringe of regenerating and planted natives.

Figure 7. Marine farm 8164 in Guards Bay (red circle) and all other marine farms in the area.



3.1 Summary

Marine farm number:	8164
Owner:	C. Redwood
Location:	Hikoekoea Bay, outer Pelorus Sound
MPI exclusion area present:	Yes (inshore of parent farm)
Consented size:	12 ha existing parent farm
Proposed extension size:	28.83 ha
Issues & recommendations:	None



Plate 1. Looking north across the Bay towards proposed offshore extension and existing backbone lines of farm 8164. The photo was taken from a position southwest of the proposed extension area and parent farm.

3.2 Historical reports

Two historical reports were found in relation to marine farm 8164. A report was produced by Bradley (1998) “as part of an application to further develop the established marine farm Licence 391”. Three dive transects were surveyed at 24 to 25 m depth. Of note was the presence of tubeworms recorded as common from all transects, while scallop and horse mussel were occasional in abundance.

Davidson and Richards (2013) surveyed the existing 12 ha marine farm consent for renewal using drop camera and sidescan sonar methods. The authors stated:

“Much of marine farm consent area was characterised by a gently sloping benthos dominated by silt and clay sized particles, at depths between 22m and 27 m. No biological communities of interest such as scallops, red algae or horse mussels were recorded from these soft substratum areas.

Most existing marine farm surface structures (backbones and floats) were located within the parent farm; however, one backbone on the southern and one on the middle blocks were located offshore of the consent.”

4.0 Methods (proposed extension survey)

The area was investigated on 28th September 2021. Before fieldwork, the consent corners were plotted onto mapping software (TUMONZ Professional). The laptop running the mapping software was linked to a Lowrance HDS-12 Gen2 with an external Lowrance Point 1 high sensitivity GPS, allowing real-time plotting of the corners of marine farm surface structures and was used to pinpoint drop camera stations in the field. This GPS system has a maximum error of +/- 5 m.

The corners of the existing marine farm surface structures in the parent farm were surveyed by positioning the survey vessel immediately adjacent to the corner floats and the position plotted. It is noted that surface structures can move due to environmental variables such as tidal current and wind. The plot of surface structures is variable from day to day and throughout tidal cycles. These data should not, therefore, be regarded as a precise measurement of the position of surface structures, but rather an approximate position.

4.1 Sonar imaging

Sonar investigations of the inshore edge of the proposed extension area were conducted using a Humminbird Solix 15 SI+ mega imaging unit. This unit provides right and left side imaging as well as down imaging. A Lowrance HDS 12 Gen2 unit fitted with a high definition 1kw Airmar transducer was used to collect traditional sonar data from the site.

Before the collection of underwater photographs, the boundary of the proposed consent area was investigated using the sonar. Any bottom abnormalities such as reefs, hard substrata or abrupt changes in depth were noted for inspection using the drop camera (see section 4.2).

4.2 Drop camera stations, mussel debris and low tide

A total of 26 drop camera photographs were collected from the proposed extension (including alongside droppers and warps). At each drop camera station, a Sea Viewer underwater splash camera fixed to an aluminium frame was lowered to the benthos and an oblique still photograph was collected where the frame landed.

The cover of benthic mussel shell from drop camera photographs were ranked as: None = no mussel shell, Low = 1-30%, Moderate = 31-50%, Moderate to High = 51-75%, and High = 76-100% cover. Percentage cover of mussel shell was estimated by a trained observer viewing drop camera photographs.

The location of photograph stations was selected to obtain a representative range of habitats and depths within the proposed extension. Additional photographs were taken when any features of interest (e.g. mussel shell, reef structures, cobbles) were observed on the remote monitor on-board the survey vessel. All photographs collected during the survey have been included in Appendix 1.

5.0 Results

On the day of the survey, the tide was low at 7.50 am (1.1 m) and high at 2.08 pm (2.3 m). During fieldwork, the tide was outgoing.

5.1 Consent corners and surface structures

The seafloor contour under the proposed extension varied from 19.3 m to 29 m depth, with a deeper 'depression' towards the northern end at boundary corner #5. (Table 1, Figure 8).

Two existing backbones were positioned within the proposed extension area, offshore of the parent marine farm consent (Figure 8).

Table 1. Depths at the consent, extension and existing surface structure corners. Depths adjusted to datum. Coordinates = NZTM (Northing/Easting).

Type	No. & Depth	Coordinates
Consent corner	1, 13.5m	1697313.1,5461862.8
	2, 23m	1697170.9,5461755.7
	3, 12m	1697098.9,5461177.0
	4, 22.5m	1696950.7,5461195.4
	5, 29m	1697030.0,5461837.5
	6, 24.5m	1697182.7,5461952.2
Structure corner	A, 26.5m	1697016.8,5461796.8
	B, 28.5m	1697088.0,5461866.9
	C, 23.4m	1697173.1,5461945.3
	D, 20.8m	1697256.6,5461876.8
	E, 23m	1697167.0,5461806.6
	F, 22.7m	1697155.5,5461724.5
	G, 17.1m	1697126.9,5461539.3
	H, 22.7m	1696990.3,5461572.8
	I, 22.1m	1696971.3,5461446.7
	J, 21.6m	1697087.3,5461444.3
	K, 16.1m	1697108.4,5461389.2
	L, 10.7m	1697090.3,5461206.2
	M, 21m	1696943.8,5461221.4
Extension	8, 19.3m	1696651.2,5461219.7
	7, 23.9m	1696776.2,5462207.2

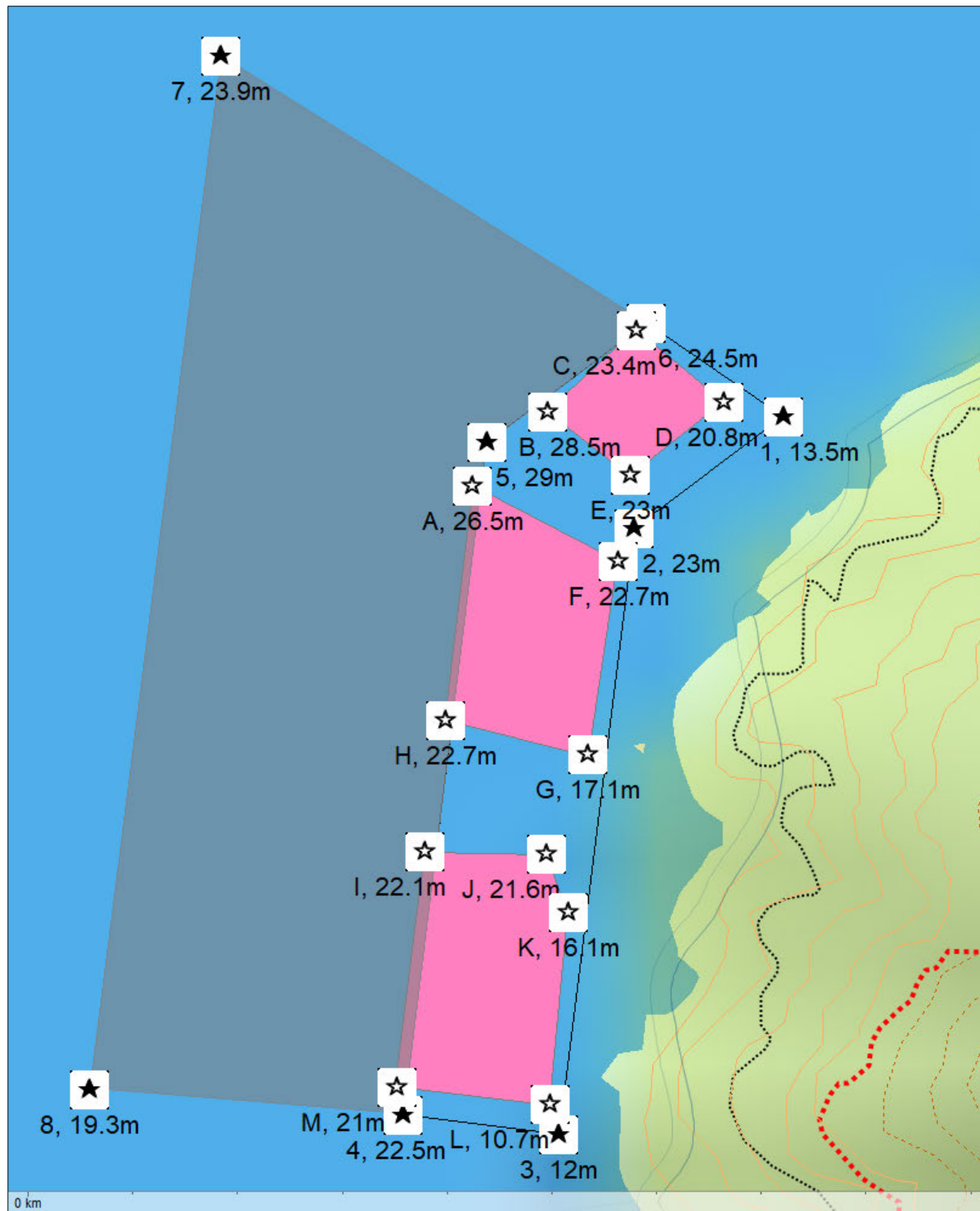


Figure 8. Depths of the proposed extension area (grey) and existing marine farm surface structures (pink) within the existing consent.

5.2 Wildlife observations

One little blue penguin was observed swimming on the surface within the proposed extension area. No other birds or marine mammals were seen.

BIRDS	Number	Flying	Water (swim)	Water (foraging)
Little shag				
Little black shag				
Pied shag				
Spotted shag				
King shag				
White fronted tern				
Caspian tern				
Black-backed gull				
Black-billed gull				
Red billed gull				
Skua				
Gannet				
Variable oyster catcher				
Mallard duck				
Paradise duck				
Little blue penguin	1		1	
White-faced heron				
Total count of species	1	0	1	0
Total count of individuals	1	0	1	0

5.3 Sonar imaging

The downscan and sidescan transects ran offshore of the existing consent boundary, adjacent to the existing farm structures. A slightly stronger signal was detected from the benthos under backbones due to the presence of mussel shell. No upright rock or reef habitat was present (Figures 9 & 10). Soft sediment was consistent throughout the proposed extension area.

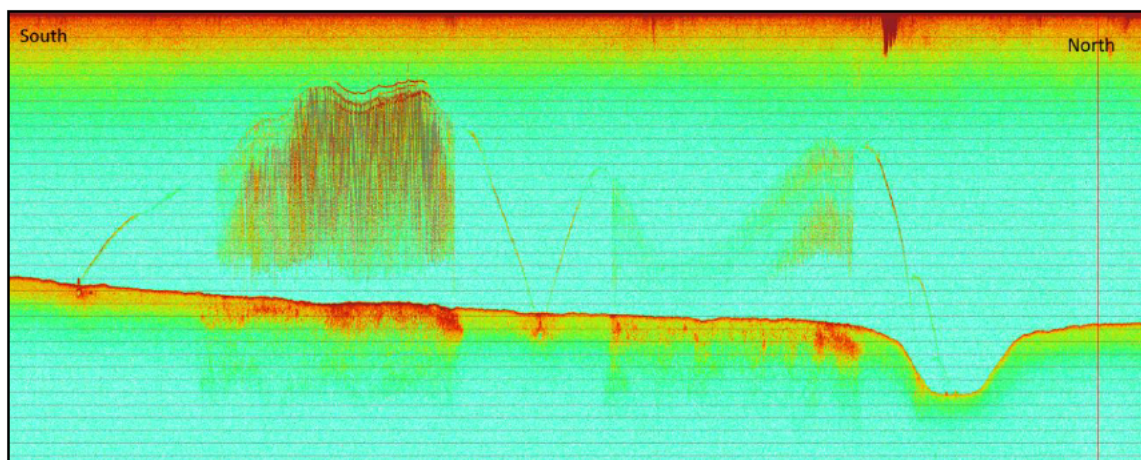


Figure 9. Downscan along the offshore boundary of the existing consent (adjacent to existing parent farm backbones).

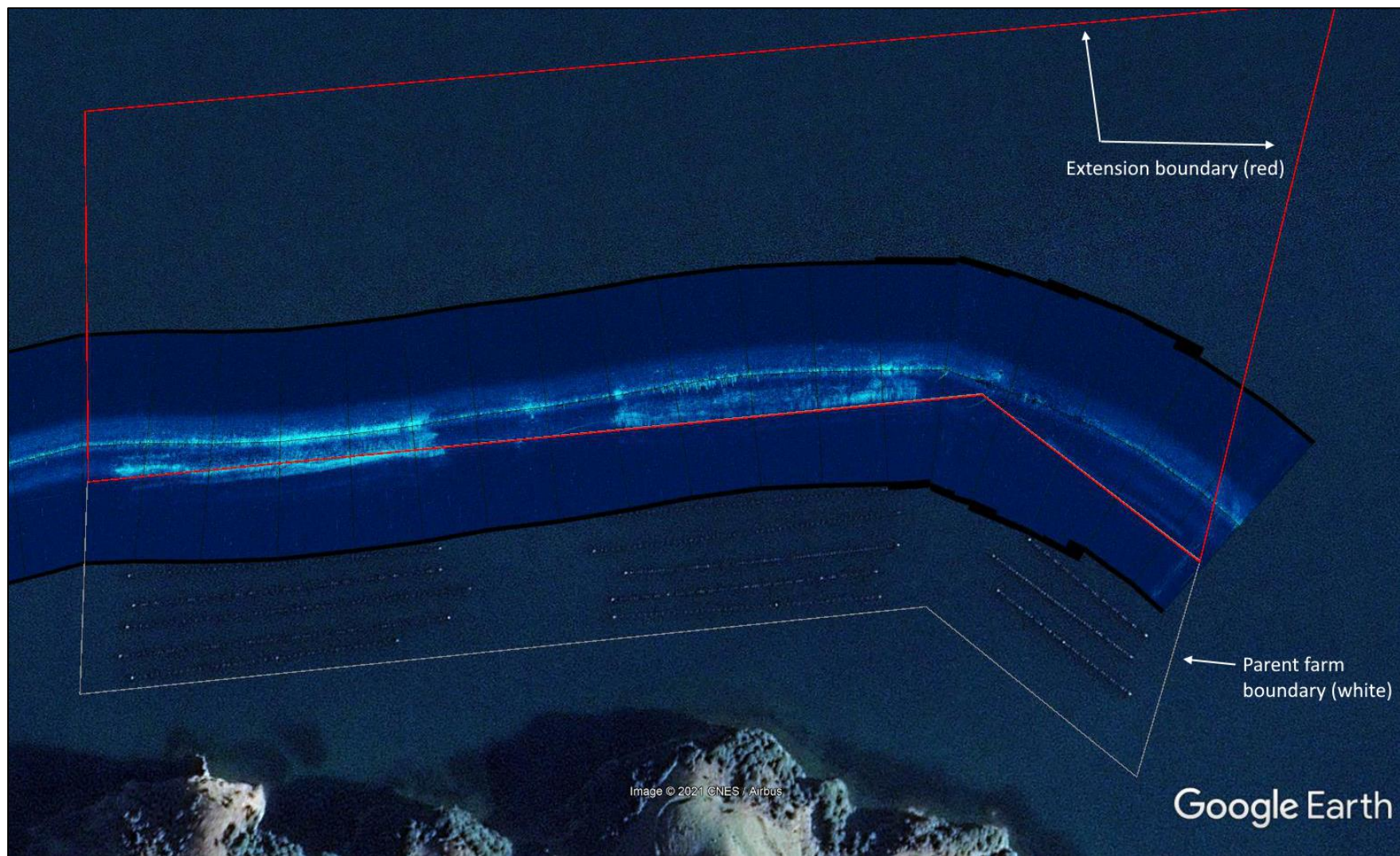


Figure 10. Sonar run offshore of marine farm 8164. Red polygon = consent boundary, glow edge = sonar track. The shoreline is at bottom of the image.

5.4 Drop camera images

Drop camera photographs were taken throughout and offshore of the proposed extension (Table 3, Figure 11, Appendix 1). Photographs were used to describe benthic substrata, mussel shell debris and the presence of biological characteristics.

Within the proposed extension

All of the seafloor under the existing consent was dominated by silt and clay (Plates 2, 3 & 4). Mussel shell was only recorded close to existing backbones in the survey conducted by Davidson and Richards, 2013).

Conspicuous species observed on the silt seafloor included solitary ascidian, scallop, ostrich foot whelk, hermit crab and pink urchin. No macroalgae species or natural shell cover were recorded from drop camera images collected during the present survey (Table 3).

Outside the proposed extension

The seafloor offshore of the proposed extension remained soft silt and clay, with no conspicuous species, macroalgae or natural shell recorded (Plate 5).



Plate 2. Silt and clay under backbones in the consent (photo 3, 19.4 m depth).



Plate 3. Silt and clay in the proposed extension (photo 14, 22.9 m depth).



Plate 4. Silt and clay in the proposed extension (photo 18, 23.8 m depth).



Plate 4. Silt and clay offshore of the proposed extension (photo 19, 19.6 m depth).

Table 3. Coordinates for drop camera stations relative to the marine farm area. Colours are grey = within consent area, blue = outside consent area, pink = under backbones. Depth, substratum, and conspicuous species are listed.

No. & Depth	Coordinates	Location	Position	Substratum	Notable species	% mussel shell	% macroalgae	% natural shell
1, 20.6m	1696851.5,5461243.0	Proposed extension	No structures	Silt and clay		0	0	0
2, 19.8m	1696779.8,5461275.6	Proposed extension	No structures	Silt and clay		0	0	0
3, 19.4m	1696687.7,5461262.7	Proposed extension	No structures	Silt and clay		0	0	0
4, 19.7m	1696714.7,5461392.0	Proposed extension	No structures	Silt and clay		0	0	0
5, 20.5m	1696832.3,5461376.8	Proposed extension	No structures	Silt and clay	pink urchin	0	0	0
6, 22.3m	1696946.4,5461505.3	Proposed extension	No structures	Silt and clay		0	0	0
7, 21m	1696851.6,5461539.5	Proposed extension	No structures	Silt and clay		0	0	0
8, 20m	1696723.1,5461562.6	Proposed extension	No structures	Silt and clay	scallop,sol. ascidian,	0	0	0
9, 20.5m	1696737.1,5461705.2	Proposed extension	No structures	Silt and clay	sol. ascidian,herm crab	0	0	0
10, 21.5m	1696866.0,5461696.1	Proposed extension	No structures	Silt and clay		0	0	0
11, 22.3m	1696931.5,5461804.9	Proposed extension	No structures	Silt and clay		0	0	0
12, 21.1m	1696806.8,5461819.8	Proposed extension	No structures	Silt and clay		0	0	0
13, 21.5m	1696785.2,5461947.9	Proposed extension	No structures	Silt and clay	sol. ascidian,	0	0	0
14, 22.9m	1696805.3,5462118.1	Proposed extension	No structures	Silt and clay		0	0	0
15, 22.9m	1696941.8,5462072.3	Proposed extension	No structures	Silt and clay	scallop	0	0	0
16, 23.2m	1697051.0,5461994.9	Proposed extension	No structures	Silt and clay		0	0	0
17, 22.6m	1696947.9,5461949.1	Proposed extension	No structures	Silt and clay		0	0	0
18, 23.8m	1697008.6,5461844.8	Proposed extension	No structures	Silt and clay		0	0	0
19, 19.6m	1696657.6,5461528.5	Offshore of extension	No structures	Silt and clay		0	0	0
20, 19.8m	1696698.3,5461795.8	Offshore of extension	No structures	Silt and clay		0	0	0
21, 28.3m	1697066.7,5461914.5	Proposed extension	No structures	Silt and clay		0	0	0
22, 27m	1697143.1,5461961.3	Proposed extension	No structures	Silt and clay		0	0	0
23, 25.4m	1696986.6,5461688.5	Proposed extension	No structures	Silt and clay		0	0	0
24, 21.4m	1696921.8,5461231.3	Proposed extension	No structures	Silt and clay		0	0	0
25, 21.9m	1696940.5,5461326.6	Proposed extension	No structures	Silt and clay		0	0	0
26, 21.9m	1696957.2,5461419.5	Proposed extension	No structures	Silt and clay		0	0	0

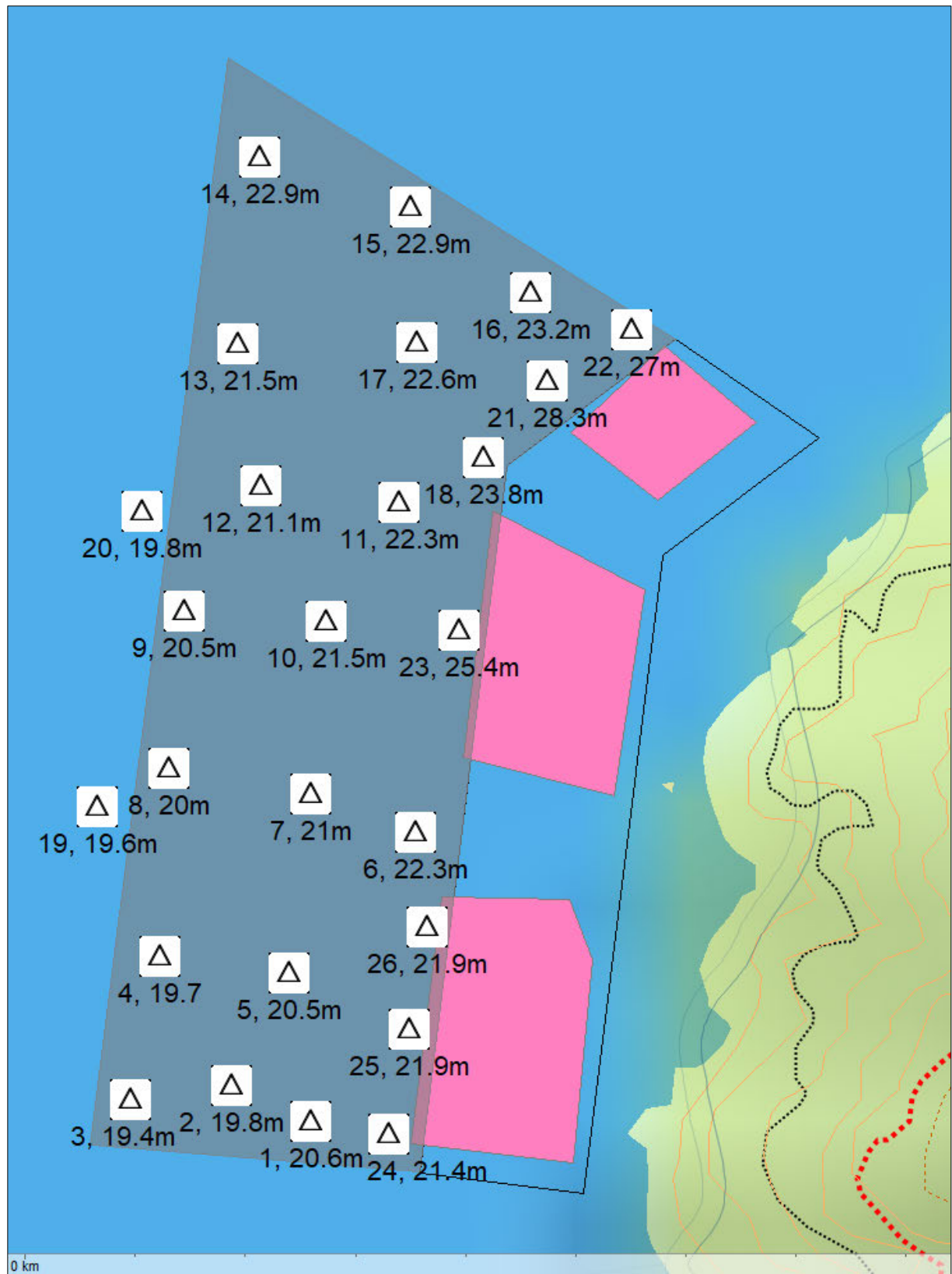


Figure 11. Drop camera stations in the consent (open triangles = soft substrate, filled circles = rocky substrate), consent area (grey), surface structures (pink). Numbers are the photo number and water depth (m).

6.0 Conclusions

6.1 Seabirds and marine farms

The mussel industry's Environmental Management System (EMS), formally known as the Environmental Code of Practice, seeks to minimise risks to wildlife and risks are likely to be minimal on well-maintained farms (Keeley *et al.*, 2009).

Based on the few studies that have investigated the interactions between mussel farms and birds, mussel aquaculture can potentially affect seabirds by altering their food resources, cause physical disturbances (e.g. noise) and/or introduce possible entanglement risks. The structures associated with aquaculture may also provide benefits including additional perching and feeding opportunities.

Overall, New Zealand (Butler, 2003) and overseas studies (Ross *et al.*, 2001; Roycroft *et al.*, 2004; Kirk *et al.*, 2007) suggest that the general attraction of particular seabirds to mussel farms is likely due to increased foraging success on fish and biofouling, and even on the cultured stock itself. The consequences of this attraction will likely depend on the species' dietary preferences and response to both direct and indirect ecosystem changes induced by mussel cultivation.

Birds are potentially at risk from operational by-products of farms, including ties and plastics. Butler (2003) found young and adult Australasian gannets (*Morus serrator*) in the Marlborough Sounds entangled in discarded rope ties from mussel farms that had been incorporated into nests by parents. Gannet colonies are established at Farewell Spit and Waimaru Peninsula within Beatrix Complex. A variety of penguin, shag and gull species are also present in the area and may potentially use ties as nesting material. It is therefore important that marine farmers minimise the introduction of ties into the marine environment.

McClellan *et al.* (2020) conducted a pilot study comparing seabird use at paired sites with and without mussel farms. Each of eight paired sites in Pelorus Sound were observed for two days (approximately 14 hours), except for one paired site, which was only observed for one day, as a harvesting vessel arrived on the morning of the second day. Counts were made of seabird species present in the farm and control sites at 15-minute intervals throughout each two-day

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period. General notes were made on the behaviours of those bird species at the sites, for example, foraging between backbone ropes, feeding on algae and other biota associated with backbone ropes, roosting on buoys, resting on the sea surface, etc. McClellan *et al.* (2020) found 11 species of birds used mussel farms (mean = 7.6 species per farm; standard error = 0.4) compared to five species of birds that used the associated control sites (mean = 1.0 species per control; standard error = 0.5).

Guards Bay farm

During the present survey, one little blue penguin was observed within the consent area (Table 2). If the proposed extension is consented, bird species may potentially use new backbone structures for foraging and roosting as seen elsewhere in the Sounds (Authors, pers. obs.).

6.2 King shags and marine farms

A variety of authors have also outlined human activities that may impact king shags including aquaculture (Schuckard, 2006; Bell, 2019a; McClellan *et al.*, 2020); commercial fishing (McClellan, 2017), colony disturbance (Butler, 2003; Davidson *et al.*, 2018), and hunting (Nelson, 1971). Apart from aquaculture, little research has occurred on these topics despite their potential importance on a high-status species.

Butler (2003) undertook the first review of the possible effects of marine farms on king shag. He described the potential effects in three categories: physical effects (structures of farms, lights, debris from farms, and shell waste); effects of activities (disturbance, noise and water pollution); and effects on marine ecology (hydrography, sediment and water column changes, creation of new habitat, exclusion of trawlers, unwanted organisms). Butler (2003) considered that most king shag feeding occurred in deeper water and that potential impacts resulting from mussel farms excluding king shag foraging may become apparent if deeper-water mussel farms were developed. Lloyd (2003) reviewed the effects of aquaculture on seabirds and cetaceans. He also appeared to believe the existing pattern of inshore mussel farms was less likely to affect king shag foraging compared to proposals for extensive mid-bay mussel farms in Admiralty Bay. Fisher and Boren (2012) undertook a rigorous study of king shag foraging distribution in Admiralty Bay and concluded that deep water marine farms posed a greater threat compared to inshore sites.

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Sagar (2013) conducted a general review of the ecological effects of aquaculture and only specifically mentioned king shag in relation to disturbance but discussed the main effects of ‘filter feeder species’ farms on seabirds in general, and their significance. The author stated the eight key effects were: entanglement with farm structures, habitat exclusion, smothering of benthos, changed abundance of prey, provision of roosts, disturbance by farm activities, ingestion and entanglement with farm debris, and attraction to lights. Sagar (2013) considered that the potential effects of habitat exclusion and smothering of benthos were, in general, insignificant to seabirds given the small area occupied by filter feeder farms. However, he qualified this, noting that the significance of effects “will depend on the spatial scale of the aquaculture facility in relation to the distribution and abundance of prey species”, and concluded that effective management could be achieved by avoiding locating farms in key foraging areas of species with restricted habitat requirements (see Sagar, 2013). The review listed “home ranges or location of important feeding and breeding habitats for most populations of seabird species” as being a key information gap for every one of the eight key potential effects.

Recent work on king shag has focused on a variety of aspects including foraging related behaviour (Bell 2019, 2019a; 2020; McClellan *et al.*, 2020). These studies have been funded by the MFA, Seafoods Innovations Limited and MPI. In the first year of a three-year study, Bell (2019a) attached GPS transmitters on birds from two Pelorus colonies located at Tawhitinui Bay and Duffers Reef. For the six tagged birds, between 7 and 13 days of data were recorded. Birds conducted between 7 and 20 foraging bouts over this period. Bell analysed the 42 complete foraging data sets to assess foraging behaviour and reported the average foraging trip duration was 4.5 hours (range: 23 minutes to 9 hours and 28 minutes). GPS data from the 42 complete datasets revealed birds spent on average 20 minutes flying to a foraging site. An average of 2 hours 59 minutes was spent foraging. Birds spent an average of 43 minutes resting or swimming on the water and 25 minutes roosting on mussel floats outside foraging bouts. Overall, birds spent 20% of each trip not foraging. Bell (2019a) reported that all six birds spent some time roosting on mussel floats including one bird that overnighted on a float. None of the birds visited land while away from the colony. The author also reported that the average foraging distance from the colony was 6.2 km (range: 0.4 km to 16.2 km).

Bell (2019a) reported that birds appear to have favoured foraging areas, with birds returning to broadly similar areas. Some birds foraged outside marine farms while some foraged within marine farms (Figures 13 & 14). Bell reported one bird foraged almost exclusively within mussel farms.

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Bell (2019a) also reported birds had preferences for diving depth, with one bird having a mean maximum depth of 12.6 m (i.e. shallow preference), while one bird preferred deep diving with a mean maximum depth of 26.9 m.

Figure 13. Heat map of foraging location of king shags from Duffers Reef colony (from Bell, 2019). Note marine farms are depicted as grey shapes and the king shag colony as a star.

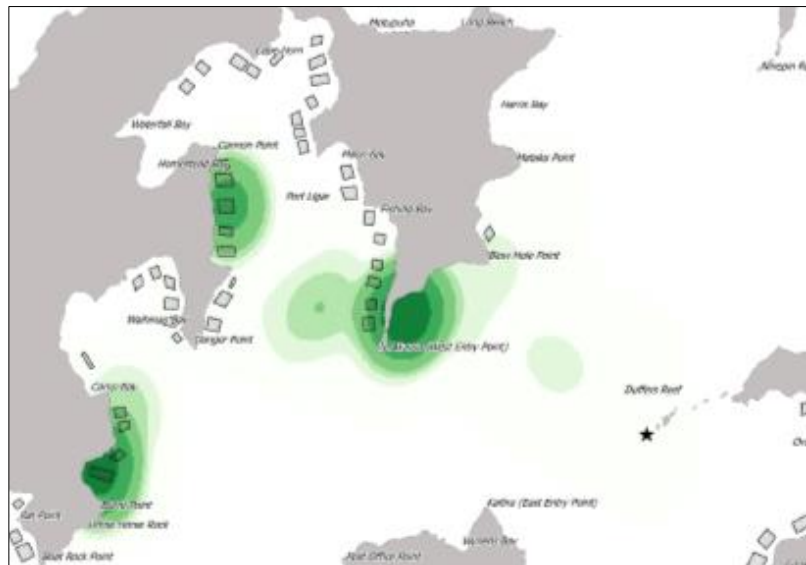


Figure 14. Duffers Reef king shag individual who preferred to forage in marine farms.



McClellan *et al.* (2020) conducted a pilot study comparing king shag use at paired sites with and without mussel farms. Each of eight paired sites in Pelorus Sound were observed for two days (approximately 14 hours), except for one paired site, which was only observed for one day, as a harvesting vessel arrived on the morning of the second day. Counts were made at the farm and control sites at 15-minute intervals throughout each two-day period. General notes were made on the behaviours at the sites, for example, foraging between backbone

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ropes, feeding on algae and other biota associated with backbone ropes, roosting on buoys, resting on the sea surface, etc. McClellan *et al.* (2020) reported that king shags were present at five of the eight study farms and four of the control sites. Birds were not observed at two of the eight paired sites. King shag roosted (no foraging) at two farms and roosted and foraged at three farms. In evidence before the Waikato Regional Council, McClellan (2019) stated “it has long been thought that mussel farms may exclude king shag from feeding in and around the structures of mussel farms due to benthic habitat changes under the farms and/or the structures themselves. The results from both this pilot study and from Bell (2019a) which involved attaching GPS loggers to six breeding adult king shags for 6-12 days, indicate that king shags do forage in mussel farms, sometimes for long periods of time and sometimes exclusively over that period.”

In the second year of the three-year programme, Bell (2020) reported on the results of tagging studies. The author tagged seven birds with results showing birds regularly returned to the same foraging sites on repeat foraging trips. The author stated there appeared differences in male and female foraging behaviour with males foraging for longer, further from the colony, diving deeper and forage later in the day compared to females. Pooling data from both years, 4 of 11 king shag tracked who foraged in areas with mussel farms, foraged within mussel farms. All 11 birds roosted on farms and all foraged immediately adjacent or close to mussel farms.

Guards Bay farm

With the closest colony at Duffer Reef, king shags are known to forage around Forsyth Island. They have not yet been recorded foraging in Guards Bay, however, it is probable foraging does occur in the area. King shags are known to forage outside and within marine farms as well as using structures for roosting between foraging bouts (Figures 13 & 14). If the extension is approved, any impact on king shags is therefore likely to be minor.

6.3 Marine mammals and marine farms

International research demonstrates that the nature and scale of any direct displacement or avoidance vary greatly between culture methods and marine mammal species (MPI, 2013). While particular species of whales or dolphins will be highly sensitive to disturbance, other species (such as bottlenose dolphins) and pinnipeds may be attracted to the structures

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(Lopez, 2012; Clement and Halliday, 2014; Davidson and Richards, 2017; Methion and Lopez, 2019).

For mussel farming, occupied farm areas may be perceived by some marine mammals (particularly those that echolocate) as a physical, visual or acoustic obstruction within their habitat. Based on research to date in Admiralty Bay, dusky dolphins appear unable to cooperatively herd schooling fish when adjacent to or within mussel farm structures (see Pearson *et al.*, 2012). Clement and Halliday (2014) also noted the reluctance of common dolphins to enter or feed near farm structures within the Admiralty Bay region. Over the course of five consecutive winters between 1998 and 2002, Markowitz *et al.* (2004) found that dolphins spent significantly less time in areas occupied by mussel farms than other parts of the inner bay. Pearson *et al.* (2012) also reported similar findings from tracking dolphin groups both inside and outside of mussel farms across all of Admiralty Bay during the winters and springs of 2005-2006. To test specifically whether these results were due to the fact that dusky dolphins might not use habitats closer to shore in general, rather than avoiding the farm areas themselves, Markowitz's study looked at the amount of time groups spent near farms (<200 m) and Pearson's study looked at time spent within the nearshore zone (<400 m of the shoreline) around inner and all of Admiralty Bay, respectively. Both studies found dolphins frequented areas occupied by mussel farms significantly less often than similar areas near farms or within the general nearshore zone.

The significance of such 'disruptions' to their foraging and feeding success over time may range from minor, (i.e. they simply employ other foraging strategies or move to other sources) to major implications (i.e. the loss of a primary food source begins to have population-level effects, such as reduced reproduction rates). It is difficult to assess whether these foraging limitations are impacting on the survival and reproduction of these dolphins at the population level and research can take several decades to determine and population dynamics (e.g. closed versus open structure) can affect the efficiency with which data can be collected (D. Clement, pers. comm.).

Displacement

Some species such as NZ fur seals may be attracted to mussel farms as hauling outs (Clement and Halliday, 2014; Davidson and Richards, 2017). Farm structures may also attract bottlenose dolphin and possibly killer whales, due to these species' curious natures and the associated aggregations of possible prey species under and near farms. Bottlenose dolphins

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have been frequently recorded 'sweeping' through mussel farms in the Sounds (D. Clement, pers. comm; Authors, pers. obs.).

Entanglement

Globally, 15 whales have been recorded as being entangled and/or damaging marine farms but only six of these have been in mussel farms with the remainder interacting with salmon farms (Clement & Elvines, 2019). There are two reported incidences of dolphin entanglement and death at a salmon farm in New Zealand, both from the Marlborough Sounds (M. Aviss, MDC). In one, an unidentified dolphin species became trapped while a predator net was being replaced, and in the other case, a Hector's dolphin became trapped under a predator net. Internationally, fatal entanglements of dolphins in predator nets on finfish farms have been reported from Australia (Kemper and Gibbs, 2001; Kemper *et al.*, 2003) and Italy (Díaz López and Bernal Shirai, 2007). This may reflect the attraction of dolphins to a food source (Kemper and Gibbs, 2001) although such interactions between finfish farms and cetaceans have not been proven (Kemper *et al.*, 2003).

There is also one record of a marine mammal becoming trapped or tangled in a mussel farm (a Bryde's whale; Wursig and Gailey, 2002). The low incidence of mussel farm entanglements is probably related to warps and backbones being under tension thereby reducing the chance of entanglement. This is in stark contrast to lobster pots that have a single line to the surface. This line is usually under little or no tension. Whales migrating up the east coast of the South Island pass hundreds of lobster lines that present a serious entanglement threat. A humpback first spotted by DOC staff near Banks Peninsula with a cray pot buoy line tangled around its tailstock and flukes then became entangled in mussel floats when it swam alongside a farm in Tory Channel several days later. This animal was cut free from the cray pot lines by a mussel farmer (Scott Madsen) and was released alive.

Wursig and Gailey (2002) stated that entanglements by larger whales in aquaculture facilities are relatively rare events.

Guards Bay farm

For dolphin species, the farm extension could represent lost foraging habitat, however, dolphins are only occasionally seen in the area.

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Based on the location of this farm and known whale migratory patterns and behaviour, this farm does not represent a threat for migrating whales through Cook Strait.

The present marine farm utilises standard mussel farming structures that are under tension and therefore present a low risk of entanglement to marine mammals.

6.4 Biosecurity issues

Most major marine farm contactors, harvesters and major companies are members of the A+ programme (<http://www.aplusaquaculture.nz/farmers-information>). The A+ programme promotes good environmental practices. In particular, the A+ programme has a major objective that “farming activities do not cause an unacceptable biosecurity risk”. All A+ members are also required to recognise the Biosecurity Act 1993, as well as the Hazardous Substances and New Organisms Act 1996.

6.5 Benthic habitats and substratum

Substratum and habitat distribution relative to the proposed extension area was based on drop camera stations and sonar imaging of the benthos. All the seafloor under the consent was characterised by silt and clay. Mud (i.e. silt and clay) is the most common subtidal habitat in sheltered areas of the Marlborough Sounds (McKnight and Grange, 1991) and has been traditionally targeted for marine farming activities. This substratum type is suitable for consideration for marine farming activities in the Marlborough Sounds.

Unlike mud, rocky substratum is not traditionally considered suitable for marine farming activities as it can be smothered by silt and shell debris and therefore may no longer function as hard substratum habitat. Rocky substrata were not present within the extension area.

6.6 Species and communities

Species abundance and diversity from the proposed extension area was lower than high current locations in the Sounds. Soft substratum habitats traditionally have a reduced epibenthic species diversity and abundance compared to hard substrata. The silt seafloor under the extension area supported four common species in very low abundance: solitary ascidian, pink urchin, scallop, ostrich foot whelk and hermit crab. No fish species, macroalgae or horse mussels were observed.

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No species, habitats or communities likely to be regarded as ecologically significant (see Davidson *et al.*, 2011 for criteria) were observed during the present study.

6.7 Mussel farming impacts

6.7.1 Benthic impacts

The entire proposed extension area is located over silt and clay benthos with very low abundance of conspicuous species. Mussel shell debris was not recorded offshore of existing backbone structures, however, Davidson and Richards (2013) recorded mussel shell close to droppers.

Mussel shell debris under backbones at the parent farm ranged from none to high cover on the benthos, with low shell cover being more common in deeper depths towards the existing offshore consent boundary (Davidson and Richards, 2013). If the proposed offshore extension is approved, the impact of shellfish farming at this site will likely result in similar deposition of mussel shell and fine sediment under and near backbone droppers.

Based on the literature and assuming the present level of farming activity remains consistent, it is likely the redox layer will be shallower compared to sites away from the farm (Hartstein and Rowden, 2004; Keeley *et al.*, 2009).

Recovery of the benthos takes approximately 5-7 years on deep soft substratum as shell is often smothered by silt thereby reducing recovery times compared to inshore coarser substratum areas (Davidson and Richards, 2014). This survey identified rocky and coarse natural shell substrata inshore of the consent boundary at the western end, with no impact visible on these habitat types.

6.7.2 Productivity

Mussel farms can influence adjacent farms by slowing water flow to farms located in downstream positions (Ogilvie, 2000). This is particularly pronounced in quiescent areas of the Sounds. However, published work by Zeldis *et al.* (2008, 2013) suggests that the major factors influencing productivity in the Marlborough Sounds relate to cyclical weather patterns in the summer (El Nino and La Nina) and river-derived nutrient inputs in winter. Slow crop cycles in some years are therefore a reflection of a weather cycle and much less about the number of farms.

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No data has been presented to show the ecological carrying capacity of the Sounds has been reached, however, this topic is not well researched. There is considerable evidence showing the major drivers of the Pelorus system, for example, naturally leads to large within and between year variability. Relative to this, the impact of mussel farms appears to be material but relatively small compared to major environmental drivers (Broekhuizen *et al.*, 2015).

Guards Bay

Tidal flows along the shoreline of Guards Bay are light for most tides (Broekhuizen *et al.*, 2015). Wind is likely to be a driver of water movement in this area, especially during northerly and northwesterly weather events. Guards Bay is close to Cook Strait proper and therefore likely to experience quicker water turnover times compared to bays within Pelorus Sound.

Based on these considerations and the existing literature, it is probable the site will likely cause phytoplankton depletion within its consent boundaries; however, these are expected to slowly return to background levels as water leaves the farm backbones. The proposed extension application poses no upstream/downstream influence to other marine farms.

6.8 Proposed Marlborough Environment Plan (pMEP)

Following two years of work between MARWG (included members of the marine farming industry, Marlborough Sounds' community organisations and central government agencies) and MDC, the proposed plan variations for managing marine and finfish farming in the Marlborough Sounds was released for public submission in December 2020. In the variation, the MARWG and the Council produced a spatial allocation for the majority of existing marine farms. It is proposed that existing marine farms will have to be located within the AMA when they re-consent. The MDC website states "it may involve moving lines or, in some cases, farms to relocate into a relevant AMA".

The proposed AMA areas are presently part of a hearing process, and their size, shape and position may change as a result. At present no AMA has been suggested for this site.

6.9 National Environmental Standards – Marine Aquaculture (NES-MA)

According to Fisheries NZ (2021), the NES-MA defines a nationally consistent set of provisions giving a more certain and efficient process for considering applications for replacement

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coastal permits of existing marine farms and for realignment and change of species applications, while ensuring farms meet best environmental practice.

From 1 December 2020, applications for replacement coastal permits that fall under the NES-MA are processed under the NES-MA. The study area or “area of interest” for subtidal marine farms with no feed is defined as the consent and an area of 20 m distance around the consent boundary. Within this area, an assessment of effects on reefs, biogenic habitat, and regionally significant benthic species is required. The assessment of biological effects is based on existing data and/or new site survey data.

In section 18(g) of the Fisheries NZ (2021) paper, a variety of aspects of how the NES deals with impacts are outlined. It includes the effects of the activity on reefs, biogenic habitat, and regionally significant benthic species within the area of interest. Regulation 18(g) provides for the effects to be considered when making decisions on resource consents. It states reefs, biogenic habitats and regionally significant benthic species within the “area of interest” may not be adversely affected by marine farming. It does explain, however, that the NES recognises biogenic habitats or regionally significant benthic species may have established in the area of interest as a result of the presence of a marine farm and consent conditions may not be needed to manage effects. Conversely, the NES records that if adverse effects are considered too significant, conditions can be set to avoid them (for example by requiring the relocation of longlines away from areas of reef habitat) or in extreme situations, consent applications could be declined (Fisheries NZ, 2021).

6.9.1 NES-MA assessment of effects for 8164

“Reef”, “biogenic habitat” and “regionally significant benthic species” are defined in NES-MA regulations 7 – 9, and criteria for applying the “biogenic habitat” and “reef” definitions are contained in NES-MA Schedule 4.

Known reef, biogenic habitats and regionally significant species within the proposed extension at site 8164 and the area of interest are listed below and in Table 4.

No NES-MA criteria were triggered by this present survey.

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6.10 Boundary adjustments, line adjustments and monitoring

No rocky substrata or ecologically important benthic characteristics were identified during the present survey, therefore no monitoring or boundary adjustments are suggested to the proposed extension to farm 8164.

Table 4. Reef, biogenic habitats and regionally significant species summary for the proposed extension at marine farm 8164.

NES	NES biotic and abiotic features	NES criteria or definition	Marine farm	Comments
7	Biogenic habitat	Section 7	None seen or known	
8	Reef	Section 8	None seen	
9 (a, b, c)	Status or significant species	Section 9	None seen or known	
9 (d)	Council significant site	Section 9	None near marine farm	
S4 1	Rhodolith	1 seen	None seen or known	
S4 2	Council recognised important dead shell	Present	Not seen or known	
S4 3 (a, b)	Biogenic prominent or raised (0.5m)	Present	None seen or known	
S4 4 (a) (i)	Biogenic (colony forming)	≥ 10%	None seen or known	
S4 4 (a) (ii)	Biogenic macroalgae or seagrass	≥ 10%	Not seen	
S4 4 (a) (iii)	Biogenic tubeworms, brachiopods, natural shellfish	≥ 10%	None seen or known	
S4 4 (b)	Natural shell	>40% cover	Not seen	
S4 4 (c)	Biogenic large habitat-forming species (e.g. horse mussel, hydroid tree)	Mean = ≥1 per m ²	None seen	

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Appendix 1. Drop camera photographs

Photo 1 silt, clay



Photo 2 silt, clay

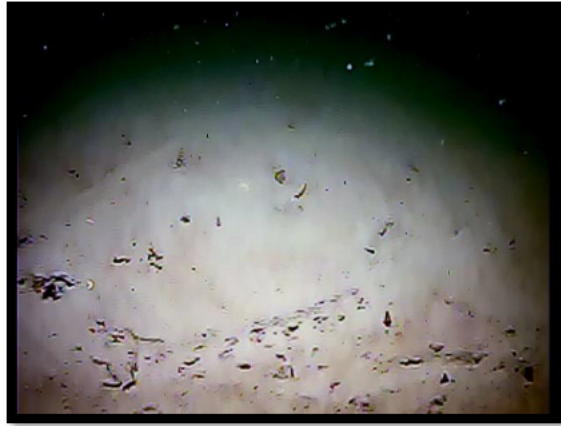


Photo 3 silt, clay



Photo 4 silt, clay

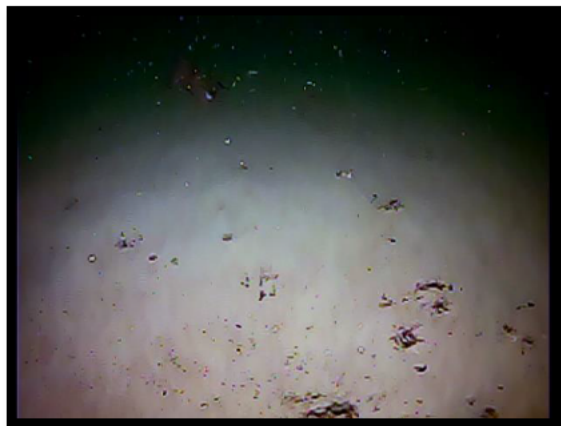


Photo 5 silt, clay

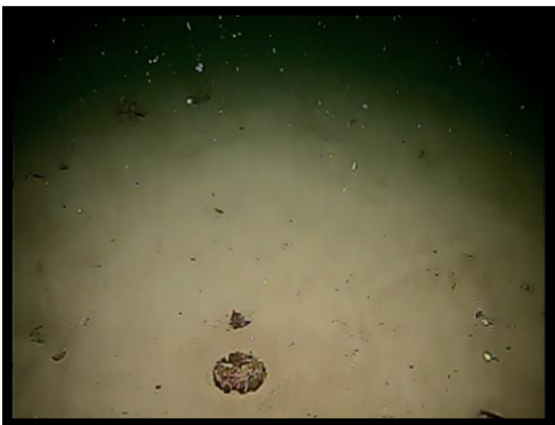


Photo 6 silt, clay



Photo 7 silt, clay



Photo 8 silt, clay



Photo 9 silt, clay

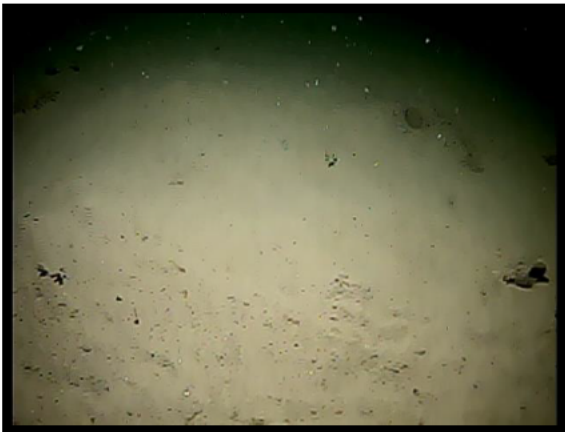


Photo 10 silt, clay



Photo 11 silt, clay



Photo 12 silt, clay

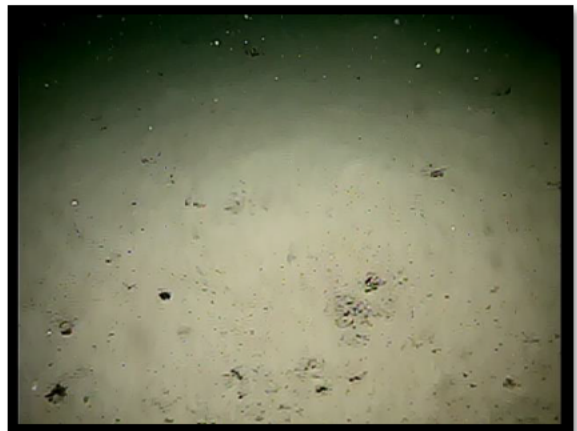


Photo 13 silt, clay



Photo 14 silt, clay



Photo 15 silt, clay



Photo 16 silt, clay



Photo 17 silt, clay



Photo 18 silt, clay



Photo 19 silt, clay



Photo 20 silt, clay

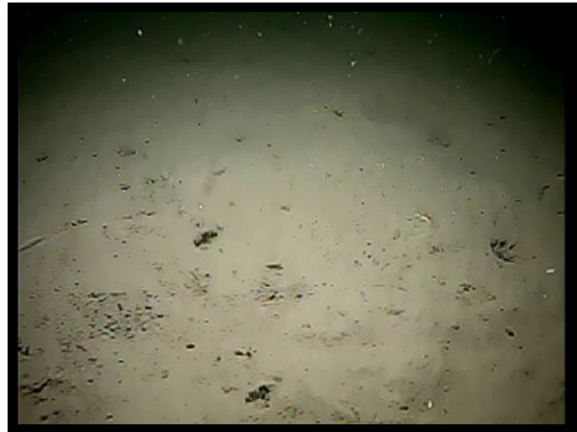


Photo 21 silt, clay

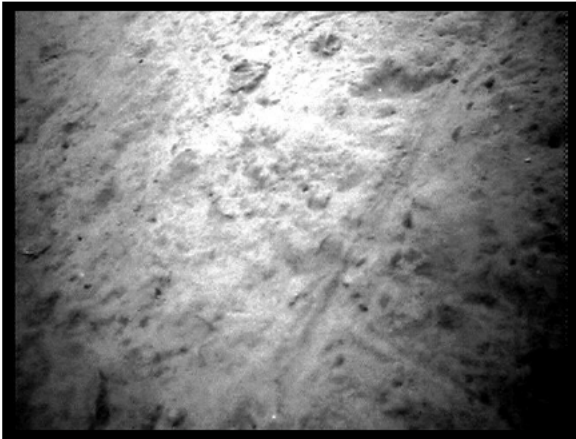


Photo 22 silt, clay

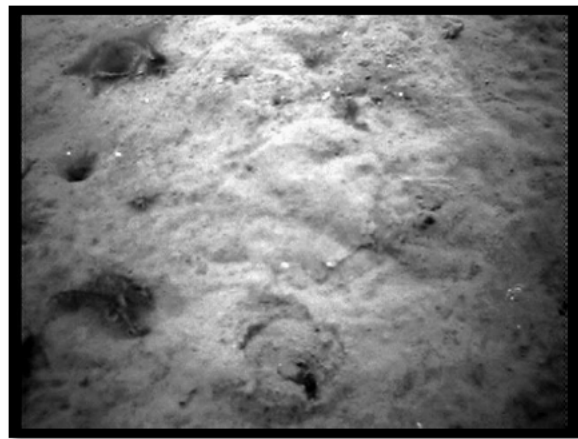


Photo 23 silt, clay

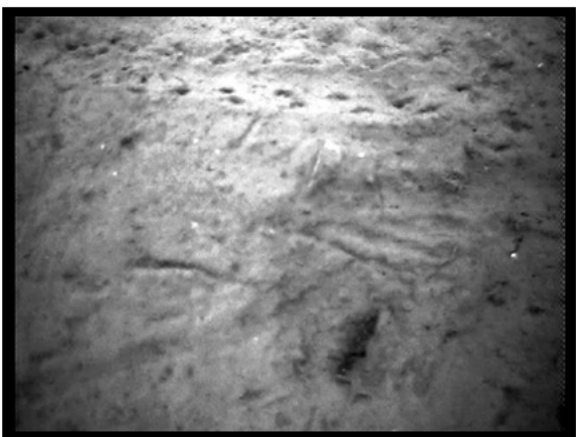


Photo 24 silt, clay

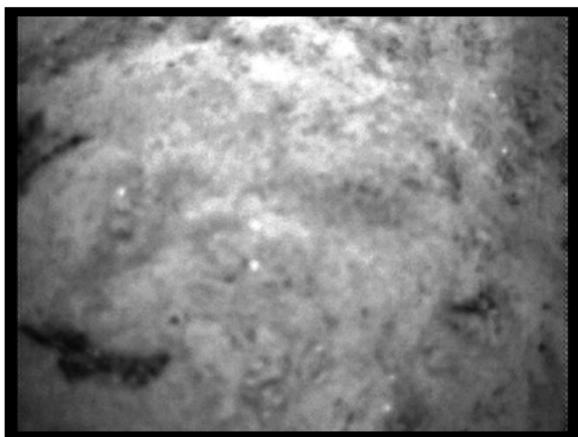


Photo 25 silt, clay

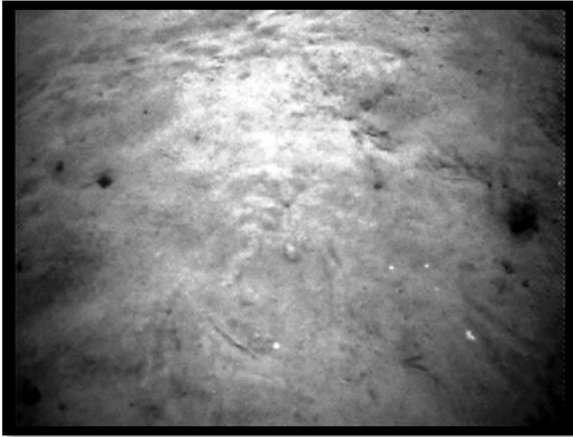


Photo 26 silt, clay

