

**BEFORE THE VARIATIONS 1 AND 1A PROPOSED MARLBOROUGH ENVIRONMENT
PLAN
AT BLENHEIM**

HEARINGS

PANEL

UNDER

the Resource Management Act 1991
(the Act)

IN THE MATTER

of proposed variations to the publicly
notified proposed Marlborough
Environment Plan under the First
Schedule to the Act

**STATEMENT OF EVIDENCE OF ROBERT JAMES DAVIDSON
IN SUPPORT OF THE SUBMISSIONS OF APEX MARINE FARM LTD**

Dated this 29th day of October 2021

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Education

1. My full name is Robert James Davidson. I am a marine biologist and hold the qualification of Master of Science in Zoology (First Class Honours) obtained from Canterbury University (1986). I have worked for the Ministry of Fisheries (1986-87), and the Department of Conservation (1987-95) (DOC). During my time at DOC, I was based at Nelson and employed as the coordinator of marine biological surveys throughout the Nelson Marlborough Conservancy. I was the principal author of several large-scale ecological reports and biological resource documents for marine areas in the DOC Nelson-Marlborough Conservancy. While at DOC I also coordinated resource inventory reports used by the Marlborough District Council, Nelson City Council, Tasman District Council and Canterbury Regional Council outlining ecologically important marine areas for inclusion in their respective coastal plans (Davidson *et al.* 1993; 1995).

Private consultancy and experience

2. In 1995, I left DOC and established my own practice, “Davidson Environmental Limited”, which specializes in ecological research, survey and monitoring. To date, I have produced 950 reports most of which have been associated with Resource Consent applications. Most of these RMA related reports have been for marine farm applications, farm impact assessments, farm revalidations and renewals and marine farm monitoring.
3. I have also coordinated up to 29 consecutive years of monitoring for each of three Marine Reserves located at the top of the South Island. Another long-term monitoring programme was the impact monitoring of ferries travelling through the Marlborough Sounds including Tory Channel (1995-2015). Recently I have coordinated a three-year programme updating and reassessing the biological value of sites in the Marlborough Sounds (Davidson *et al.* 2011). This programme was extended from 2015 onwards with sites being revisited and new data collected to confirm their location and biological values (e.g. Davidson and Richards, 2015).
4. I have also been involved in several reviews and advisory roles including the Ecological Advisory Group for reviewing monitoring of the Tasman Bay Marine Farm Ring Road development, as a member of the MDC marine focus group, Top of the South Biosecurity Partnership, MAF *Undaria* Expert Advisory Group, Tasman and Golden Bay marine farm EAG group, and Mapua FCC contaminant clean-up programme.
5. I am the author or co-author of 19 conference papers in New Zealand and overseas. I have published 12 papers in international peer-reviewed scientific journals including papers on marine reserves, subtidal soft bottom and reef communities. Based on a wide range of long-term studies combined with over 4000 working dives in the Marlborough Sounds, I have a very good understanding of the subtidal environment of the Marlborough Sounds.

Summary of experience

- **Working in Marlborough Sounds: 1988-2021 (31 years)**
- **Working dives: >4000**
- **Long term monitoring programmes: 29 years**
- **Resource Consent reports: 950**
- **Published papers: 12**
- **Conference presentations: 18**
- **Boating: SRL skippers ticket, 29 years navigating in the Marlborough Sounds**
- **Conflict of interest declarations**

6. I am part owner of several marine farm consent areas in the Marlborough Sounds. Water space is leased out or is managed by a variety of marine farming companies on contract. I have no shareholding or other beneficial interest in the present marine farm application.
7. I conduct contract work for a variety of organisations some of whom regularly submit or are involved with the process of marine farm applications (e.g. Department of Conservation (DOC), Marlborough District Council (MDC), Ministry for the Environment (MFE), Ministry of Primary Industries (MPI), Marine Farming Association (MFA)). I contract to the MDC and have or presently coordinate science-based studies (i.e. marine farm recovery study in East Bay, ferry impact study in Queen Charlotte Sound and Tory Channel, significant site survey and monitoring).
8. I take care to ensure that my investment in marine farms and my role as a consultant for a variety of clients does not influence my role as an independent consultant. My relationship with clients and standing as an expert witness has been based on my responsibilities as a scientist, my expertise and my experience. My evidence today is therefore consistent with the best principles of scientific inquiry and any opinions and conclusions are based on my experience and understanding of biological theory, integrated with data collected during fieldwork throughout the Sounds and New Zealand.

Code of practice

9. I have read and agree to be bound by the Environment Court Code of Conduct for Expert Witnesses and confirm that I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express in the following evidence. The evidence I give is within my expertise, save where the context indicates otherwise.
10. I confirm that to the best of my ability I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express, and that this evidence is within my area of expertise, except where I state that I am relying on the evidence of another person.

1.0 Summary

11. My evidence summarises biological data collected for a proposed new marine farm (3 blocks) located in Onapua Bay, Tory Channel (Figure 1). Data was collected during two surveys for a Private Plan Change and resource consent application by Apex Marine Farm Limited (Apex). Apex now seeks that three AMAs be created in the proposed Marlborough Environment Plan (pMEP) for the proposed farm in Onapua Bay. A third survey was undertaken on behalf of Apex in response to a series of information gaps identified by Dr Hilke Giles, who prepared a series of ecological reports on behalf of Council.
12. Having undertaken these surveys and reviewed the relevant evidence, my conclusions remain unchanged regarding the position of the proposed marine farm, and the recommended exclusion zone for the reef in the middle block. This conclusion is based on previous and recently collected sonar, low and high definition imagery and diver sample transects.
13. References to “farm blocks” or the “AMAs” are used interchangeably in this evidence.
14. Apart from the tip of a reef that penetrates the middle AMA, all proposed farm blocks are located over a low gradient, mud dominated benthos.
15. The reef located adjacent to and partly within the middle block has been surveyed three times. Its location and biotic and abiotic attributes have been well described. A farm structure exclusion area aimed to ensure the reef is not adversely impacted has been carefully placed over and around the reef and adjacent coarse sediments as part of the Private Plan Change and resource consent application.
16. The reef is of note for *Galeolaria* mounds found in moderate abundance. Some mounds along the reef are relatively large.
17. The bay edges (i.e. shore slope) support a range of rocky and coarse substrata habitats and associated communities.
18. Dense beds of *Chaetopterus* tubeworms have colonised the mid and lower slopes of the bay edges. They were present inshore of all blocks but were most abundant near the middle and northern blocks. It remains unknown if this is a native species exhibiting a population boom or an introduced species.
19. *Chaetopterus* are present in sufficient numbers to form beds that act as a biogenic habitat. These beds support other species such as branching red algae.
20. Several species were recorded growing on offshore mud bottoms under the application blocks. None were common or abundant with most being patchy and or sparse. Species included scallop, horse mussel, hermit crabs, whelks, and non-calcareous tubeworm patches.

21. Notable changes between surveys conducted between 2016 and 2021 include (1) the appearance of scallops and (2) the formation of dense beds of *Chaetopterus* and the establishment of a biogenic community on the shore slope. It is unlikely these beds will be considered ecologically significant until the species status of *Chaetopterus* is confirmed (i.e. native or invasive).
22. No habitats, species or communities observed inside the application blocks are likely to be considered of particular ecological importance.



Figure 1. Location three application blocks in Onapua Bay, Tory Channel. The red hatching is the suggested exclusion zone aimed to avoid a reef.

2.0 Scope of Evidence

23. My evidence:
 - a. Lists the data available for the proposed AMA, and provides a very high level overview of the findings in the ecological reports prepared on behalf of Apex;
 - b. Responds to the information gaps identified in the s 42A materials prepared by Dr Hilke Giles; and
 - c. Confirms whether they additional evidence and recent field work have altered any of the conclusions reached in my earlier reports.
24. In preparing this evidence and the accompanying report, I have reviewed the following reports:

- a. Dr Giles, Potential effects of longline oyster, mussel, and macroalgae farming in Onapua Bay, Tory Channel, Marlborough Sounds (25 August 2021, prepared for Marlborough District Council) (Giles 2021a);
- b. Dr Giles, Technical review of previous assessments of a proposed AMA in Onapua Bay, Tory Channel, Marlborough Sounds (25 August 2021, prepared for Marlborough District Council) (Giles 2021b);
- c. Dr Giles, Assessment of ecological effects of a proposed AMA in Onapua Bay, Tory Channel, Marlborough Sounds (25 August 2021, prepared for Marlborough District Council) (Giles 2021c);
- d. Mead S, Davies-Campbell J, 2021. Marine Ecological Investigations of Onupua Bay, Tory Channel. Prepared by eCoast for Friends of Onapua Bay Inc;
- e. The assessment of Dr Ulrich included in the Technical Advisory Group (TAG) Report (August 2019, prepared for Marlborough District Council); and
- f. Section 42A Report Technical Evidence: Coastal Ecological, prepared by Dr Hilke Giles (4 October 2021).

3.0 Data

25. Three surveys have been commissioned by the applicant. In addition, NIWA collected multibeam data from the area and a survey was undertaken by Mead and Davies-Campbell (2021).
26. A detailed description of these surveys can be obtained from the original reports, however, a summary of the findings of the applicant's reports are outlined below.

3.1 Davidson et al. (2016)

27. A variety of data were collected including 48 drop camera stations, sonar, 13 infauna grabs, organic content, sulphides, epibenthic dredge tows, and current speeds and current directions at 4 stations.
28. Davidson et al. (2016) concluded “The application investigated during the present study was dominated by silt and clay substratum with a very small component of natural shell (broken and dead whole). It is probable that most of Onapua Bay, away from its shallow edges, is comparable, however, no widespread survey of the bay has been conducted to confirm this likelihood. Rocky shores were recorded from sonar imagery and photos collected from inshore of the application. Rocky substrata formed a relatively narrow fringe above and below the low tide mark. At a number

of locations rocks were observed extending offshore, but the offshore extent of these structures always remained well inshore of the application.”

29. Based on the volume and abundance of epibenthic material recorded from dredge tows collected inside the applications, it was concluded that the surface flora and fauna was characterised by a low biomass and diversity of species. No iconic or edible species such as horse mussels, red algae or scallops were recorded from the dredge tows collected in 2016.
30. The authors concluded the infaunal community in the application blocks was typical of sheltered muddy areas in the Sounds. No species indicative of enrichment or contamination were recorded.
31. The authors stated Onapua Bay has relatively low flows compared to the main reaches of the Sounds (e.g. Tory Channel) where moderate to strong tidal flows occur (i.e. > 0.1 m/sec (Hadfield et al. 2014; Broekhuizen 2015)).
32. The authors reported enrichment as indicated by sulphide levels were low and in the Oxidic range.
33. The authors found that lower intensity shellfish farming at Ngaruru Bay has little impact on sediment enrichment and infauna. This site was used for the purposes of supplying relevant and comparable data because oyster farming involves a lower biomass of shellfish than traditional mussel farming (i.e. the impact of mussel farms are well known, however, the impact of non-rack oyster farming is poorly known).
34. No boundary adjustments were recommended to the proposed blocks based on information available at that time. No biological reasons for a site-specific monitoring programme or staged development were identified.
35. A copy of this report is attached to this evidence as **Appendix RJD1**.

3.2 Davidson (2019)

36. Multibeam data from NIWA indicated the presence of a reef was extending towards the middle block of the proposed farm. The applicant commissioned Davidson (2019) to sample the area using a drop camera and sonar. A copy of the resulting report is attached to this evidence as **Appendix RJD2**.
37. Davidson (2019) stated drop camera images and sonar confirmed the presence of rock substrata extending inside the proposed farm. Rock outcrops were most common along and near the spine of the submerged ridge and extended to close to the foot of the ridge (approximately 10 m distance inside the application). No rock was observed in areas north and south of the ridge. Some areas identified by NIWA as rocky outcrops adjacent to the reef were instead confirmed as silt and whole and broken shell.

38. The author also stated “rock substrate is traditionally avoided for marine farming activities. It is therefore recommended that the applicant modify the application to avoid rocky habitats. It is also suggested that a sufficient buffer zone between production structures and rocky areas is achieved. In this area, it is recommended that a 20 m buffer be applied to the offshore separation. For areas north and south of the rocky substrata, a smaller buffer zone is acceptable as the adjacent farm would be occupied by anchors and warps thereby providing additional buffer space between rock and growing structures.”
39. A backbone exclusion zone was suggested in the survey report. The suggested exclusion aimed to avoid rocky and coarse soft-sediment areas (see the red hatched area in Figure 3).

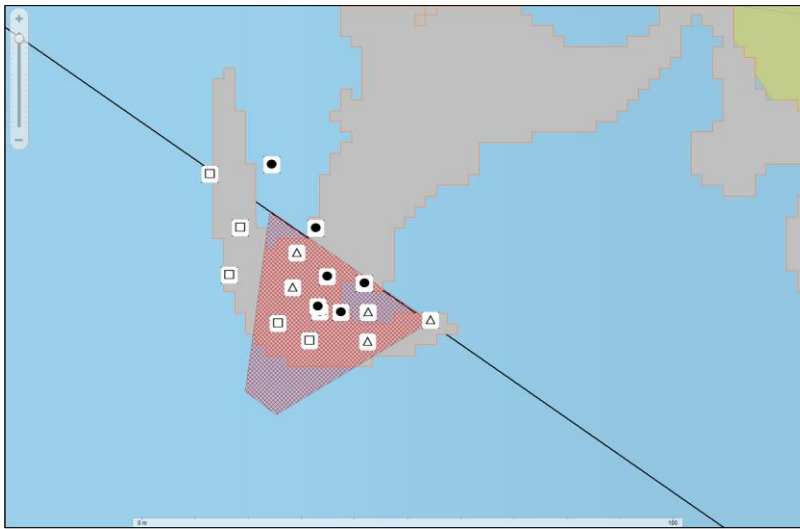


Figure 2. Suggested 0.068 ha area to be removed from the application (red hatched). The grey area was identified as a reef from the NIWA multibeam.

3.3 Davidson et al. (2021) and response to s 42A Report

40. In response to reports filed by landowners in Onapua Bay, the MDC commissioned a review that identified some information gaps and raised some areas of uncertainty concerning biological information provided by the applicant and submitters (Giles, 2021a, b, c).¹ In response, the applicant commissioned a third report (Davidson et al. (2021)). A copy is attached to this evidence as **Appendix RJD3**. The most recent study aimed to fill gaps and assist with addressing

¹ Dr Giles' three reports are appended to the s 42A report "Variation 1 Apex Marine Farm Submission and Further Submission – Appendix B". These are also summarised in "Section 42A Technical Evidence: Coastal Ecology", Dr Hilke Giles (4 October).

uncertainties between the Davidson et al (2016, 2019) and Mead & Davies-Campbell (2021) reports.

41. Davidson et al. (2021) collected new data to respond to the following points raised by Dr Giles:²
- a. Further characterises the area of reef within the inshore boundary of block B (the middle AMA), to better inform an assessment of potential effects on that reef, to determine whether that area should be removed from the proposed AMA and/or determine what is an appropriate buffer.
 - b. Describes the habitats and communities within and inshore of the proposed farm blocks/AMAs and comments on their sensitivity.
 - c. Summarises existing literature outlining the historic degradation in Onapua Bay.³
 - d. Comments on biosecurity issues, particularly for macroalgae farming.
 - e. Discusses the potential nutrient uptake from macroalgae farming.
 - f. Summaries the potential effects of shading on the benthos or water column.
42. I briefly summarise the findings of Davidson et al. (2021) below. Refer **Appendix RJD3** for full details.
43. Davidson et al. (2021) collected diver sampled transects, hand-held and remote high-definition video and sonar sample shore profiles. From these data, a comprehensive description of habitats and communities present at the reef, along the shoreline and within the application blocks were generated. All footage was compiled into videos and is available from the MDC database.
44. Excluding the reef, two major habitats from this area of Onapua Bay were recognised: (1) the shore slope, and (2) low gradient offshore soft bottoms. The application blocks were located over the offshore low gradient benthos. This habitat was surveyed in 2016 and 2021 using drop camera, dredge tows (Plate 1), cores (Appendix 1) and high definition video (Plate 2 & 3). The benthos under the applications supported a range of species typical of mud bottoms in Marlborough. All species were in low abundance or were sparse or rare or in patches (e.g. non-calcareous tubeworms). Species included horse mussels, scallops, hermit crabs, cushions seastars, heart urchin, solitary ascidian, camouflage crab, colonial ascidian, whelks branching red algae and occasional clumps of non-calcareous worms likely to be *Spiochaetopterus* spp. and *Acromegalomma suspiciens*. At this site, clumps of these worms are sparse and patchy and not at an abundance level that could be considered a bed. Both *Spiochaetopterus* spp. and *Acromegalomma suspiciens* (Plate 2) are found on mud bottoms in the Marlborough Sounds

² Giles 2021c at p 43.

³ Giles 2021b at p

(Anderson et al., 2020). In Port Underwood, they have formed dense beds and have themselves been colonised by a variety of species, particularly sponges and colonial ascidians (Davidson et al. in prep.). They appear to be tolerant of high turbidity environments.



Plate 1. Contents of 285m and 385 m long dredge tows from Davidson et al (2016).

Plate 2. *Acromegalomma suspiciens* and encrusting colonial ascidian from dredge tows in Davidson et al. (2016).



45. The shore slope habitat was located inshore of the applications and supported a more diverse range of habitats and associated communities

compared to offshore areas. *Chaetopterus* was sufficiently abundant in places on the mid to lower shore slope to constitute a bed and thereby acted as a biogenic habitat (Plate 4). *Chaetopterus* formed beds on the shore slope and were inshore of the application and outside the zone of farm impact. These beds are now widespread in the Sounds, however, it is not known if they are native or introduced (Geoff Read, pers. comm.).



Plate 4. *Chaetopterus* bed and associated branching red algae located on the shore slope inshore of the application blocks (Video transect 5 (northern block) 7.4 m adjusted depth).

46. The authors confirmed the presence, location, extent and biotic attributes of a reef located adjacent to the middle application block. Davidson et al. (2021) stated the exclusion area encompassed the narrow terminal foot of the reef and also provided a buffer area around the rock substrata. The authors suggested an additional buffer zone was also established by the warp and anchor zone. In the alongshore direction, warps provided 25m distance separation in each direction between droppers and the edge of the exclusion. The impact under warps was documented in an 11-year study looking at the recovery of a mussel farm in East Bay (Davidson and Richards, 2014). The authors reported at the start of the study, impacts under warps were very low compared to production areas and the epifauna and substrata under warps were little-different to control sites. Based on the existing knowledge around the detectable impact of marine farming (see Keeley et al 2009 for review), the authors argued impacts on the reef from Apex's

proposal would be unlikely due to the physical separation between production droppers and the reef. Davidson et al. (2021) confirmed the original calculations made by Davidson (2019) for the location and extent of the reef. The 2021 study confirmed no further change to the exclusion area were required to ensure the reef would remain free of farm related impacts.

47. The Davidson et al. (2021) report also discussed the wider subtidal environment of Onapua Bay and suggested that the subtidal environment would likely be affected by periodic forestry harvest events in the adjacent catchments. After harvests, large sediment pulses were predicted if they coincided with heavy rain events. During periods with no harvesting, some recovery was expected.
48. Biosecurity threats were considered and assessed as low by Davidson et al. (2021), however one genus on the list of species was recognised as having an exotic representative and the authors recommended that it be excluded from farming (i.e. *Grateloupia turuturu*).
49. Nutrient depletion by macroalgae was discussed and the authors concluded the effects would likely be minor in a wider environment subjected to significant nutrient enrichment from catchments and nearby salmon farms.
50. Shading was also discussed by Davidson et al. (2021). Based on a Cawthron study by Newcombe et al. (2015) the effect of shading by a farm was reported to be detectable but at a minor level and therefore unlikely to result in adverse impacts on the benthos or water column.

4.0 Conclusions

51. The proposed marine farm blocks/AMAs are located over habitats and communities that are traditionally considered suitable for consideration for marine farming activities (i.e. silt and clay). Mud is traditionally targeted for marine farming activities because it is a widespread and a common habitat in the Marlborough Sounds and is subject to a lower level of change if farmed compared to inshore rocky and coarse substrata habitats and communities.
52. The applicant has proposed an exclusion zone around the reef that will ensure the associated habitats and communities are not adversely impacted by farming.
53. The site is shallow and sheltered and based on many marine farm impact assessments it is likely to have impacts at the low end of the spectrum. Farming of seaweed and oysters are also recognised as having low environmental impacts.
54. No further changes to the proposed farm boundaries are suggested on biological grounds.

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Appendix 1 Core samples from farm areas in Davidson et al. (2016).



G1.JPG



G2.JPG



G3.JPG



G4.JPG



G5.JPG



G6.JPG



G7.JPG



G8.JPG



G9.JPG



G10.JPG



G11.JPG



G12.JPG



G13.JPG



G14.JPG



G15.JPG



G16.JPG



Davidson Environmental Limited

Biological report for a marine farm application located in Onapua Bay, Tory Channel

Research, survey and monitoring report number 827

*A report prepared for:
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January 2016

Bibliographic reference:

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1.0 Introduction

The present study provides biological information for an application to establish a new marine farm along the north-eastern shoreline of Onapua Bay (Figure 1). The marine farm application comprises three adjacent, but separate marine farm sites of varying sizes (7.5 ha (north), 5.43 ha (middle) and 2.8 ha (south)) (Figure 2, Plates 1, 2 and 3). The total area of the marine farm application is 15.73 ha and extends along approximately 1.7 km of mildly indented coastline.

Biological information is provided on the benthos (infauna and epibiota), habitats, as well as organic matter, redox (ORP), and total free sulphide levels in sediments. As a comparison, the present report also provides biological information on the impact of an existing marine farm owned by the applicant (Apex Marine Farm Limited) and located in a bay adjacent to Tory Channel (Ngaruru Bay).

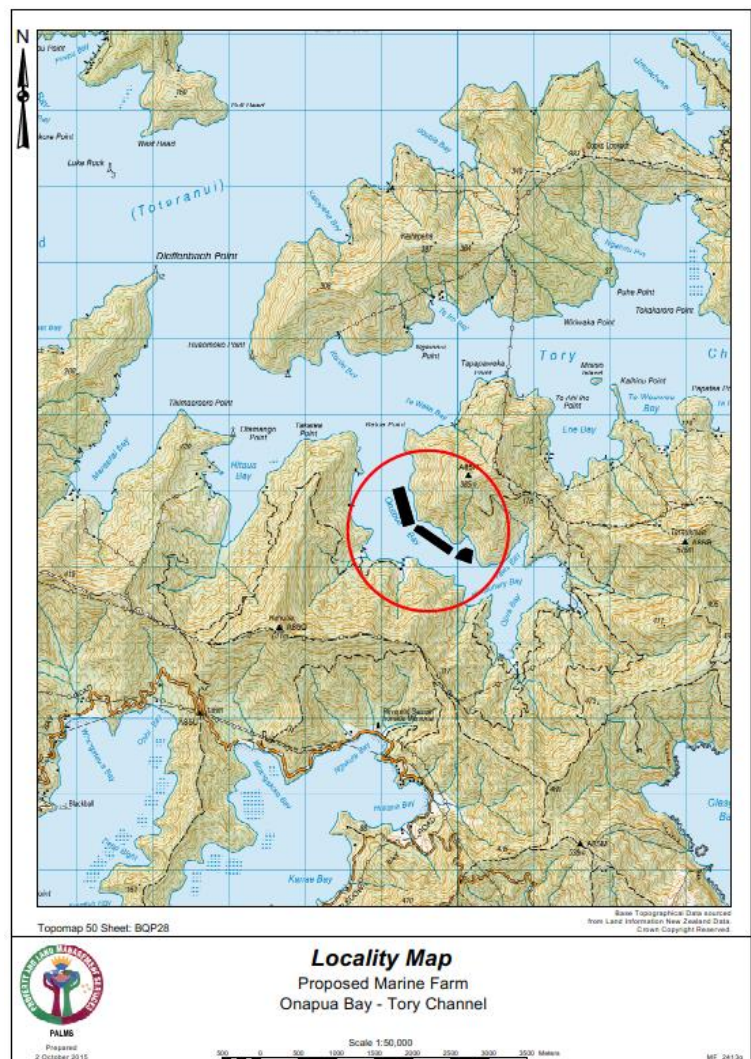


Figure 1. Proposed marine farm (3 parts) located in Onapua Bay, Tory Channel.

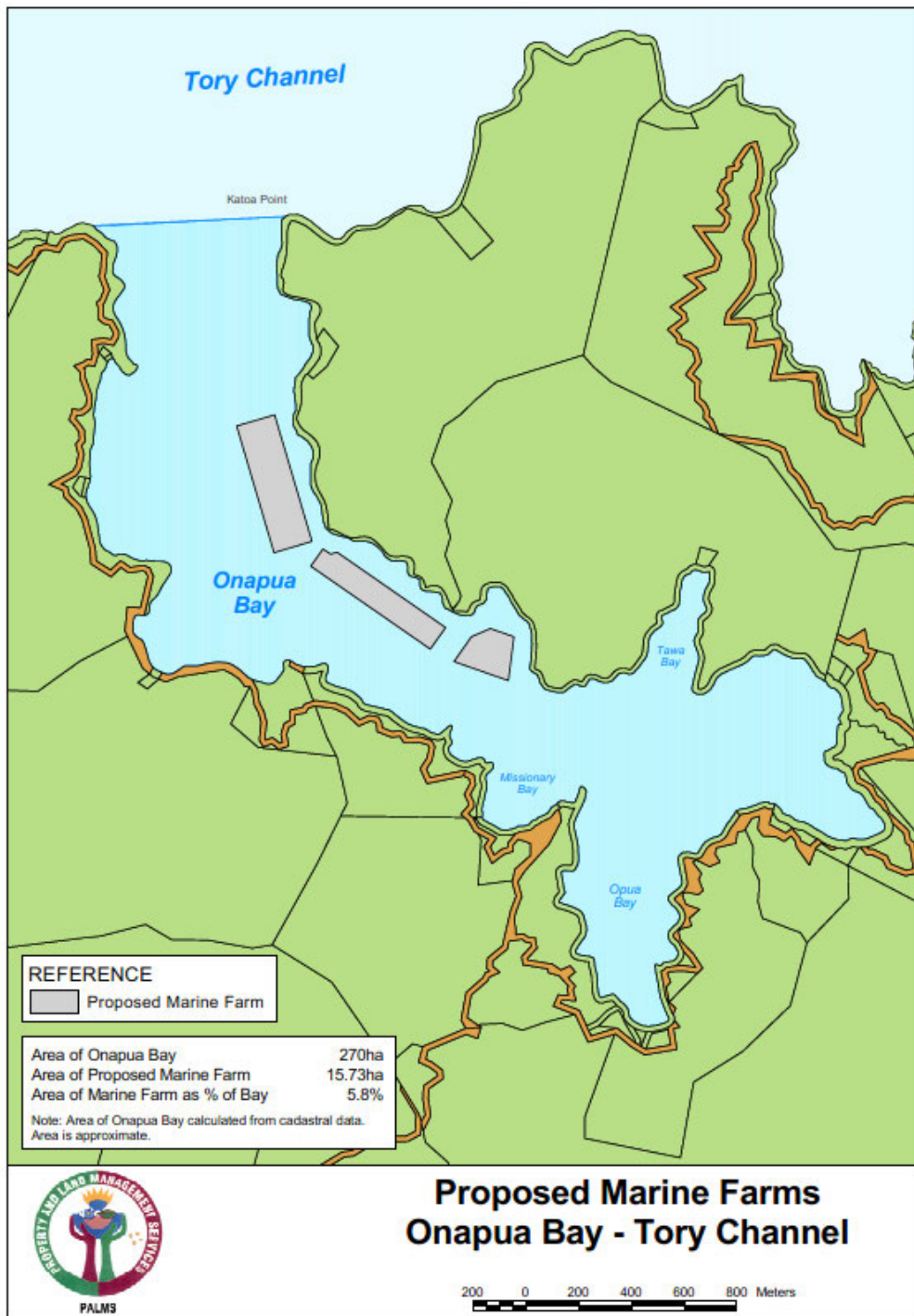


Figure 2. Proposed new marine farm (3 parts) located in Onapua Bay.

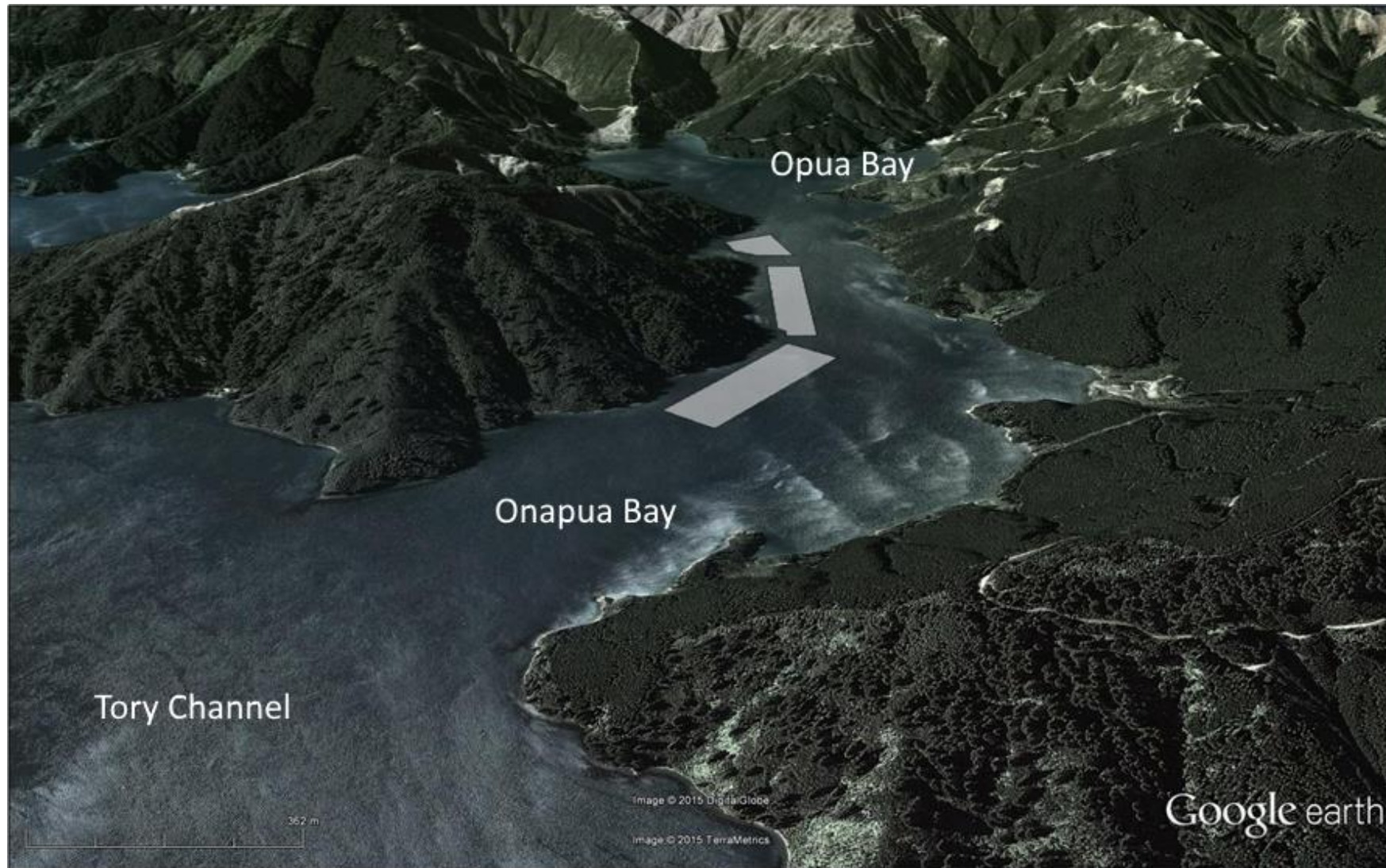


Plate 1. Proposed marine farm sites (grey) in Onapua Bay.

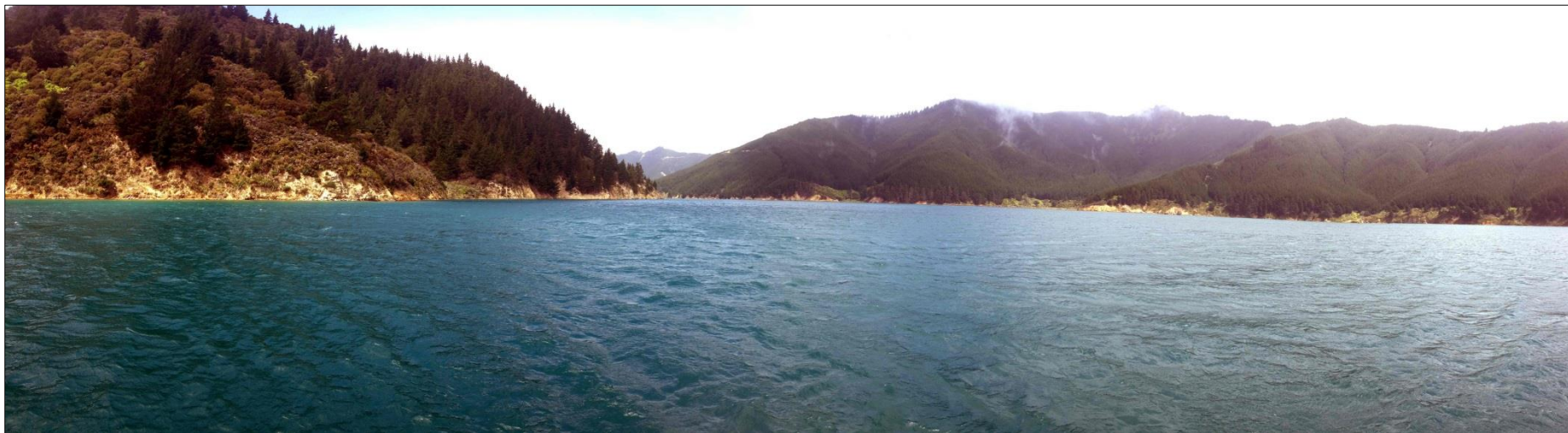


Plate 2. Looking southward from a position north of the northern most site.



Plate 3. Looking south-eastward from a position north of the middle site.

2.0 Background information

2.1 Study area

Onapua Bay is a large bay complex along the southern coastline of Tory Channel. Onapua Bay has a coastline length of approximately 12.2 km and encompasses an area of sea of approximately 270 ha, and is approximately 710 m across at the bay mouth. The bay is approximately 19.5 km by water from Picton, and 14.5 km from Cook Strait.

There are no marine farm consents in Onapua Bay, however, mussel farms are located in Hitaua Bay (n=1), Ngaruru Bay (n=1) and Oyster Bay (n=6) (Figure 3). Two existing salmon farms are located in the main reach of Tory Channel and another new salmon farm has been consented and recently installed near Deep Bay (light grey polygon in Figure 3).



Figure 3. Location of the proposed application in Onapua Bay (red circle) and other consented marine farms in the vicinity. White = existing salmon and mussel farms, grey = new salmon farm.

2.2 Historical reports and existing information

Relatively little biological information is known from Onapua Bay. A shallow site near the western entrance to the Bay has been repeat monitored as part of ferry impact monitoring since 1995 (Davidson *et al.* 2010). At this site, data for the density of kina, paua and cats-eye snail have been collected annually from the shallow subtidal. Intertidal counts of invertebrates living under and on cobbles have also been collected as part of that study.

Monitoring work in relation to the toxic dinoflagellate *Alexandrium catenella* has been conducted in Onapua and Opua Bays (MacKenzie *et al.* 2012, 2013).

2.3 Ngaruru farm history

In order to investigate the impact of marine farming activities in the bays located along Tory Channel, a marine farm site in Ngaruru Bay was sampled. The area sampled was used as a mussel spat holding site for a period of approximately 3-4 years by Sealord followed by 4-5 years by Apex Marine Farm Limited. Although the marine farm site in Ngaruru Bay has not been used for oyster farming, it is likely that spat holding, like oyster farming, has a lower level of impact compared to traditional production mussel farming. As such, the site in Ngaruru Bay provides an indication of impact levels for low intensity aquaculture in a shallow bay located adjacent to Tory Channel.

3.0 Methods

A biological survey for the application in Onapua Bay was conducted on 18th November 2015. Prior to 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 proposed marine farm and to pinpoint drop camera stations in the field. This GPS system has a maximum error of +/- 5 m.

3.1 Sonar imaging

Sonar investigations of the area 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™. These units also provide real time plotting of StructureMap™ overlays onto the installed Platinum underwater chart. A Lowrance HDS 10 Gen1 unit fitted with a high definition Airmar transducer was also used to collect traditional sonar data from the site.

Prior to the collection of underwater photographs, the boundaries of both the consent area and the marine farm surface structure area were 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 3.2).

3.2 Drop camera stations and depths

Drop camera photographs were collected from the proposed marine farm site during the present study. A total of 44 photographs were collected from the application and adjacent areas. 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 benthic mussel shell, Low = 1-30%, Moderate = 31-50%, Moderate to High = 51-75%, and High = 76-100% cover.

The location of each photograph station was selected in an effort to obtain a representative range of habitats within the application. Additional photographs were collected when any features of particular 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.

Four GPS positions were collected from the low tide mark inshore of the proposed application. Low tide was determined by positioning the GPS receiver over the low tide

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mark. The position of the low tide mark was determined using the transition zone between intertidal and subtidal biological communities.

3.3 Surface photographs

Two surface photographs were collected looking along the coast from two positions. Photos were collected using an iPhone 4s in panoramic function to minimize any distortion usually associated with “stitching” separate photos together. Some distortion, however, does occur using this technology.

3.4 Core sampling

Seabed sediment samples were collected from 13 stations in Onapua Bay and three stations located within an existing marine farm located in Ngaruru Bay. Samples were collected using a 0.1 m² Van Veen grab sampler deployed from the survey vessel.

3.4.1 Infauna

A 130mm internal diameter core was collected from each grab sample to investigate macrofauna living on and within the seabed sediments. The core was pushed into the sediment sample to approximately 100mm depth and the captured material gently washed through 0.5mm mesh material. The organisms retained were preserved with an ethanol based preservative and transported back to the laboratory for sorting. All organisms within the sample were identified and enumerated by Biolive laboratories to ascertain the number of taxa (diversity) and their abundance.

3.4.2 Total organic material and sulphides

Total organic matter (TOM %) was analyzed from two 64mm internal diameter sediment sampling cores both inserted into the grab sample to approximately 150mm depth. The upper 50mm of the cores were then collected and combined. Samples were analyzed at Hills laboratories for organic matter content. Organic content was measured by drying the sample at 105° C followed by ashing / ignition at 550° C for 6 hours.

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Total free sulphides (TFS - μM) levels were measured using a 5ml syringe driven into the upper layers of the undisturbed sediments in the grab-sample. The sample contents were extracted and quantified by the Cawthron Institute laboratory within 24 hours of collection following the methods of Wildish *et al.*, 1999.

3.4.3 Redox and core photos

A redox value (ORP - EhNEH, mV) was collected using an ExTech ExStik-RE300 ORP probe that was placed gently into the upper surface layer of the sediment sample (1 cm deep). The probe measured the oxidative/reductive potential (redox potential).

The two subsample cores collected for total organic matter analysis were also photographed to look for any layering in sediments (including possible aRPD layers). The presence of any sulphide smells was also noted.

3.5 Dredge tows

A modified recreational scallop dredge, fitted with a 10 mm interior capture bag was used to sample the epibiota. One tow was conducted through the northern-most proposed application site and a small part of the middle application site. The second tow went through part of the middle application site.

All living epibiota within the dredge tows contents were identified, enumerated and recorded. Information about other non-living material (such as shell) was also noted and a photograph of the sorted contents collected.

3.6 Drogue tracking

A water current drogue fitted with a GPS was deployed at two locations on the incoming tide and two locations (northern and southern) on the outgoing tide. On each occasion the drogue was left for between 104 and 148 minutes.

4.0 Results

4.1 Application corner depths

Inshore corner depths of the proposed marine farm ranged from 12.6 m to 14.7 m, while the offshore corner depths ranged from 12.1 m to 16.2 m (Table 1, Figure 4a and 4b). In general depths gradually increased from inshore to offshore and from north to south. Greatest depths were recorded from the southern offshore corner of the application.

The distance between low water and the inshore boundary of the application varied. Distances were: south = 61.4 m; middle (south) = 54.4 m; middle (north) = 61 m; and north = 48 m (Figures 4a and 4b).

Table 1. Depths recorded from the corners of proposed consent corners. Depths adjusted to datum. Coordinates = NZTM (Northing/Easting). Low tide coordinates and the distance to the application inshore boundary are listed in order from east to west.

Type	No. & Depth (m)	Coordinates
Consent corner	1, 12.1m	1699146.4,5432015.2
Consent corner	2, 12.6m	1699290.3,5432057.7
Consent corner	3, 14m	1699431.9,5431578.1
Consent corner	4, 13.8m	1699288.0,5431535.7
Consent corner	5, 14m	1699427.4,5431484.1
Consent corner	6, 14.7m	1699473.1,5431549.8
Consent corner	7, 13.8m	1699501.8,5431529.8
Consent corner	8, 13.4m	1699527.1,5431536.7
Consent corner	9, 14.3m	1699937.7,5431251.4
Consent corner	10, 15.9m	1699880.0,5431169.8
Consent corner	11, 16.1m	1699969.4,5431123.0
Consent corner	12, 14.7m	1700035.8,5431216.9
Consent corner	13, 13.6m	1700107.4,5431248.0
Consent corner	14, 13.6m	1700197.1,5431216.6
Consent corner	15, 16.2m	1700175.7,5431050.8
Low tide	South	1700250.5,5431148.1
Low tide	Middle (southern)	1699965.7,5431298.2
Low tide	Middle (northern)	1699551.1,5431592.7
Low tide	North	1699343.1,5432049.7

4.2 Substratum and habitats

Substratum and habitat distribution relative to the application were based on 44 drop camera images combined with sonar runs, grab samples, dredge tows and depth soundings conducted throughout the site (Figures 5a, 5b, Table 2, Appendix 1). Four drop camera images were also collected from an existing marine farm located in Ngaruru Bay (Figure 6).

Substratum in Onapua Bay

All drop camera and grab sample stations located within the application were dominated by silt and clay (mud) substratum (Table 2) (e.g. Plates 4 and 5). A component of natural shell was recorded from one area located at the inshore edge of the application where depths decreased (Plate 6). Inshore of the application where depths began to shallow, silt and shell substratum was widespread (Plate 7). Closer to shore a strip of cobble, small boulder and shell substratum was observed (Plate 8). Isolated clumps of the brown macroalgae (*C. maschalocarpum*) were observed in the shallows.

Substratum in Ngaruru Bay

Four drop camera images and three grab samples were collected from under mussel backbones at marine farm site 8406 located in Ngaruru Bay (Figure 6). The substratum was dominated by silt and clay (Plate 9). Based on the texture of sediment, Ngaruru Bay samples had a small component of sand that was absent from Onapua samples. No mussel shell debris was observed on the surface, however, a small component of mussel shell was observed in the three grab samples (e.g. Plate 10). In comparison, almost no shell material was observed in grab samples collected in Onapua Bay (Plate 10).



Figure 4a. Depths of the northern and middle applications (teal). The position of low tide is also indicated (see Table 1).

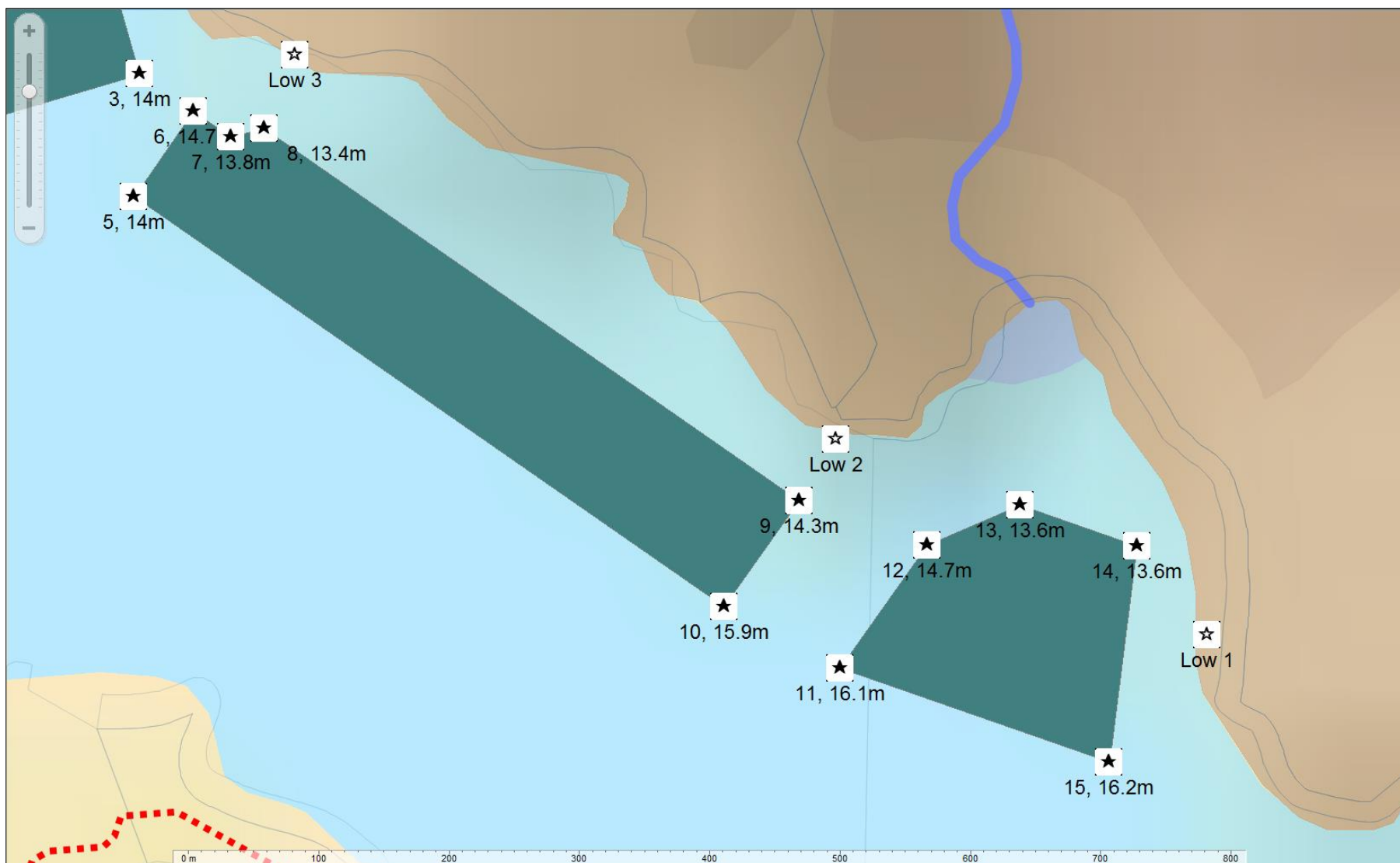


Figure 4b. Depths of the middle and southern application areas (teal). The position of low tide is also indicated (see Table 1).

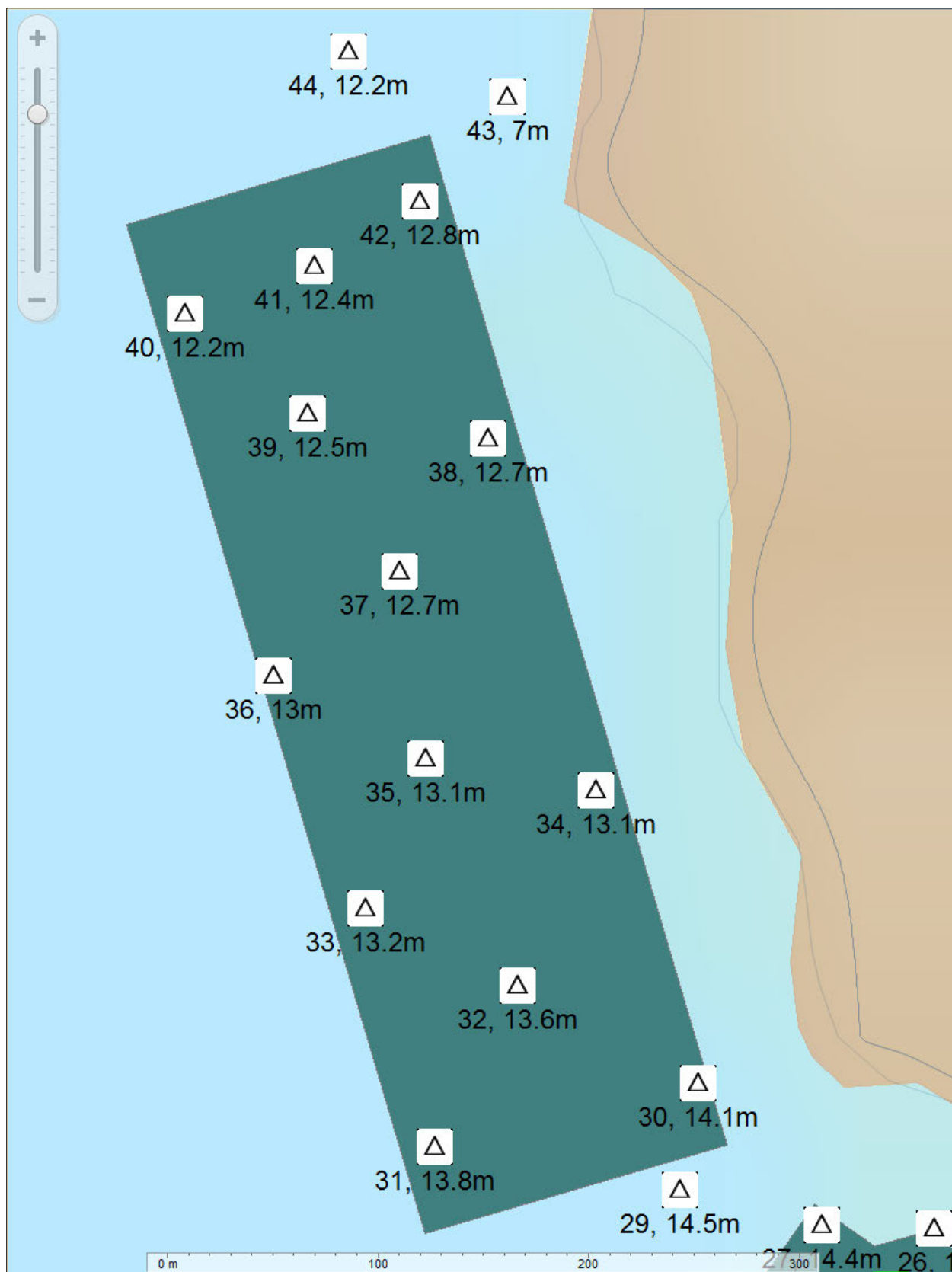


Figure 5a. Depths of the northern application area (teal), drop camera stations (triangles), photo number and depth (m) (Table 2).

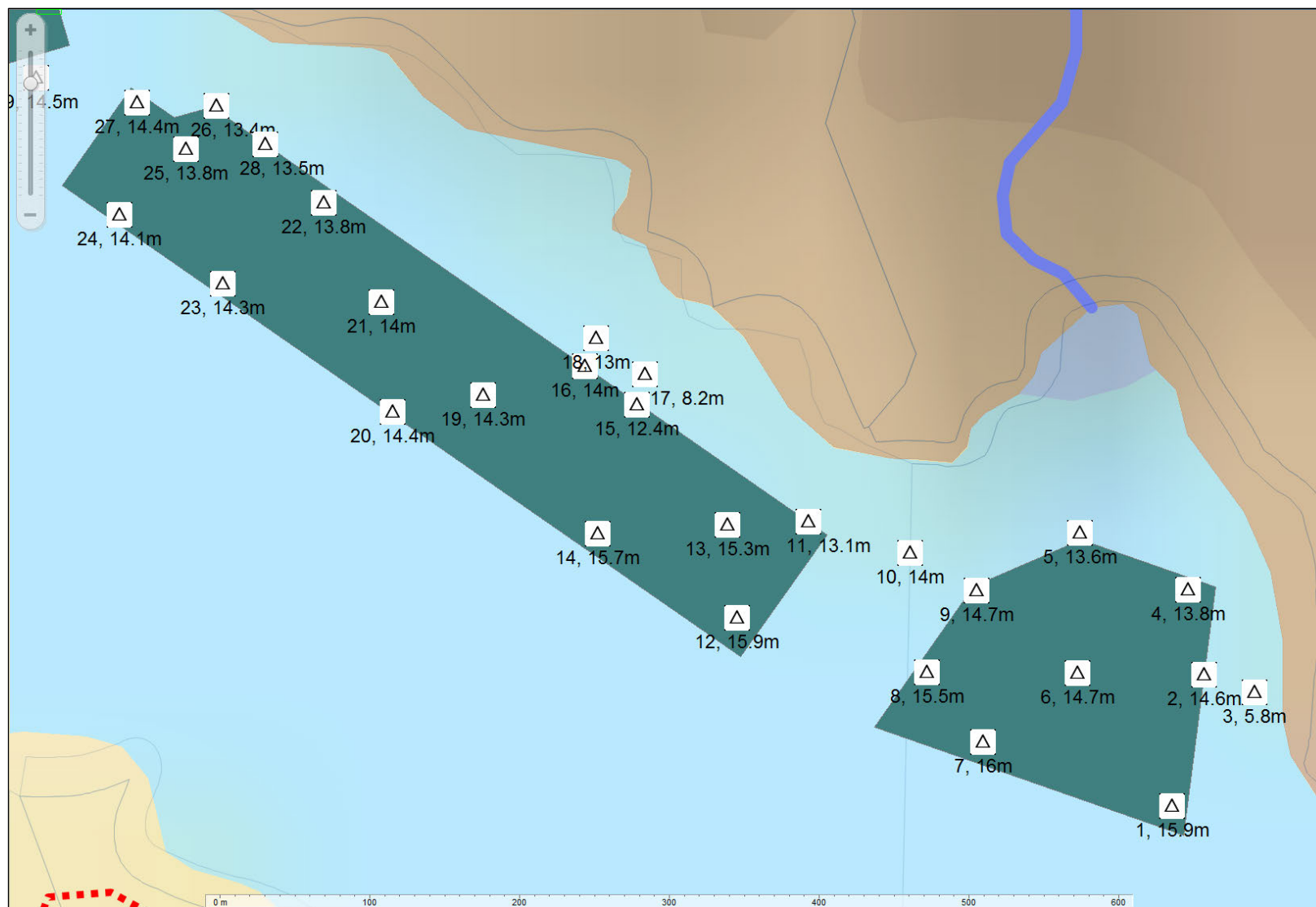


Figure 5b. Depths of the middle and southern application areas (teal), drop camera stations (triangles), photo number and depth (m) (Table 2).

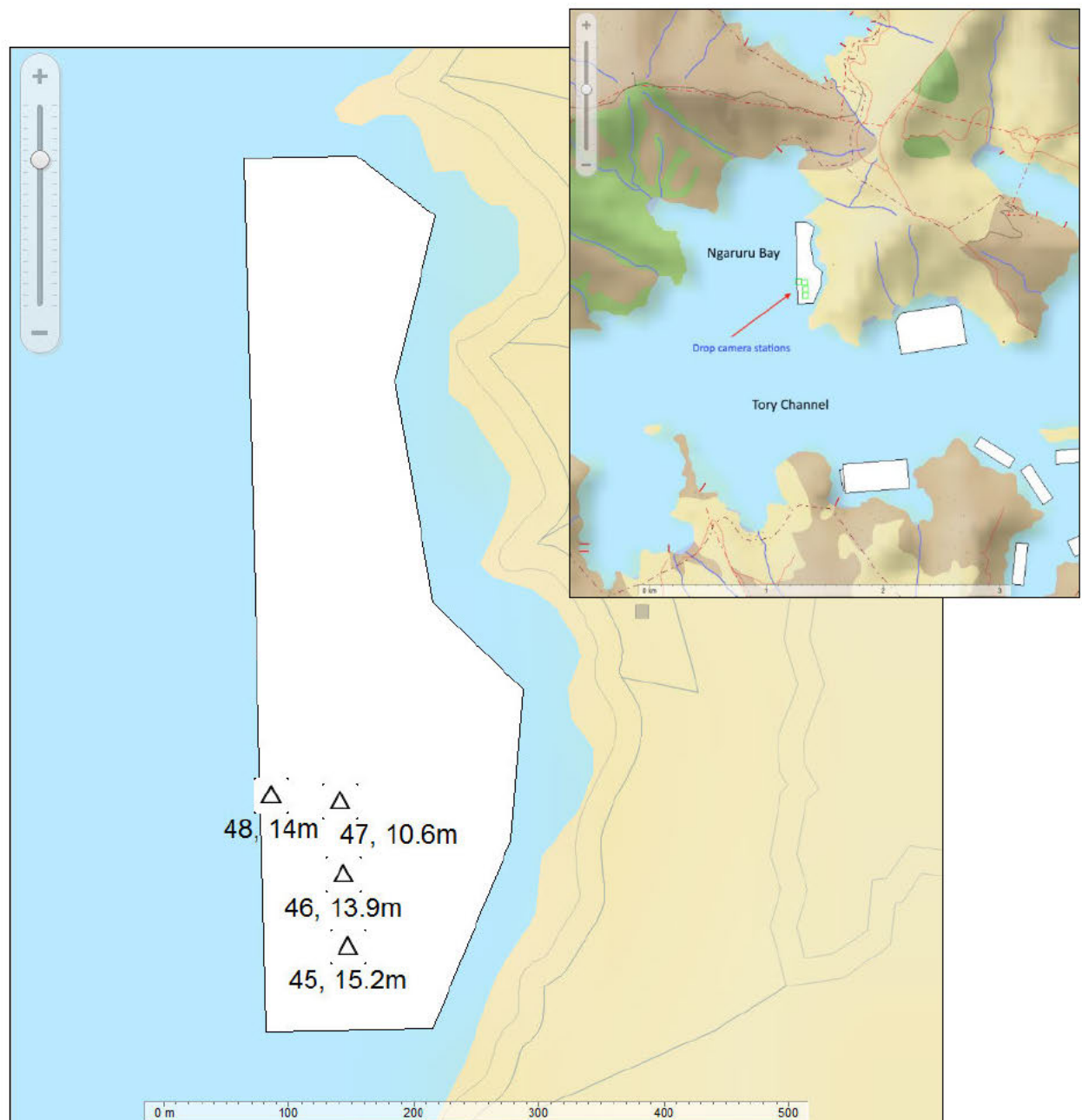


Figure 6. Drop camera stations located in a marine farm in Ngaruru Bay.

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Plate 4. Silt and clay substratum located within the application (photo 34, 13.1m depth).



Plate 5. Mud with microalgae/diatom film on sediment surface. (photo 2, 14.6m depth).

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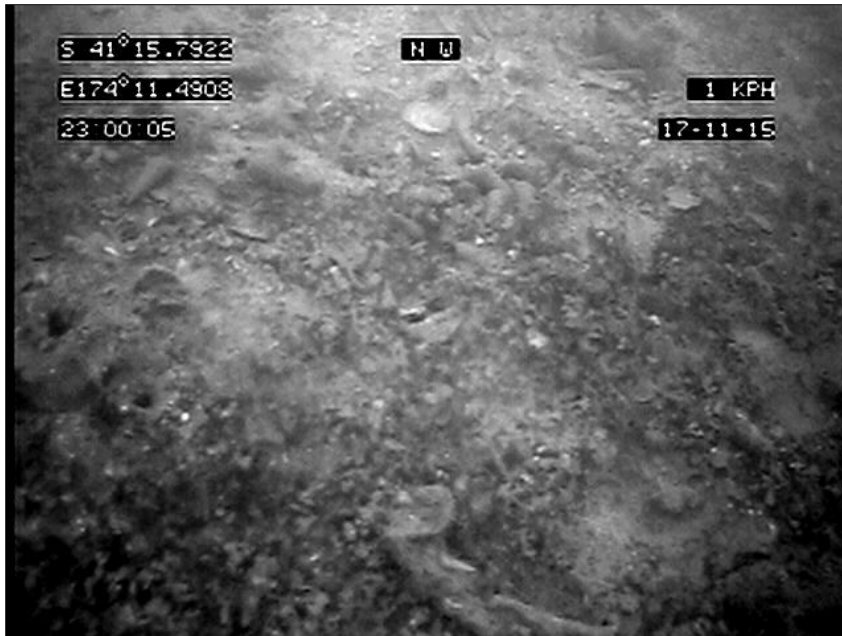


Plate 6. Mud with a component of natural dead whole and broken shell (photo 15, 12.4m).



Plate 7. Silt, natural dead whole and broken shell (photo 17, 8.2m). Note epibenthic algae.

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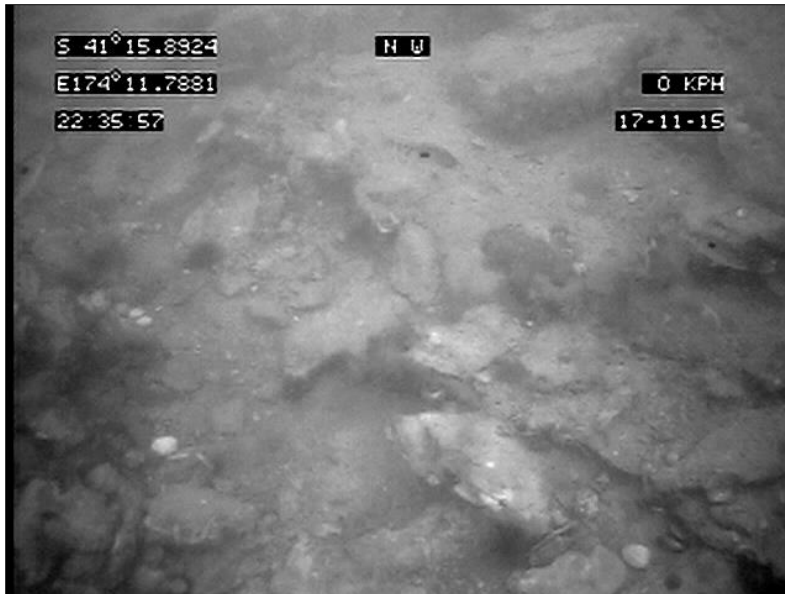


Plate 8. Cobble, small boulder, silt and shell located along the shoreline adjacent to the application (photo 3, 5.8m).



Plate 9. Silt and clay substratum under a marine farm in Ngaruru Bay (photo 45, 15.2m).

Table 2. Coordinates of drop camera stations showing location relative to the marine farm application (NZTM). Colours are: pink = under backbones in adjacent farm, grey = application. Depth, substratum and biological feature data are also listed.

No. & Depth (m)	Coordinates	Location	Farm structures	Substratum	Shell debris
1, 15.9m	1700168.4,5431069.9	In application	No structures	Silt and clay	None
2, 14.6m	1700189.4,5431157.6	In application	No structures	Silt and clay	None
3, 5.8m	1700223.1,5431146.1	Outside application	No structures	Cobbles, small boulders, silt, shell	None
4, 13.8m	1700179.1,5431214.5	In application	No structures	Silt and clay	None
5, 13.6m	1700106.9,5431252.3	Outside application	No structures	Silt and clay	None
6, 14.7m	1700105.1,5431158.6	In application	No structures	Silt and clay	None
7, 16m	1700042.1,5431112.8	In application	No structures	Silt and clay	None
8, 15.5m	1700004.5,5431159.6	In application	No structures	Silt and clay	None
9, 14.7m	1700037.7,5431214.1	In application	No structures	Silt and clay	None
10, 14m	1699993.5,5431238.8	Outside application	No structures	Silt and clay	None
11, 13.1m	1699925.2,5431260.1	In application	No structures	Silt and clay	None
12, 15.9m	1699878.1,5431195.6	In application	No structures	Silt and clay	None
13, 15.3m	1699871.7,5431257.9	In application	No structures	Silt and clay	None
14, 15.7m	1699785.0,5431251.9	In application	No structures	Silt and clay	None
15, 12.4m	1699811.1,5431338.1	In application	No structures	Silt and clay, natural shell	None
16, 14m	1699776.5,5431363.8	In application	No structures	Silt and clay	None
17, 8.2m	1699816.6,5431358.2	Outside application	No structures	Silt, fine sand, shell, algae	None
18, 13m	1699783.9,5431382.1	Outside application	No structures	Silt and clay	None
19, 14.3m	1699708.3,5431344.3	In application	No structures	Silt and clay	None
20, 14.4m	1699647.8,5431333.2	In application	No structures	Silt and clay	None
21, 14m	1699640.4,5431406.2	In application	No structures	Silt and clay	None
22, 13.8m	1699601.8,5431472.6	In application	No structures	Silt and clay	None
23, 14.3m	1699534.3,5431418.6	In application	No structures	Silt and clay	None
24, 14.1m	1699465.7,5431464.8	In application	No structures	Silt and clay	None
25, 13.8m	1699510.2,5431508.8	In application	No structures	Silt and clay	None
26, 13.4m	1699530.3,5431537.6	Outside application	No structures	Silt and clay	None
27, 14.4m	1699477.2,5431539.7	In application	No structures	Silt and clay	None
28, 13.5m	1699562.7,5431511.6	In application	No structures	Silt and clay	None
29, 14.5m	1699409.9,5431556.1	Outside application	No structures	Silt and clay	None
30, 14.1m	1699418.6,5431606.7	In application	No structures	Silt and clay	None
31, 13.8m	1699293.1,5431576.7	In application	No structures	Silt and clay	None
32, 13.6m	1699332.5,5431653.2	In application	No structures	Silt and clay	None
33, 13.2m	1699260.6,5431689.7	In application	No structures	Silt and clay	None
34, 13.1m	1699369.6,5431745.8	In application	No structures	Silt and clay	None
35, 13.1m	1699289.1,5431761.2	In application	No structures	Silt and clay	None
36, 13m	1699216.8,5431800.4	In application	No structures	Silt and clay (soft tubeworms with ascidians = occasional)	None
37, 12.7m	1699276.7,5431850.2	In application	No structures	Silt and clay	None
38, 12.7m	1699318.6,5431913.0	In application	No structures	Silt and clay	None
39, 12.5m	1699233.2,5431924.6	In application	No structures	Silt and clay	None
40, 12.2m	1699174.6,5431972.4	In application	No structures	Silt and clay	None
41, 12.4m	1699236.1,5431994.7	In application	No structures	Silt and clay	None
42, 12.8m	1699286.2,5432025.8	In application	No structures	Silt and clay	None
43, 7m	1699328.0,5432075.3	Outside application	No structures	Silt and clay, natural shell	None
44, 12.2m	1699252.2,5432096.9	Outside application	No structures	Silt and clay	None
45, 15.2m	1703127.1,5434586.9	In existing marine farm (Ngaruru Bay)	Under backbones	Silt and clay, drift algae	None
46, 13.9m	1703124.1,5434644.9	In existing marine farm (Ngaruru Bay)	Under backbones	Silt and clay	None
47, 10.6m	1703121.7,5434703.8	In existing marine farm (Ngaruru Bay)	Under backbones	Silt and clay	None
48, 14m	1703066.1,5434707.9	In existing marine farm (Ngaruru Bay)	Under backbones	Silt and clay	None



Plate 10. Material remaining after infauna samples were passed through a 0.5 mm sieve (left = Sample DE14 Ngaruru; right = Sample DE13, Onapua).

4.3 Sonar

No rocky features extending from shore into the application were recorded from the three sonar runs conducted through the application and along its inshore edges (Figures 7a, 7b and 7c). Small areas of rock substratum were observed at a variety of locations close to shore. These areas were interspersed by cobble and small boulder substrata that extended along the shallow inshore areas of the coast.

One ridge was observed near the inshore boundary of the middle application site (Plate 7b). No other notable bottom features were observed inside the application areas.

4.4 Drogue tracks

A drogue was deployed on four occasions through the day at sites located in Onapua Bay. Two incoming tide and two outgoing tide deployments were conducted. The drogue was located and collected between 104 to 148 minutes after deployment (Table 3). Drogue 2 spanned both the incoming and then the early part of the outgoing tide. The tide was low at



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7.09 am (0.2 m) and high at 1.45 pm (1.2 m). In Tory Channel, tides range from approximately 0.9 m to 1.4 m height. The wind on the day of sample was a gusty southerly (approximately 10-20 knots).

Drogue 1 (incoming) travelled southwards and moved in an offshore direction at an average rate of 0.03 m/sec (Figure 8). Drogue 2 initially started to travel eastwards, however, changed direction to travel northwards, presumably as the tide changed to outgoing. This drogue travelled at an average rate of 0.034 m/sec.

Drogue 3 travelled northwards and inshore on the outgoing tide and was the slowest rate recorded (0.026 m/sec) for all the deployments. Drogue 4 travelled the fastest at 0.04 m/sec in a northwards offshore direction (Figure 8).

Table 3. Drogue deployment data.

	Time in	Time out	Total time (mins)	Distance covered (m)	Average speed (m/sec)	Tidal state
Drogue1	1044	1228	104	190	0.030	Incoming
Drogue2	1236	1421	105	214	0.034	Incoming then outgoing
Drogue3	1435	1703	148	233	0.026	Outgoing
Drogue4	1711	1913	122	295	0.040	Outgoing



Figure 7a. Sonar runs ($n = 3$) through the north application (yellow boundary).

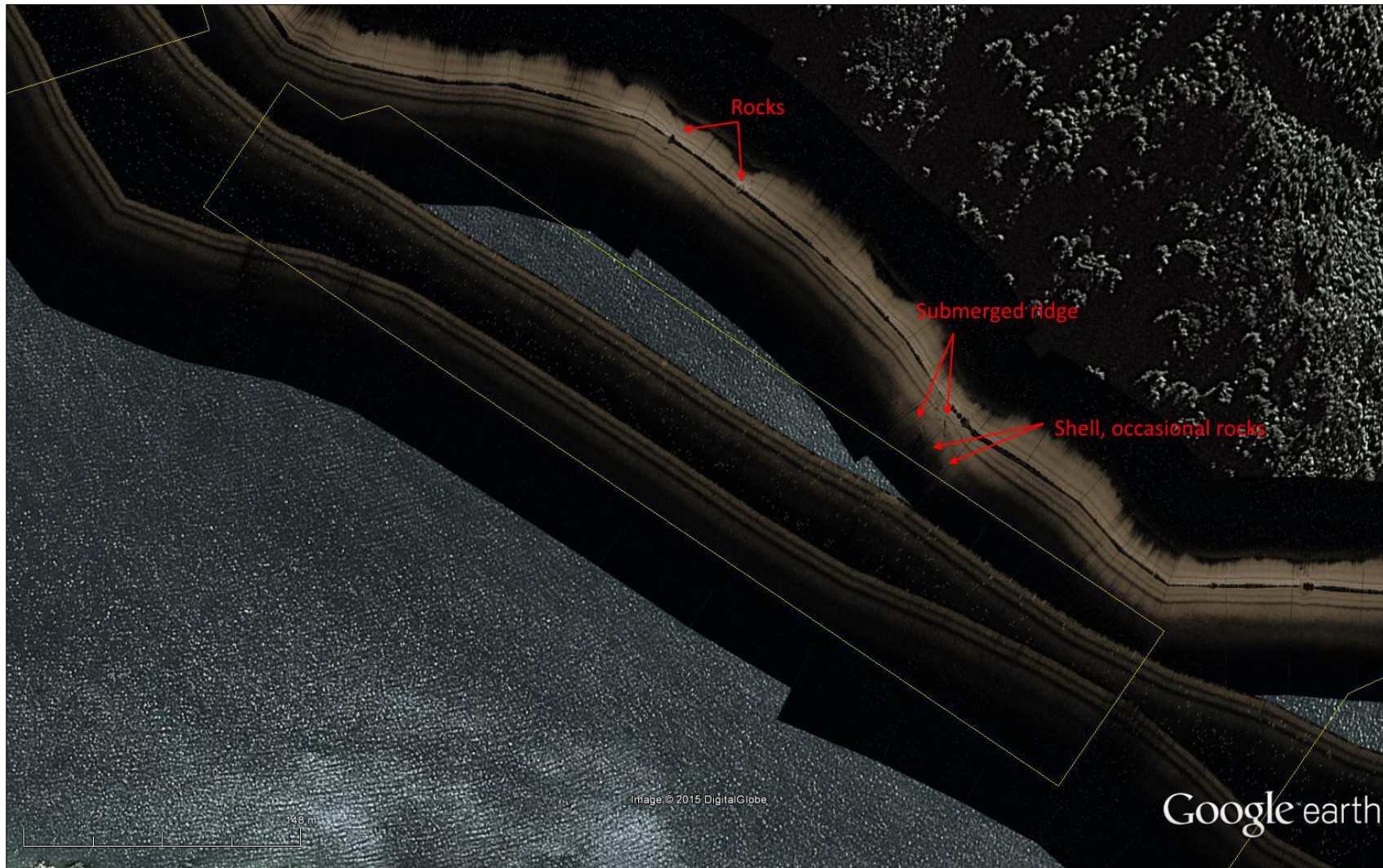


Figure 7b. Sonar runs ($n = 3$) through the middle application (yellow boundary).

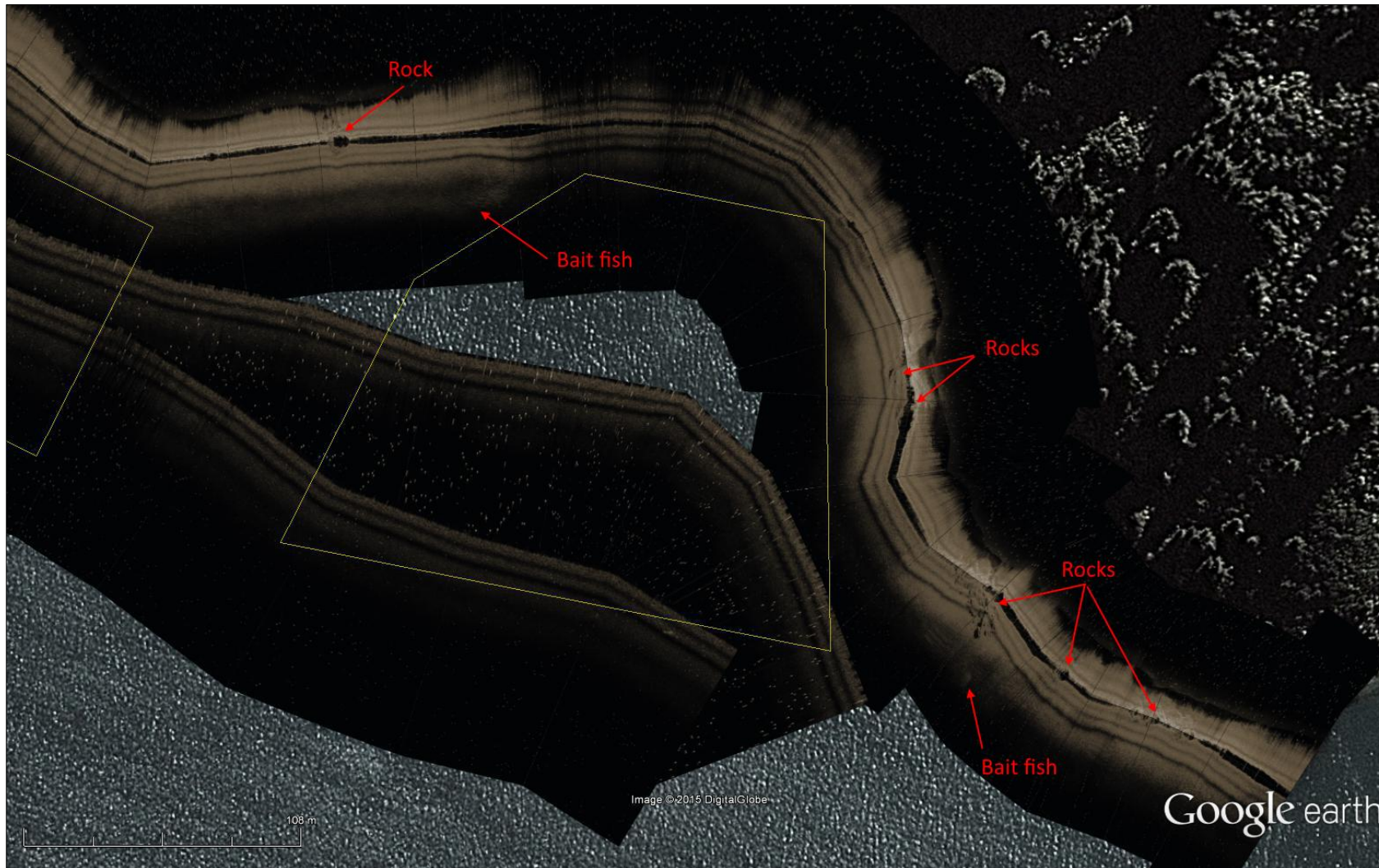


Figure 7c. Sonar runs ($n = 3$) through the southern application (yellow boundary).

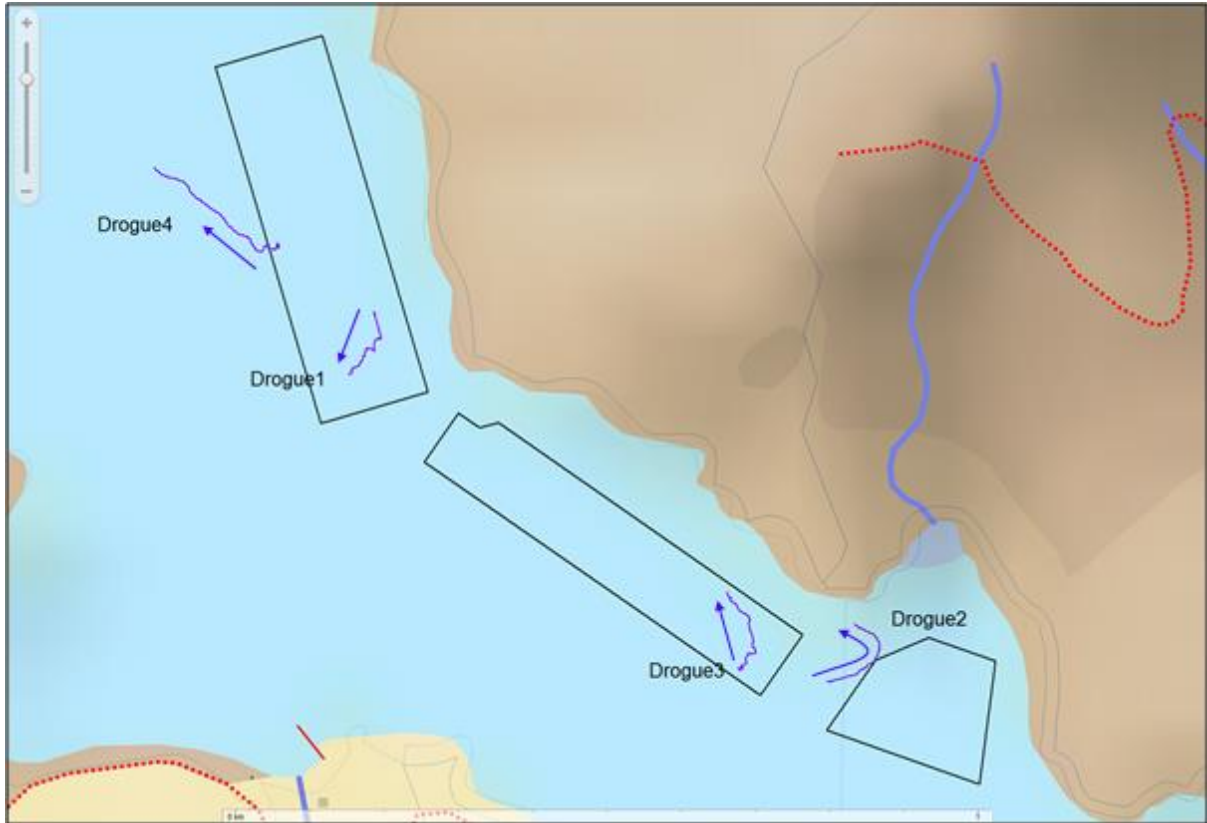


Figure 8. Drogue tracks (purple lines) collected on incoming ($n=2$) and outgoing ($n = 2$) tides.

4.5 Sediment infauna

A total of 13 grab samples were collected from Onapua Bay and three from Ngaruru Bay (Figure 9). Grab samples in Ngaruru Bay were collected from within the marine farm backbone structures. In Onapua Bay, a total of six samples were collected from the application area and seven grabs from approximately 50 m distance outside the application proposed boundaries (Table 4).

Visual inspection revealed grab samples were all dominated by silt and clay substrata. Occasional tubeworms were observed in samples and a microalgae/diatom mat was also often observed on the surface of the mud in Onapua Bay.

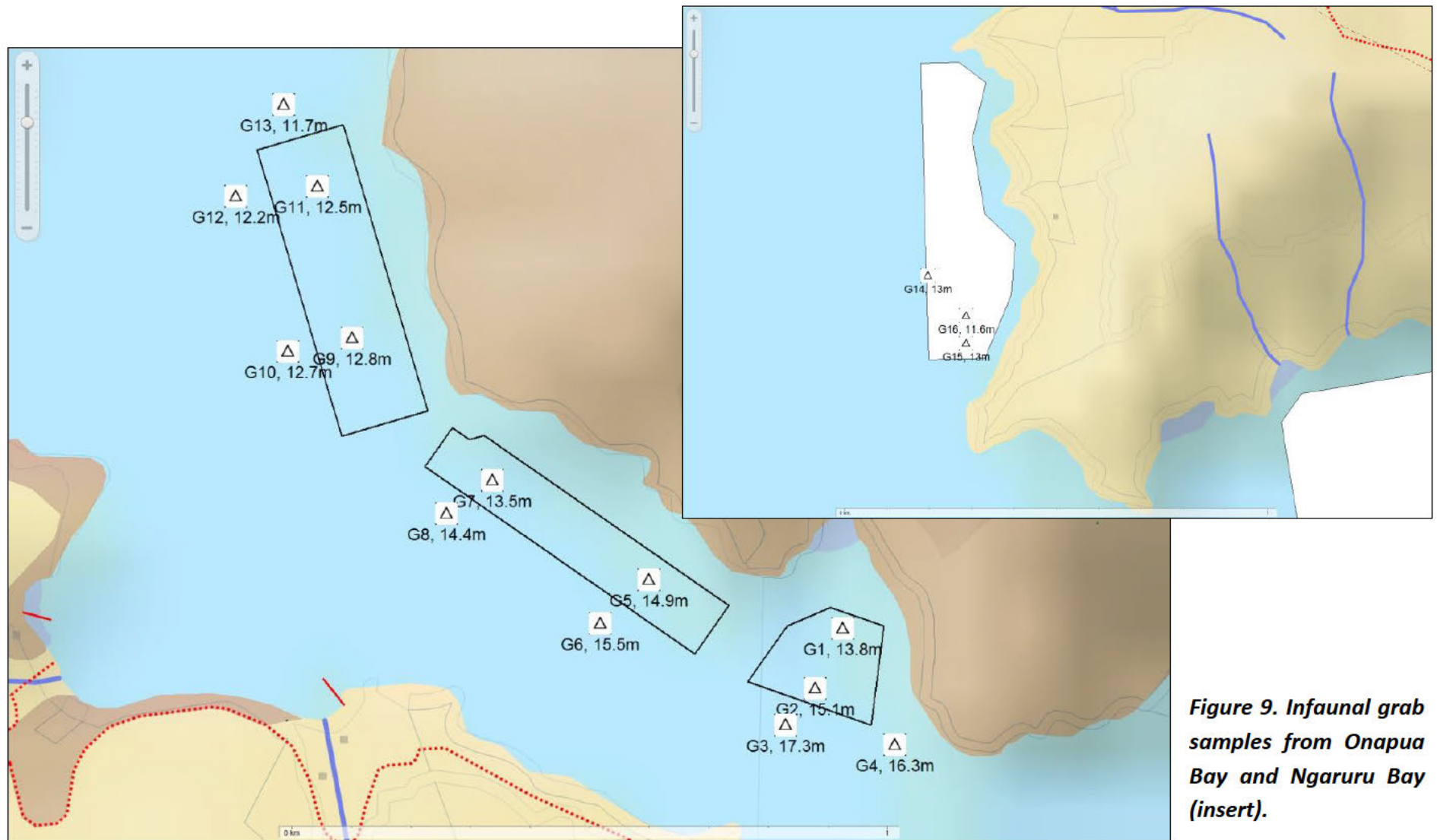


Figure 9. Infaunal grab samples from Onapua Bay and Ngaruru Bay (insert).

Table 4. Summary of infaunal data collected from core samples in Onapua and Ngaruru Bays.

General Group	Taxa	Common Name	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15	G16
			Onapua In app	Onapua In app	Onapua Control	Onapua Control	Onapua In app	Onapua Control	Onapua In app	Onapua Control	Onapua In app	Onapua Control	Onapua In app	Onapua Control	Onapua Control	Ngaruru Farm	Ngaruru Farm	Ngaruru Farm
Anthozoa	Edwardsia sp.	Burrowing anemone	3				2	2	1						1			
Nemertea	Nemertea	Proboscis worms									1							
Priapula	Priapula	Priapularins	1					2	2	1	1			2		1		
Scaphopoda	Cadulus telfer	Tusk Shell					1											
Opisthobranchia	Philine auriformis	White Slug								1	1	1		1			1	
Bivalvia	Arthritica bifurca	Small bivalve		1		8		1										
Bivalvia	Dosinia sp. (juvenile)	Surf Clam								1								
Bivalvia	Maorithyas marama	Small bivalve						1										
Bivalvia	Theora lubrica	Window shell	1				3	1	3			2				2	1	1
Bivalvia	Varinucula gallinacea	Nut shell									1							1
Polychaeta: Nereididae	Neanthes cricognatha	Rag Worm														3		
Polychaeta: Orbiniidae	Phylo novaezealandiae	Polychaete worm						1				1	1		2	2	1	1
Polychaeta: Cossuridae	Cossura consimilis	Polychaete worm	1										3					
Polychaeta: Spionidae	Prionospio yuriei	Polychaete worm		1									1					
Polychaeta: Maldanidae	Maldanidae	Bamboo Worms	5	6	2	5	6	3	2	1	6	5	3	2	6	1	3	8
Polychaeta: Opheliidae	Armandia maculata	Polychaete worm														6		2
Polychaeta: Phyllodocidae	Phyllodocidae	Paddle worms					1		1									
Polychaeta: Sigalionidae	Sigalionidae	Polychaete worm	2	2	1		2		2	3	1	1			1		1	
Polychaeta: Hesionidae	Hesionidae	Polychaete Worm																2
Polychaeta: Syllidae	Syllidae	Polychaete worm		1														
Polychaeta: Glyceridae	Glycera americana	Polychaete worm	1			1												
Polychaeta: Goniadidae	Goniada sp.	Polychaete worm												1				
Polychaeta: Nephtyidae	Aglaophamus sp.	Polychaete worm	1				1										1	
Polychaeta: Onuphidae	Onuphis aucklandensis	Polychaete worm														1		
Polychaeta: Lumbrineridae	Lumbrineridae	Polychaete worm	5	2		1			3		3	1	5	2		2	1	1
Polychaeta: Dorvilleidae	Dorvilleidae	Polychaete worm												2		22	2	1
Polychaeta: Cirratulidae	Cirratulidae	Polychaete worm											1					1
Polychaeta: Terebellidae	Terebellidae	Polychaete worm	1			1	1	1	1	1	1	1						
Polychaeta: Trichobranchidae	Terebellides stroemi	Polychaete worm	4				4		1		1			5	2			
Polychaeta: Sabellidae	Euchone pallida	Fan worm							1									
Crustacea	Nebalia sp.	Small crustacean															1	
Cumacea	Cumacea	Small crustacean	1				1			2	1				1			
Tanaidacea	Tanaidacea	Tanaid shrimp	1	2			2		2	1					1	1		
Isopoda	Natatolana pellucida	Fish lice	1					1		4			1		1		1	
Isopoda	Asellota	Isopod													1			
Amphipoda	Lysianassidae	Amphipod (family)															3	1
Amphipoda	Phoxocephalidae	Amphipod (family)	1								1				1	2	2	1
Amphipoda	Ampelisca sp.	Amphipod (large)	1	2							1							
Amphipoda	Amphipoda Unid.	Amphipod	6			1		1	1		3	1		1	1		5	2
Decapoda	Alpheus sp.	Snapping shrimp				1												
Decapoda	Natantia Unid.	Shrimp																1
Ostracoda	Cypridinoides concentrica	Ostracod									1				1			
Echinoidea	Echinocardium cordatum	Heart Urchin										1				2		
Holothuroidea	Paracaudina chilensis	Sea Cucumber												1				
Holothuroidea	Rynkatorpa uncinata	Sea cucumber										1						
Ascidacea	Molgula sp.	Sea squirt									1							
Ophiuroidea	Ophiuroidea	Brittle Stars	1	1	1	1												
Count: No of Individuals			37	18	4	19	24	14	20	15	24	15	15	17	19	45	23	24
Count: No of Taxa			18	9	3	8	11	10	12	9	15	10	7	9	12	12	13	14
SW_Diversity			2.6090	1.9851	1.0397	1.6453	2.1885	2.2056	2.3889	2.0262	2.4555	1.9652	1.7321	2.0337	2.2327	1.8293	2.3785	2.3116
SW_Evenness			0.9026	0.9034	0.9464	0.7912	0.9127	0.9579	0.9614	0.9222	0.9067	0.8944	0.8901	0.9256	0.8985	0.7362	0.9273	0.8759

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Between 4-37 individual infaunal organisms were collected in samples from Onapua Bay (mean = 18.5, SE = 2.08), compared to 23-45 individuals in Ngaruru Bay (mean = 30.7, SE = 7.2) (Table 4, Figure 10). Taxa richness ranged from 3-18 species were recorded in Onapua Bay (mean = 10.2, SE = 1.02) compared to 12-14 species in Ngaruru Bay (mean = 13.0, SE = 0.58). No obvious consistent patterns in the total number of individuals or taxa were obvious from samples collected in Onapua Bay (e.g. proximity to Tory Channel, distance from shore).

Shannon-Weaver Diversity scores exhibited a greater range at Onapua Bay sites compared to Ngaruru Bay. In contrast, relatively little variation was recorded for Evenness values in Onapua Bay.

Ngaruru Bay cores often contained a higher number of taxa and total number of individuals compared to most samples in Onapua Bay (Figure 10). For example, the highest number of infaunal individuals from any core was recorded from site G14 in Ngaruru Bay.

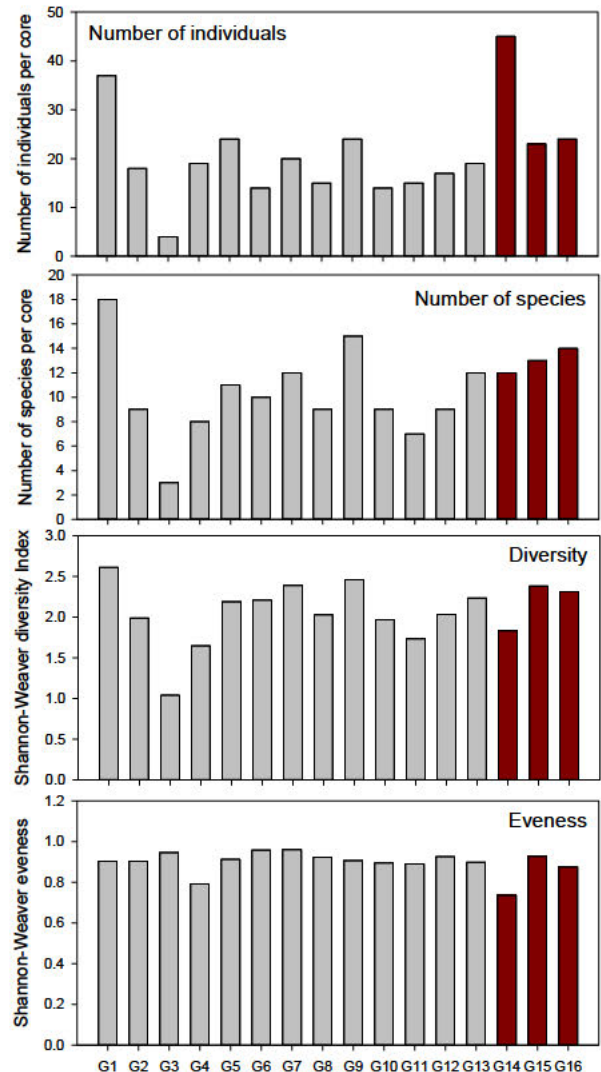


Figure 10. Infauna data collected from sample sites in Onapua (grey bars) and Ngaruru Bay (red bars).

4.6 Dredge tows and surface dwelling fauna

Dredge 1 (385 m long) and dredge 2 (285 m long) were collected in the northern most and middle application blocks respectively (Figure 11). Dredge 1 had a greater biomass and number of individuals compared to dredge 2 (Plate 11).

Both dredge tows revealed a comparable number of species (Table 5). Cushion seastar (*Patiriella regularis*), tubeworm clumps (parchment worms) and hermit crabs (*Pagrus* spp.) were the most commonly recorded species in Dredge 1 (Table 5). A colonial ascidian (*Didemnum* sp.) was recorded on the tubes of some of the tubeworm colonies.

Dredge two was dominated by a solitary ascidian and hermit crabs, while a single piece of *Undaria* was also collected. Heart urchins were uncommon in the dredge samples, however, they are most often found within sediment (infauna) and are usually under-sampled by this type of dredge.

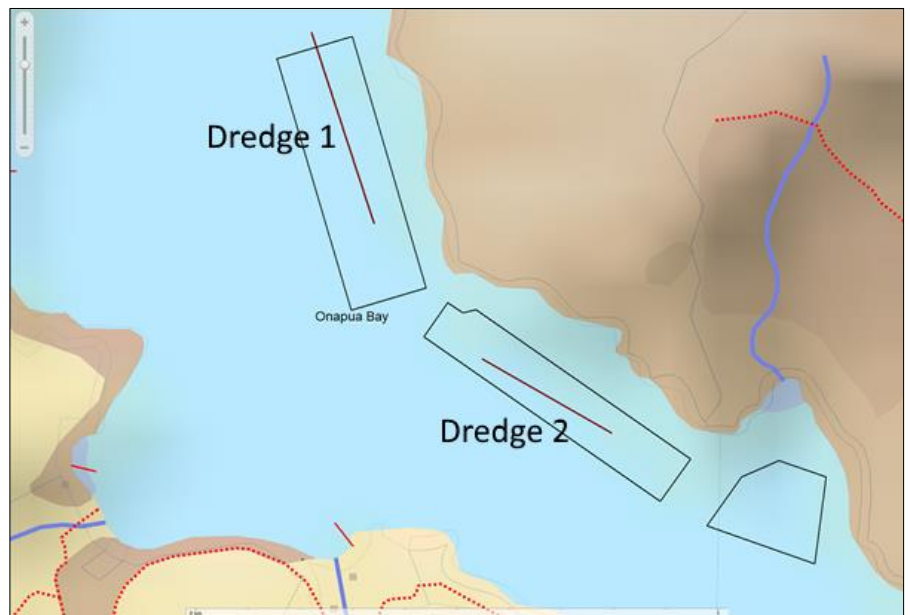


Figure 11. Location of dredge tows in Onapua Bay. Both tows progressed from north to south.

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Plate 11. Dredge 1 (left) and dredge 2 (right) contents.

Table 5. Dredge tow contents.

	Dredge 1	Dredge 2
Cushion seastar	24	2
Heart urchin	3	
Hermit crab	18	4
Camouflage crab		3
Tubeworm clumps	8	
Whelk		1
Solitary ascidian		6
Colonial ascidian	2	
Red foliose algae	2	
Drift algae		1
Total species	6	6

4.7 Redox, sulphide and total organic matter (TOM)

Redox (ORP), total free sulphides and total organic matter (TOM %) was analyzed from each grab sample collected in Onapua (n=13) and under a marine farm site located in Ngaruru Bay (n = 3).

Redox values in Onapua Bay ranged from 165 to 235 mV, while values under the marine farm ranged from 201 to 244 mV (Table 4, Figure 12).

Sulphide values from both bays were variable between sites, with the highest and lowest values recorded from Onapua Bay (<8 and 424 µM).

Total organic material (TOM %) in Onapua Bay ranged from 3.6 to 5.4 (mean = 4.6, SE = 0.19) (Table 6). In Onapua Bay, TOM values generally decreased from south to north or proximity to the main reach of Tory Channel. Ngaruru Bay samples collected under the marine farm were within the range recorded for Onapua Bay (mean = 4.23, SE = 0.15) (Figure 12, Table 6).

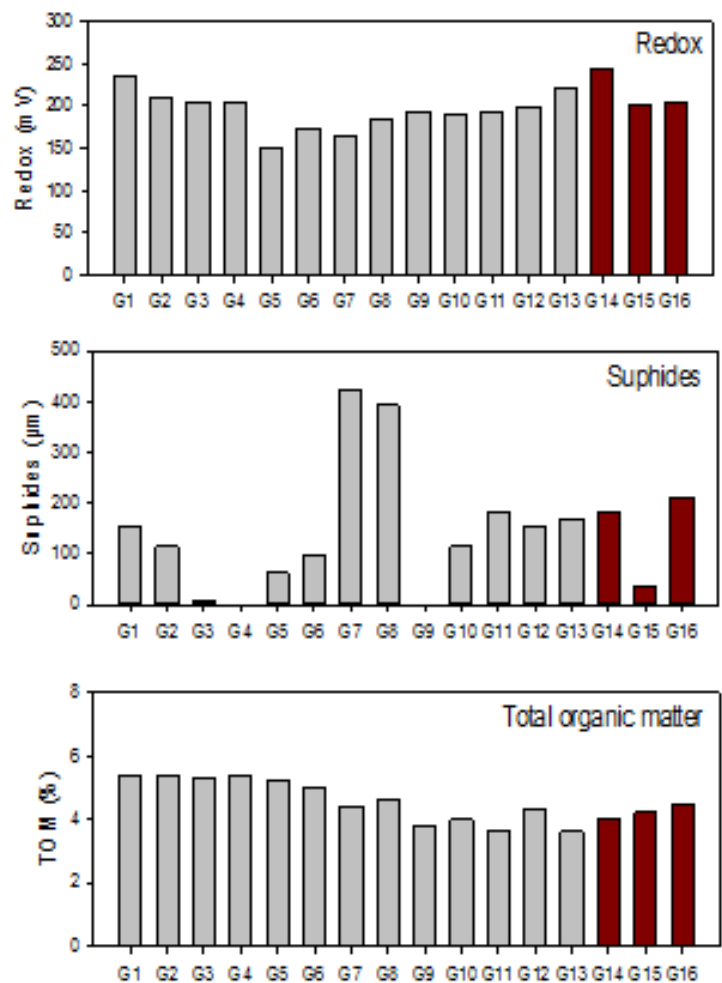


Figure 12. Sediment analysis results from Onapua (grey bars) and Ngaruru Bay (red bars).

Table 6. Results from benthic grab samples collected from Onapua and Ngaruru Bays.

Station	Location	Redox (ORP) (mV)	Total Free Sulphides (µM)	TOM
G1	Onapua Bay	235	156	5.4
G2	Onapua Bay	210	115	5.4
G3	Onapua Bay	205	9	5.3
G4	Onapua Bay	204	<8	5.4
G5	Onapua Bay	150	62	5.2
G6	Onapua Bay	174	98	5
G7	Onapua Bay	165	424	4.4
G8	Onapua Bay	185	393	4.6
G9	Onapua Bay	193	<8	3.8
G10	Onapua Bay	190	115	4
G11	Onapua Bay	192	182	3.6
G12	Onapua Bay	199	156	4.3
G13	Onapua Bay	222	168	3.6
G14	Ngaruru Bay	244	182	4
G15	Ngaruru Bay	201	36	4.2
G16	Ngaruru Bay	205	212	4.5

5.0 Summary and Conclusions

5.1 Substratum

The application investigated during the present study was dominated by silt and clay substratum with a very small component of natural shell (broken and dead whole). It is probable that most of Onapua Bay away from its shallow edges is comparable, however, no widespread survey of the bay has been conducted to confirm this likelihood. Rocky shores were recorded from sonar imagery and photos collected from inshore of the application. Rocky substrata formed a relatively narrow fringe above and below the low tide mark. At a number of locations rocks were observed extending offshore, but the offshore extent of these structures always remained well inshore of the application.

Summary: the marine farm application is located over mud (i.e. silt and clay) substratum.

5.2 Biological features

Surface dwelling (epibiota)

The biological communities on and within sediment under the application were dominated by species usually associated with mud sea beds in the Sounds. The epibiota was more abundant and diverse with proximity to the main reach of Tory Channel. Isolated patches of soft tubeworms were more often observed in the northern application site compared to the middle and southern sites. Further, 24 cushion seastars (*Patiriella regularis*) were recorded from the northern dredge tow compared to only two from the southern tow. Similarly, 18 hermit crabs were recorded from the northern tow compared to four from the southern tow. Solitary ascidians and camouflage crabs were, however, encountered more often in the south.

Based on the volume and abundance of material recorded from dredge tows, it was concluded that the surface flora and fauna is characterised by a low biomass and diversity of

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species. No iconic or edible species such as horse mussels, red algae or scallops were recorded from the dredge tows.

Summary: Surface dwelling species under the application were sparse and recorded in low abundance. Numbers of species and their abundance increased towards Tory Channel.

Within sediment dwelling (Infauna)

Polychaetes have long been an obvious choice to act as representative species in the analysis of the health of benthic communities as they are usually the most abundant taxon taken in benthic samples, both in terms of the number of polychaete taxa and numerical abundance (Dean 2008). Dean (2008) also stated unlike nektonic or reptant organisms, the polychaetes usually live within the sediments or attached to hard surfaces and, while their larvae may be capable of long distance transport, the adults are relatively inert. This relative immobility ensures chronic exposure to any toxic materials in the environment rather than the episodic exposures of a more vagile organism (Dean 2008). Any long-term changes in the well-being of the benthos should therefore be reflected in the polychaete community (Papageorgiou *et al.* 2006). When a benthic community is undergoing stress due to detrimental environmental conditions there are presumed to be notable changes in community parameters such as diversity, abundances, dominance, biomass, and so on (Pearson & Rosenberg 1978).

Dean (2008) listed indicator species based on the literature. He states, “a brief incomplete list of positive indicators of a stressed community due to pollution include the capitellids *C. capitata*, (Mendez *et al.* 1998, Belan 2003, Rivero 2005) and *Heteromastus filiformis* (Ahn *et al.* 1995), the spionids *Malacocerus fulginosus*, *Paraprionospio pinnata*, and *Polydora ligni* (Mendez *et al.* 1998, Dix *et al.* 2005), the nereid *N. (H.) diversicolor*, the dorvilleid *Ophryotrocha adherens* (Bailey-Brock *et al.* 2000) and the cirratulidae *Chaetozona setosa* (Rygg 1985). Other polychaete species, such as members of the Lumbrineridae, Maldanidae (Belan 2003) and Terebellidae (Olsgard *et al.* 2003) have been used as negative indicators of poor benthic conditions, that is, their absence in a community is an indication of poor environmental conditions.”

McKnight and Grange (1991) collected infaunal data from a wide range of sites throughout the Marlborough Sounds and separated communities into similar groups. These groups

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often corresponded to sediment type. The mud substratum group was the most common and widespread community type recorded in their study.

The infauna at Onapua Bay was dominated by polychaete worms (n = 20 taxa), followed by 5 bivalve taxa and four amphipod taxa. Although the infauna was dominated by polychaetes, no taxa were notably more abundant. Dorvilleidae polychaetes reached 22 individuals within a single core at Ngaruru, however, this family is not recognised as being indicative of enrichment. Spionidae spp. are an enrichment indicator, however, their numbers in Onapua Bay were low. Further, they were not recorded under the marine farm site in Ngaruru Bay. No Capitellids (i.e. the major enrichment indicator family) were recorded in Onapua or Ngaruru Bays. In comparison, Capitellids are abundant under salmon farms located in Tory Channel.

Summary: the infaunal community under the application is typical of sheltered muddy areas in the Sounds. No species indicative of enrichment or contamination were recorded from either bay.

5.3 Water currents

The main reach of Tory Channel is known for regular and strong tidal currents (>0.4 m/sec) on both incoming and outgoing tides (Hadfield *et al.* 2014). In contrast, currents in the side bays are often low in comparison.

Drogue data from the present study suggested that water currents in Onapua Bay increased with increasing proximity to Tory Channel. Drogue data also suggested that the outgoing tide was slightly stronger than the incoming tide in Onapua Bay. These difference however, were relatively small with most movements being at the low end of value for the Sounds. The effect of wind on water currents is unknown, but it is probable it has an effect as the bay is narrow funneling wind and is relatively shallow (<15m depth).

Summary: Onapua Bay has relatively low flows compared to the main reaches of the Sounds (e.g. Tory Channel) that exhibit moderate to strong tidal flows (i.e. > 0.1 m/sec (Hadfield *et al.* 2014; Broekhuizen 2015)).

5.4 Sediment properties

Almost all marine coastal ecosystems have complex structural and dynamic characteristics that can be easily modified by anthropogenic influences. Any change in chemical properties of the sediments can affect benthic communities, including their survival (Pearson and Rosenberg 1978).

Organic material (TOM)

In benthic communities, it is generally expected that increased concentrations of TOC in sediment will result in increased abundance and productivity, with decreased species richness and diversity in changes to benthic community structure and possibly function (Pearson and Rosenberg 1978).

There exists a correlation between organic carbon and sediment granulometry that can be partly explained by the similar settling velocity (i.e. hydrodynamic) of the particulate organic constituents and the fine grained mineral particles (Tyson 1995). The correlation also reflects the greater surface area of the fine particles (sediment-specific surface area), and thus the greater amount of organic carbon that can be adsorbed on their surfaces (Hedges et al. 1993). Muddy sediment (i.e. with a greater surface area compared to sediments composed of larger particles), therefore has a higher probability for elevated TOM values compared to coarse sediments subjected to the same level of enrichment.

In the present study TOM was used as an indicator of sediment enrichment. In general, considering that more than 50% of the organic matter is composed by organic carbon (Jackson 1964, Emery and Uchupi 1984), the organic carbon content can be multiplied roughly by 1.7 to 1.9 to give the relative total organic matter (TOM) in recent bottom sediments (Tissot and Welte 1984, Burone *et al.* 2003). Marine sediment typically ranges between 0.5% and 10% TOC or 3% and 20% TOM (Hyland 2005). Sediment total-organic matter levels in muddy sediments collected from Ruakaka and Blackwood Bays in the main branch of the Queen Charlotte Sound (Forrest *et al.*, 2011), ranged from 6-7%, while mud sediments beneath a salmon farm in Ruakaka Bay in the same study reached 14.7% total organic matter.

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Sediment data recorded from Onapua and Ngaruru Bays were comparable with Ngaruru sediments likely to support a small component of sandy substratum. Although sediment grain size analysis was not undertaken, visual examination of sediment grabs revealed both bays were dominated by muddy sediment. TOM values collected from each bay are therefore able to be compared relatively reliably as an indicator of enrichment levels.

Sulphides

Since 2006 in Canada, sulphides have been used to assess organic enrichment in sediments associated with fish farms (Chang *et al.*, 2013) (Table 7). The main reasons for choosing this indicator were:

- scientific confidence in this indicator and sampling methods to describe changes in benthic community structure;
- repeatability and consistency in sampling and analysis;
- clear specification of spatial and temporal bounds; and
- cost effectiveness (NBDENV 2006).

Various studies have shown that the diversity of sediment macrofauna under salmon farms declines with increasing sediment sulphide concentrations (Brooks & Mahnken 2003, Giles 2008, Hargrave *et al.* 2008, Hargrave 2010). Sulphide levels under fish farms can range from Oxidic A to Anoxic depending on a variety of factors such as water current, stocking rate and water depth.

Crawford *et al.* (2003) investigated sulphide rates under three oyster and mussel farms in Australia. The authors recorded maximum sulphide levels under the growing structures of Mean = 400 μM , while at control sites levels were <120 μM . At two of the oyster farms surveyed in this study sulphide levels were little different between inside and outside farms (Crawford *et al.* 2003). All levels were within the Oxidic A category (Table 7) suggesting impacts on the infaunal community would be low.

Sulphide values recorded from the Ngaruru Bay marine farm were little different to Onapua values. Values from both bays fall into the Oxidic A category where effects on the fauna would likely remain at the “low” end of the spectrum of effects (Table 7).

Table 7. Table based on NBDENV (2006) guidelines from Chang *et al.*, 2013.

Table 1. Environmental ratings based on average sediment sulfide concentration (total S^{2-}) in annual monitoring of finfish farms in southwestern New Brunswick. Based on NBDENV (2006)

Environmental rating class	Sediment sulfide (total S^{2-}) (μ M)	Effects on marine sediments
Oxic A	<750	Low effects
Oxic B	750–1500	Low effects
Hypoxic A	1500–3000	May be causing adverse effects
Hypoxic B	3000–4500	Likely causing adverse effects
Hypoxic C	4500–6000	Causing adverse effects
Anoxic	>6000	Causing severe damage

Redox

Wilding (2012) sampled 159 sites for redox within and at variable distances away from mussel farms in Scotland. The author reported that redox values were influenced by mussel farms with values rising rapidly >7 m away from the farm edge. The author reported that redox also varied widely across sites ranging between -125 mV to 588 mV.

In the present study redox values in Onapua Bay ranged from 165 to 235 mV (mean = 194.1, SE = 6.3), while values under the marine farm ranged from 201 to 244 mV (mean = 216.7, SE = 13.7). Overall, there was little difference between redox values from the low intensity marine farmed site compared with the non-farmed sample sites in Onapua Bay.

5.5 Farming impacts (shellfish and algae)

The applicant proposes to farm a variety of species but the predominant activity is farming dredge oysters on dropper lines. The impact on the benthos of traditional production mussel farming is well documented (see Keeley *et al* 2009 for review), however the impact of oyster farming on droppers has been less studied and in most cases in New Zealand has dealt with intertidal rack farming of Pacific oysters (Forrest *et al.* 2007). For intertidal oysters, seabed impacts tend to be restricted to the immediate vicinity of the site, and typically extend no further than a few tens of meters or less from the perimeter of the culture area (Forrest and Creese 2006). They arise primarily from the deposition of organic-rich particulates produced by the cultured oysters, the drop-off of oysters and build-up of

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shell litter, changes to water flows and patterns of sediment accretion or erosion, and physical disturbance from farm operations (Forrest *et al.* 2007). Further, negligible enrichment effects from oyster farms in Tasmania have been attributed to low stocking densities and adequate flushing (Crawford 2003; Crawford *et al.* 2003).

The impact of mussel spat holding on the benthos is not well known, however, like oysters a lower biomass of shellfish is suspended on droppers compared to production mussel farming. The present investigation of a farm in Ngaruru Bay therefore provides an indication of the impact of farming shellfish at lower densities compared to traditional production mussel farming.

To investigate enrichment levels, total organic matter (TOM), total free sulphide and redox (ORP) values were collected from the farmed and application site (unfarmed). Further, the infauna was also sampled at both farmed and unfarmed sites to determine if low intensity farming had impacted faunal abundance or composition. Sediments attributes and the infaunal community were little different between the unfarmed (Onapua) and marine farmed site (Ngaruru). Of note was the absence of pollution indicating infaunal organisms at both bays (see Pearson and Rosenberg 1978).

Summary: low intensity shellfish farming at Ngaruru Bay has little impact on sediment enrichment and the infauna.

The applicant has also applied for several macroalgae (seaweed) species. The impact of growing algae on dropper lines is often considered to be low compared to shellfish farming, however, there is a lack of impact assessments due to a lack of commercial production algae farms in New Zealand. MPI (2013) states “The cultivation of seaweeds such as *Undaria* will generally have minor ecological effects on the seabed and water column as they function at a lower trophic level and use dissolved nutrients (mainly dissolved inorganic nitrogen) for growth. Based on overseas studies, the only potential water column effect is nutrient extraction, with a possible flow-on effect of reduced nutrient availability for natural phytoplankton populations. Shading of the water column could affect light penetration to the seabed.”

MPI considers the most likely candidate for algae farming in New Zealand is *Undaria pinnatifida* (MPI 2013). This introduced species of Asian kelp grows on artificial surfaces like

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mussel farm backbones, droppers and anchor warps and is present on most marine farms in the Marlborough Sounds including Tory Channel. *Undaria* is classified as an “Unwanted Organism” under the Biosecurity Act 1993, however, MPI introduced a policy that allows for commercial harvesting from artificial surfaces and farming of *Undaria* in areas already heavily infested. The exact cultivation methods for *Undaria* in New Zealand are not developed, but based on grow-out trials in New Zealand and overseas culture methods it is likely that floating subtidal cultivation methods will be used.

Tory Channel supports populations of *Undaria* growing on subtidal rocky shores. *Undaria* presently naturally settles onto mussel growing structures lines (Plate 12) and it is likely it would seed naturally onto any new structures in Onapua Bay. This species appears to grow all year in Tory Channel showing no signs of summer die-back that occurs in the warmer areas of Marlborough. Observations from under mussel farms heavily infested with *Undaria* show adult plants on the seafloor. This may occur naturally or during harvest. *Undaria* is highly palatable and likely enters the food chain relatively quickly by direct consumption or after natural breakdown of cellular material. There is at least one company in the Marlborough Sounds that removes *Undaria* from lines for use as a fertilizer.

Undaria likely acts to mitigate ecological effects of other aquaculture activities by absorbing excess nutrients in the water column (MPI 2013).

With respect to other algae species MPI (2013) states “There are a number of native seaweed species which may also have aquaculture potential in New Zealand (for example, kelp (*Macrocystis pyrifera* and *Ecklonia radiata*) and red algae (*Gracilaria* sp. and *Pterocladia lucida*). It is assumed that the effects of farming these native species will be similar to those for *Undaria* (with the exception of the biosecurity issues associated with *Undaria*), so long as similar farming methods are used.”

Recently, there has been some interest in farming *Asparagopsis armata* due the ability of a closely related species (*A. taxiformis*) to reduce methane production in cattle (Kinley *et al.*, 2016). *A. armata* is common in outer Queen Charlotte Sounds and Tory Channel and is present in many temperate marine areas of the world. *Asparagopsis armata* is a fine branching red algae that often grows amongst other macroalgae species (Plate 13). This algae spreads vegetatively and readily breaks off and drifts or adheres to surfaces like divers wetsuits using fine barbs. This may explain its world-wide distribution. I have conducted

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dives under several mussel farms with dense coverage of macroalgae on droppers (Figure 12). Large heavy species like *Undaria* often sink to the benthos and are consumed by a variety of species, especially kina. Lighter species like sea lettuce appear to be carried away in tidal currents and do not seem to settle under farms. *Asparagopsis* is a light species and it is probable plant material would be carried by currents and quickly enter the marine food chain providing a source of productivity to the wider marine system. It is my opinion an impact would be difficult to detect, let alone an adverse impact.



Plate 12. Variety of algae naturally settled onto a mussel line in Tory Channel.



Plate 13. *Asparagopsis armata*.

5.6 Boundary adjustments

No species, habitats or communities that would be considered biologically significant (see Davidson *et al.* 2011 for criteria) were recorded from within or close to the application site. No adjustments to the boundaries to avoid such values is therefore necessary.

5.7 Significant sites and wildlife issues

Apart from a large marine mammal migratory area, no other significant sites are known from Onapua Bay (Davidson *et al.* 2011). Several significant sites are, however, known from the main Tory Channel (Davidson and Richards 2015). The closest site is 994 m north-west of the northern most application boundary. The significant sites located along the edges of Tory Channel are high current communities. No studies investigating mussel farm impacts have described an adverse impact at this distance with most mussel farm impact studies suggesting the maximum detectable impact distance being <35 m. Further, the present application is for an activity that will likely result in a lower level of impact compared to traditional production mussel farming.

The marine mammal area includes Cook Strait, Tory Channel and much of Queen Charlotte Sound. Cook Strait is recognised as a major migratory route for a variety of marine mammals and occasional whales enter Tory Channel and Queen Charlotte Sound. Within New Zealand, marine mammal entanglement in aquaculture structures to date has been a relatively minor issue, despite over 25 years of sea-cage salmon farming and several decades of oyster and mussel farming (MPI 2013). Generally, larger whales are considered more at risk of entanglement (Slooten *et al.* 2002). Collectively, seven incidences of baleen whale entanglements were associated with shellfish aquaculture (i.e. mussel, pearl and abalone) within New Zealand and western Australian waters between 1990 and 2011 (Groom & Coughran 2012). In New Zealand, there have been two reported incidences, the first was in 1996 and involved a Bryde's whale. The whale was found dead at Great Barrier Island, with a mussel spat line in its mouth. It was undetermined whether the whale had first died, then become entangled in the line, or if it died because of the entanglement (Lloyd 2003). The other incident was in 2011 and involved a humpback whale. First spotted by DOC staff near Banks Peninsula with a cray-pot buoy line tangled around its tail stock and flukes, the whale became entangled in mussel floats when it swam alongside a mussel farm in Hitaua Bay, Tory Channel several days later where it was cut free and released alive by a mussel farmer (S. Madsen pers. comm.).

5.8 Cumulative impacts

Concerns have been raised in the Marlborough Sounds in relation to the cumulative impact of food depletion by mussel farms. While depletion of zooplankton (e.g., direct consumption of fish eggs), or effects on zooplankton because of reduced food availability (i.e., phytoplankton depletion), are recognised as ways in which shellfish farms may affect coastal and estuarine food webs (Gibbs *et al.* 2005), knowledge of actual effects appears non-existent, and the literature on these issues focuses on phytoplankton depletion alone (Forrest *et al.* 2007).

Water current modelling studies suggest that mussel farms may be a “material” factor, but there also exist major drivers of the system such as cyclic weather patterns, water flow, and land nutrient input that likely have a greater influence on productivity (Zeldis 2008). Hadfield *et al.* (2014) and Broekhuizen (2015) have demonstrated that salmon farms likely result in elevated summer phytoplankton and zooplankton due to the release of nutrients. Two existing salmon farms and a recently developed new farm are in Tory Channel.

Hadfield *et al.* (2014) states in relation to Queen Charlotte Sound and Tory Channel that:

Winter: “Inspection of the relative concentration plots for the mussel farms scenario suggests that mussel farming has an almost imperceptible influence upon winter-time nitrate concentrations, but that ammonium concentrations are increased by 20-30% within the environs of the mussel farms (e.g. at the bay-scale in Otanerau/East Bay and in Port Gore). On the other hand, consumption of particulate organic matter (phytoplankton, zooplankton, small and large detritus) by the mussels induces reductions of ~10–15% in these bays.”

Summer: During the summer period, the presence of fish farms leads to dramatic (up to 200%) increases in the concentration of ammonium and large detritus in the immediate environs of the fish-farms. The far-field effects are of a much lesser magnitude (but evident throughout Queen Charlotte, and to a lesser extent Tory Channel). In the far-field, near-surface concentrations of ammonium (increase of 10-20% relative to the no farms situation), nitrate (0–10% increase), large detritus (10–20% increase), small detritus (0–5%, increase), chlorophyll (0–10%, increase) and zooplankton (0–15%, increase). The largest far-

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field increases tend to occur in inner Queen Charlotte Sound, whilst the smallest changes are in outer Tory channel.

The reduced effects in Tory Channel are likely related to strong tidal currents and the large tidal volume fluxes at around $20,000 \text{ m}^3 \text{ s}^{-1}$ at neap tide and $30,000 \text{ m}^3 \text{ s}^{-1}$ at spring tide.

Within Onapua Bay, currents are dramatically slower and consumption of food by mussels would likely be measurable, but results from modelling suggest that Onapua Bay may be subjected to elevated levels of phytoplankton and zooplankton due to the presence of salmon farms. No mussel farms presently exist in the bay making this proposed site the only source of marine farm food depletion. The depletion effect of this site if approved would, however be reduced due to the low stocking rates and biomass for oyster farming compared to production mussel farms.

Summary: Tory Channel is subject to large tidal fluxes; however, the side bays are slow moving. Salmon farms in Tory Channel elevate phytoplankton and zooplankton levels in Queen Charlotte Sound and the side bays of Tory Channel. This additional production will likely offset consumption of food by oysters and mussels in these side bays.

5.9 Monitoring and staged development

Based on the data collected during the present study, there have been no biological issues raised that show a need for staged development or biological monitoring. Further, the activity proposed is likely to have a lower impact compared to traditional mussel farms.

Should the MDC consider some monitoring occur, the following would be useful candidates for investigating the impacts associated with oyster farming:

- (a) Monitor sulphide and redox.
- (b) Monitor infauna.
- (c) Monitor chlorophyll *a* concentration.
- (d) Collect drop camera photos.

Summary: No biological reasons for a site-specific monitoring programme or staged development have been identified.



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Appendix 1. Onapua drop camera photographs

Photo site 1



Photo2

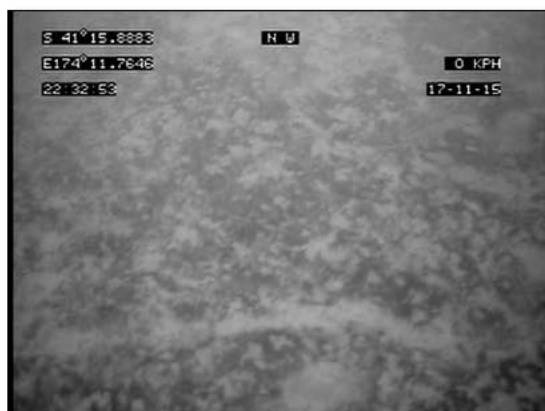


Photo site 3

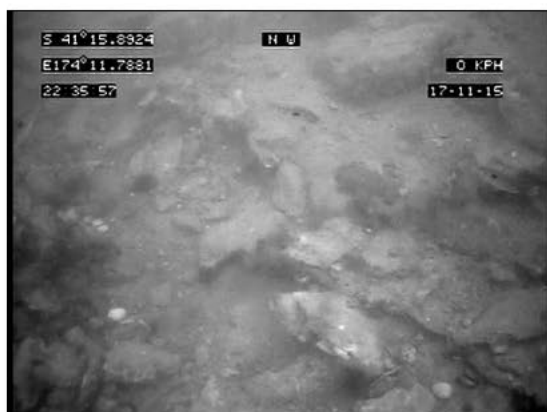


Photo site 4



Photo 5



Photo site 6



Photo site 7

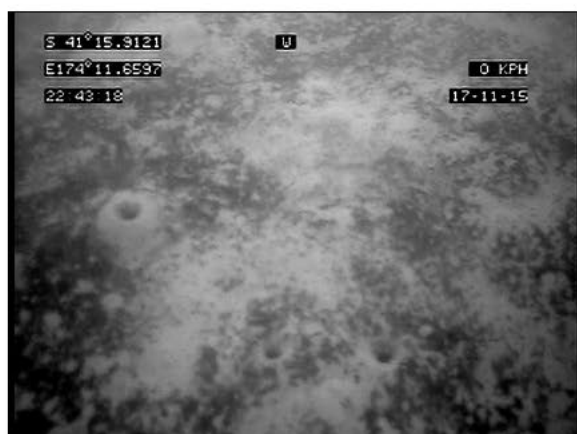


Photo site 8



Photo 9

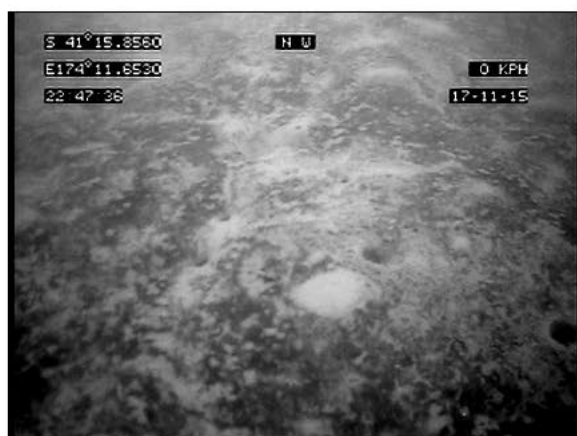


Photo 10



Photo 11



Photo 12



Photo 13



Photo 14



Photo 15



Photo 16



Photo 17



Photo 18



Photo 19

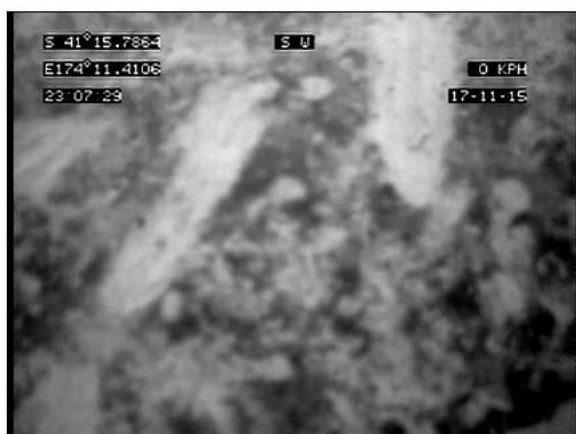


Photo 20



Photo 21



Photo 22



Photo 23



Photo 24



Photo 25



Photo 26



Photo 27

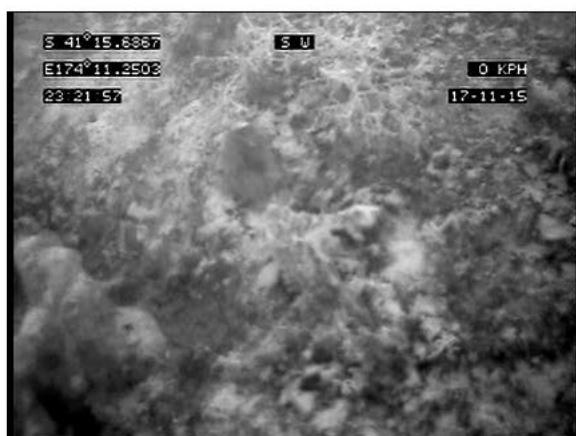


Photo 28

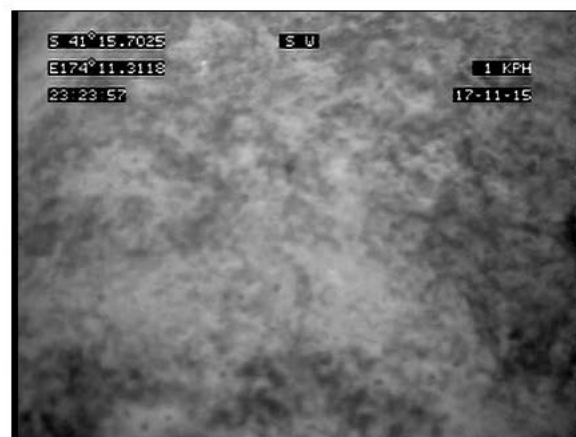


Photo 29



Photo 30



Photo 31



Photo 32



Photo 33



Photo 34



Photo 35



Photo 36



Photo 37



Photo 38



Photo 39



Photo 40



Photo 41



Photo 42



Photo 43



Photo 44



Appendix 2 Ngaruru Bay drop camera photographs

Photo 45



Photo 46



Photo 47



Photo 48





Davidson Environmental Limited

Additional data on a reef associated with an application for a new marine farm located in Onapua Bay, Tory Channel

Research, survey and monitoring report number 967

A report prepared for:
Apex Marine Farm Limited
C/O PALMS Ltd.
P.O. Box 751
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2.2 DROP CAMERA STATIONS	6
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1.0 Introduction and background

The present report provides additional information in relation to a proposed new marine farm located in Onapua Bay (Figure 1).

This additional information was collected in response to a letter provided to MDC from Dr Steve Ulrich, Department of Environmental Management, Lincoln University. Dr Ulrich reviewed new data collected by NIWA during a multibeam survey of Queen Charlotte Sound and Tory Channel (Neil et al. 2018). Using the new bathymetry data Dr Ulrich pointed out an area identified as rock outcrops that appeared to penetrate the middle farm application block (Figure 2). This habitat feature was not detected in the initial biological survey for the application (Davidson *et al.*, 2018).

The present study provides additional information in relation to this benthic feature. In particular, drop camera imagery is used to ground-truth the NIWA multibeam data to confirm the presence and extent of the rocky substrate.

Figure 1. Proposed marine farm (3 parts) located in Onapua Bay, Tory Channel.

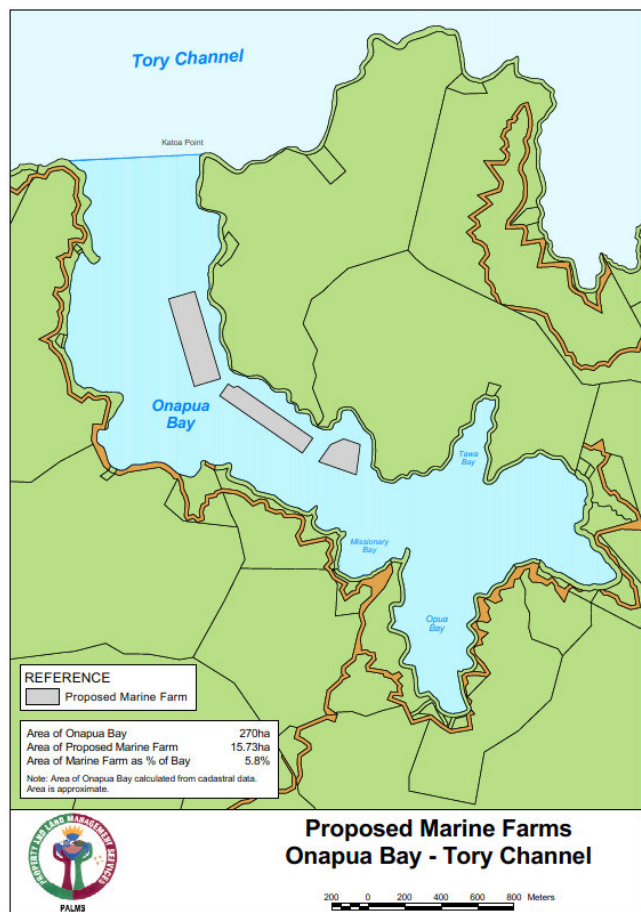




Figure 2. Figure produced in the letter by Dr Steve Ulrich showing area interpreted by NIWA as rock outcrops penetrating the proposed middle marine farm block.

2.0 Methods

The area was investigated on 26th June 2019. Prior to fieldwork, the proposed marine farm boundary and the NIWA shapefile for “rock outcrops” provided by Draughting Plus Limited were plotted onto mapping software (TUMONZ Professional). The shapefile data were initially obtained from the MDC smart maps database.

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



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marine farm surface structures and to pinpoint drop camera stations in the field. This GPS system has a maximum error of +/- 5 m.

2.1 Sonar imaging

Sonar investigations of the area were conducted using a Lowrance HDS-12 Gen 2 and HDS-12 Gen2 linked with a Lowrance StructureScan™ Sonar Imaging LSS-1 Module. These units provide right and left side imaging as well as DownScan Imaging™. The unit also allows real-time plotting of StructureMap™ overlays onto the installed Platinum underwater chart. A Lowrance HDS 10 Gen 1 unit fitted with a high definition 1kw Airmar transducer was used to collect traditional sonar data from the site.

Two alongshore sonar runs were conducted during the survey. One was conducted from a position inshore of the rocky structure and the other from a position offshore of the structure.

2.2 Drop camera stations

A total of 18 drop camera photographs were collected from the area around and within the target survey area (Figure 3). At each drop camera station, a Sea Viewer underwater splash camera and a wide beam, Sealife 4500 light, fixed to an aluminium frame was lowered to the benthos and an oblique still photograph was collected where the frame landed.

The location of each photograph station was selected in an effort to ground-truth substrata and habitats associated with the submerged ridgeline that penetrated the farm application area. All photographs collected during the survey have been included in Appendix 1.

3.0 Results

3.1 Drop camera stations

Of the 18 drop camera photos collected, three were located inshore of the farm application boundary (Figure 3, Table 1). Five of the 18 photographs were collected adjacent to the

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NIWA rocky substrate polygon with the remaining 13 collected in the NIWA rocky polygon (Figure 3, Table 1).

Rock was present at five stations sampled in the application (Figure 3, Table 1). Rock was characterised by vertically aligned outcrops (Plate 1). Some outcrops were raised up to an estimated 1-2 m from the surrounding benthos while others were low-lying (Plate 2). Areas supporting occasional cobbles were also observed around outcrop areas. Rock outcrops were confined to an area along the main subtidal ridge (Figure 3).

Areas on the ridge and offshore of rocky substrata and near the foot of the subtidal ridge were also characterised by combinations of silt, fine sand and whole and broken natural shell (Plate 3). Further seaward, deeper and at the foot of the submerged ridge, the benthos was dominated by silt (mud) with little or no shell material (Plate 4). Based on NIWA and Davidson *et al.* (2016) data, mud is widespread and covers the remainder of the farm application area.



Plate 1. Bedrock outcrops located inside the marine farm application (Photo 15, 9.6m depth).

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Plate 2. Low-lying bedrock outcrops surrounded by soft sediments in the farm application (Photo 14, 9.6m depth).



Plate 3. Low-lying bedrock outcrops surrounded by soft sediments in the farm application (Photo 18, 13.5m depth).

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Plate 4. Silt (mud) in the farm application (Photo 5, 14m depth).

6.2 Sonar data

An offshore (Figure 4) and an inshore (Figure 5) sonar run were collected relative to the submerged ridge identified by the NIWA multibeam data. The submerged ridge penetrates the proposed marine farm. The rock outcrops detected from drop camera images are visible on the inshore sonar run and shows rock extending into the proposed farm (Figure 5). The outcrops appear restricted to areas around the main spine of the submerged ridge. No rocky outcrops were detected further offshore.

Combining sonar and drop camera ground-truthing images confirm rock substrata in areas around the ridge spine. Adjacent areas were surrounded by shelly soft substrata. At the foot on the ridge, mud substrata becomes dominant (Figure 6).

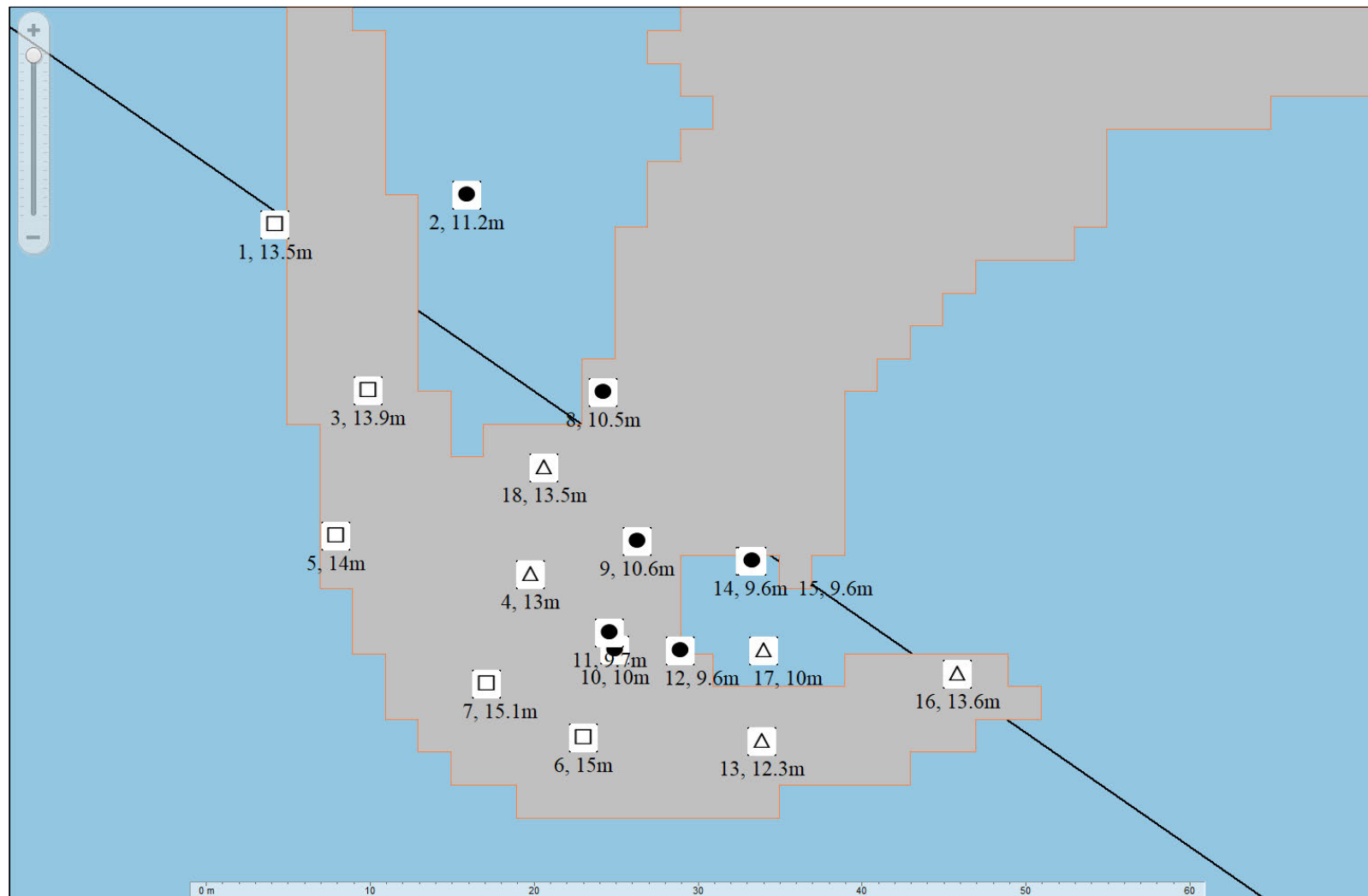


Figure 3. Proposed marine farm boundary (black line), rocky substrata polygon identified by NIWA (grey) and location of drop camera stations with station number and depths adjusted to datum. Open triangles = silt; open squares = silt and shell; closed circles = rock present.

Table 1. Drop camera data from stations inside the farm application (green) and outside the application. Stations are also colour coded according to inside the NIWA polygon (grey) or outside the NIWA polygon (blue).

No. & Depth (m)	Coordinates	Location of station	Relative to application	Substratum	Biological features seen
1, 13.5m	1699784.3,5431357.1	Adjacent to NIWA polygon	Inside farm application	silt (mud)	
2, 11.2m	1699796.0,5431358.9	Inside of NIWA polygon	Outside farm application	silt, whole natural shell, occasional cobbles	horse mussels, 11 arms star
3, 13.9m	1699790.0,5431347.0	Inside NIWA polygon	Inside farm application	silt (mud)	
4, 13m	1699799.9,5431335.8	Inside NIWA polygon	Inside farm application	silt, whole natural shell	
5, 14m	1699788.0,5431338.1	Inside NIWA polygon	Inside farm application	silt (mud)	horse mussel
6, 15m	1699803.1,5431325.8	Inside NIWA polygon	Inside farm application	silt (mud)	
7, 15.1m	1699797.2,5431329.1	Inside NIWA polygon	Inside farm application	silt (mud)	
8, 10.5m	1699804.3,5431346.9	Inside NIWA polygon	Outside farm application	bedrock, fine sand, broken natural shell	
9, 10.6m	1699806.4,5431337.8	Inside NIWA polygon	Inside farm application	fine sand, natural shell, occ cobbles, small outcropping rocks	scallop
10, 10m	1699805.0,5431331.2	Inside NIWA polygon	Inside farm application	silt, fine sand, whole & broken natural shell, occ cobble	
11, 9.7m	1699804.7,5431332.2	Inside NIWA polygon	Inside farm application	sand, whole & broken shell, occ cobbles, small rock outcrops	
12, 9.6m	1699809.0,5431331.1	Inside NIWA polygon	Inside farm application	bedrock, broken natural shell	tubeworm mounds
13, 12.3m	1699814.0,5431325.6	Inside NIWA polygon	Inside farm application	silt, whole natural shell	
14, 9.6m	1699813.3,5431336.6	Adjacent to NIWA polygon	Inside farm application	bedrock, sand, broken natural shell	
15, 9.6m	1699813.4,5431336.6	Adjacent to NIWA polygon	Inside farm application	bedrock	tubeworm mounds
16, 13.6m	1699825.9,5431329.7	Inside NIWA polygon	Outside farm application	silt, whole natural shell	
17, 10m	1699814.1,5431331.1	Adjacent to NIWA polygon	Inside farm application	silt, broken natural shell	
18, 13.5m	1699800.7,5431342.3	Inside NIWA polygon	Inside farm application	silt, whole natural shell	

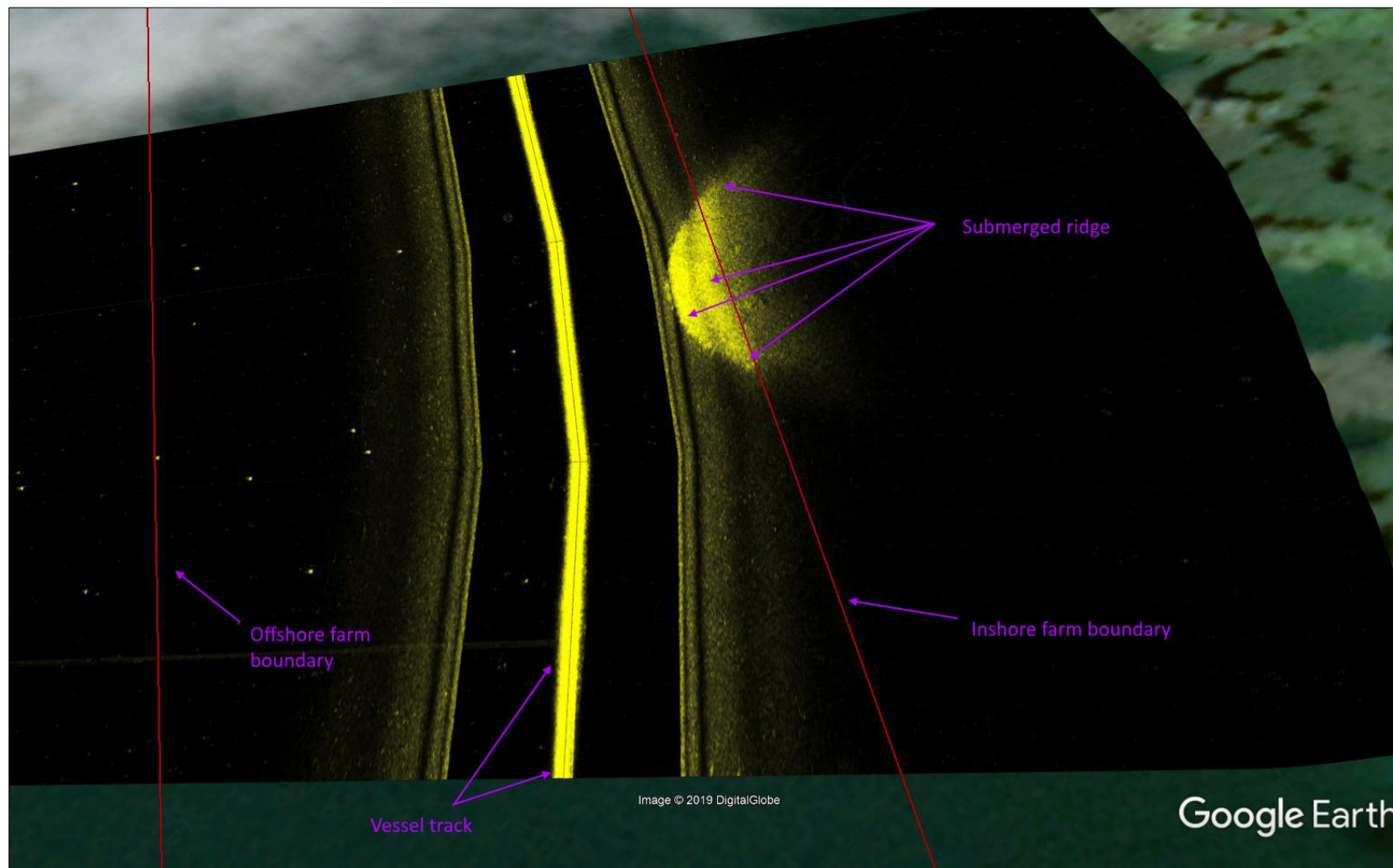


Figure 4. Offshore sonar run showing submerged ridge relative to the proposed farm.

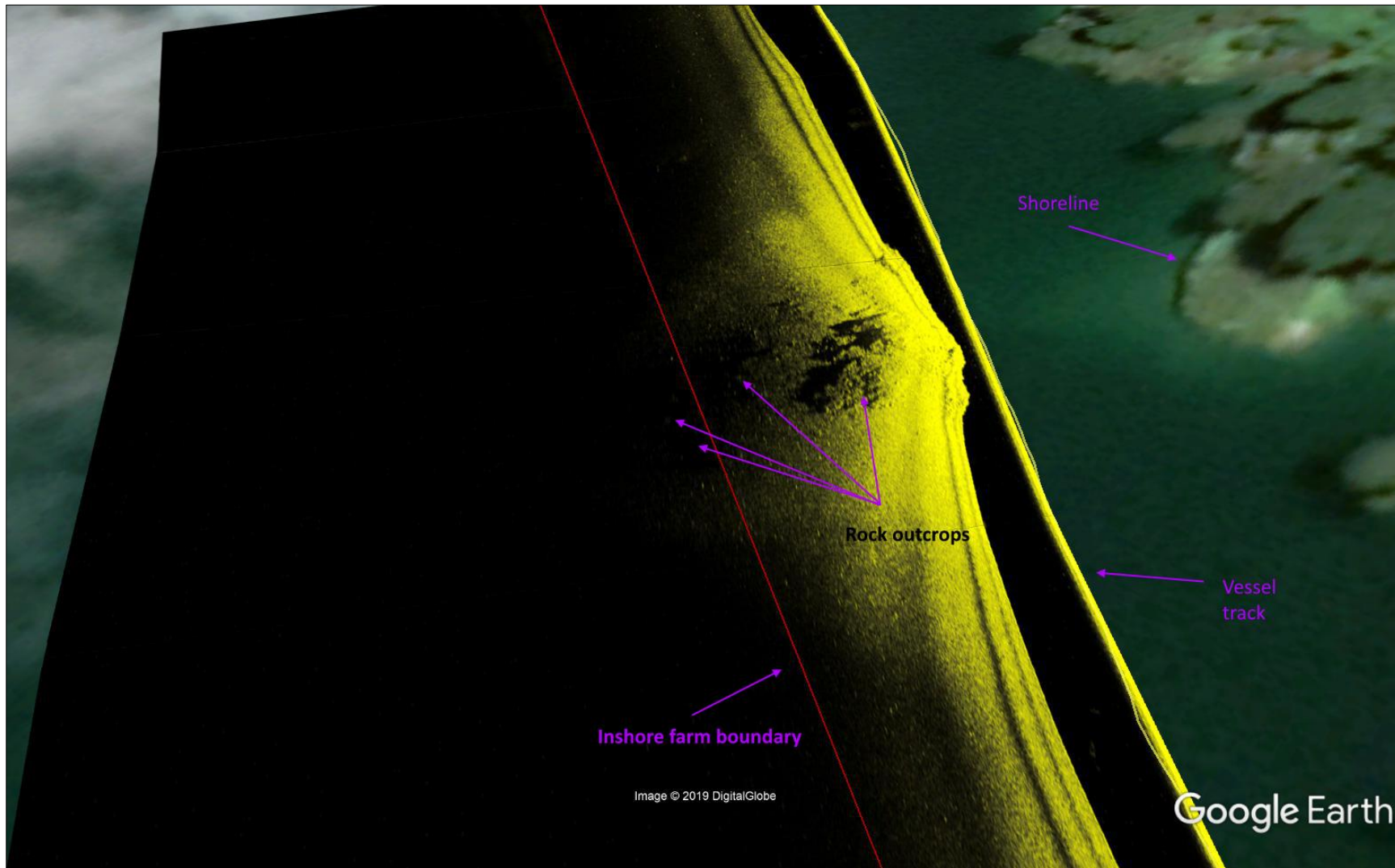


Figure 5. Inshore sonar run showing submerged ridge relative to the proposed farm. Rock outcrops are indicated on the image.

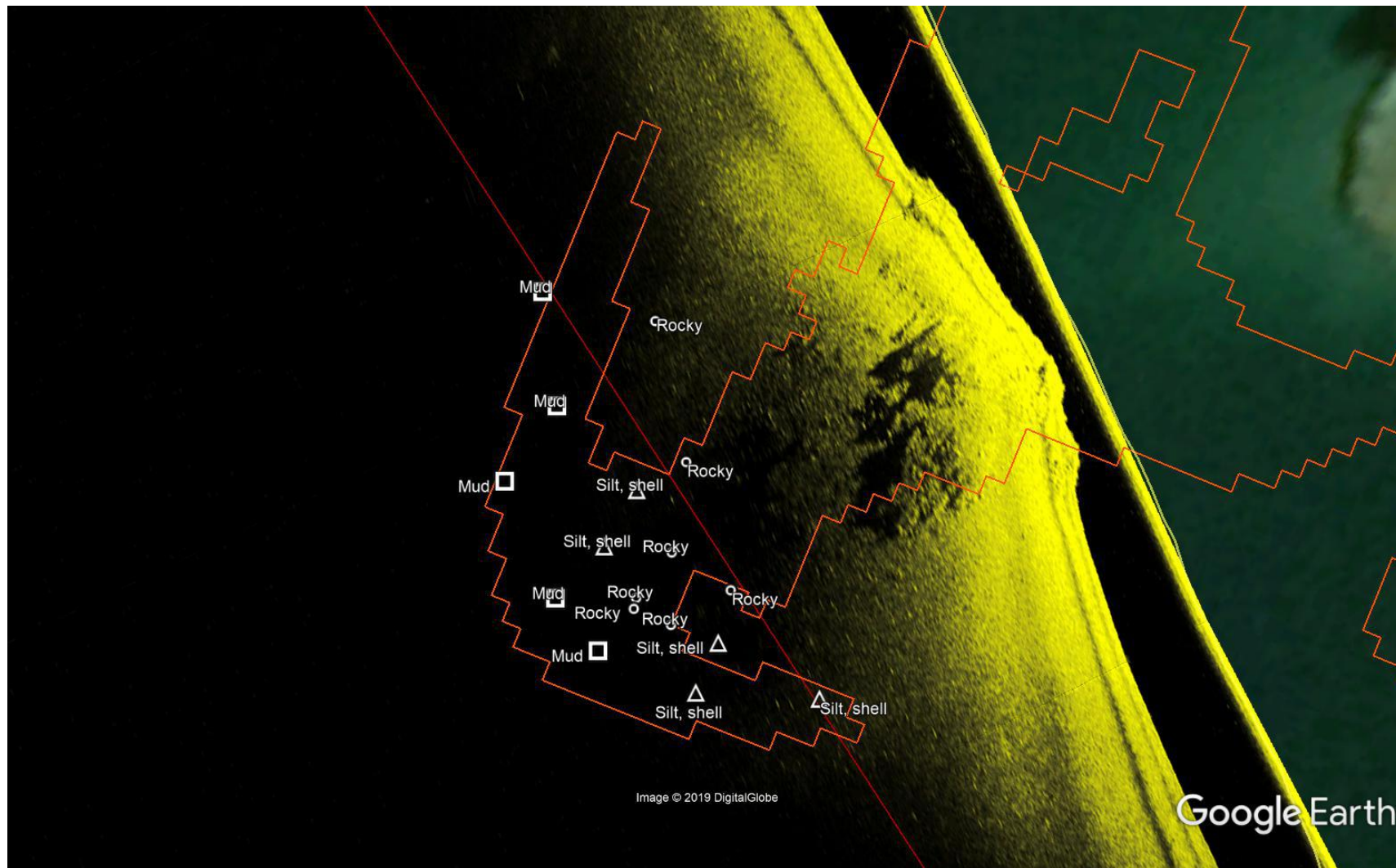


Figure 6. Location of substrata identified from drop camera images positioned onto the sonar data. Orange line = NIWA shapefile, red line = application boundary.

4.0 Conclusions and recommended boundary change

Both drop camera images and sonar data confirm the presence of rock substrata inside the proposed farm. Rock outcrops were most common along and near the spine of the submerged ridge and extended to close to the foot of the ridge (approximately 10 m distance inside the application). No rock was observed in areas north and south of the ridge. Some areas identified by NIWA as rocky outcrops were instead characterised by silt and whole and broken shell.

Rock substrate is traditionally avoided for marine farming activities. It is therefore recommended that the applicant modify the application to avoid rocky habitats. It is also suggested that a sufficient buffer zone between production structures and rocky areas is achieved. In this area, it is recommended that a 20 m buffer be applied to the offshore separation. For areas north and south of the rocky substrata, a smaller buffer zone is acceptable as the adjacent farm would be occupied by anchors and warps thereby providing additional buffer space between rock and growing structures.

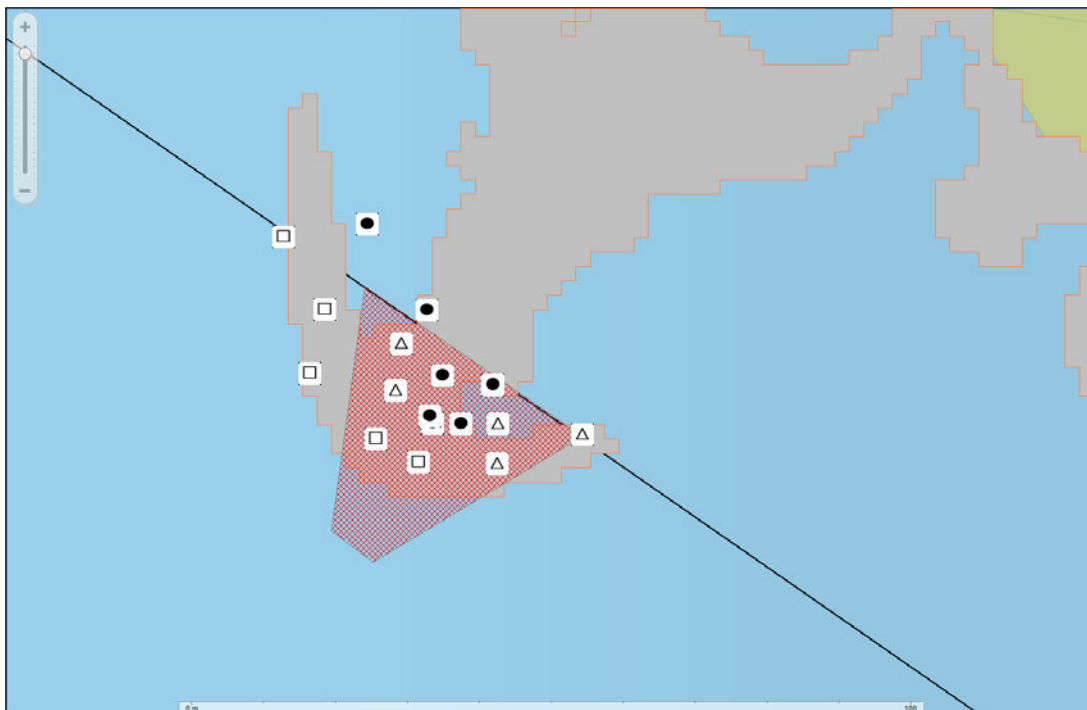


Figure 7. Suggested 0.068 ha area to be removed from the application (red hatched).

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Appendix 1. Onapua drop camera photographs 2019

Photo site 1



Photo2



Photo site 3

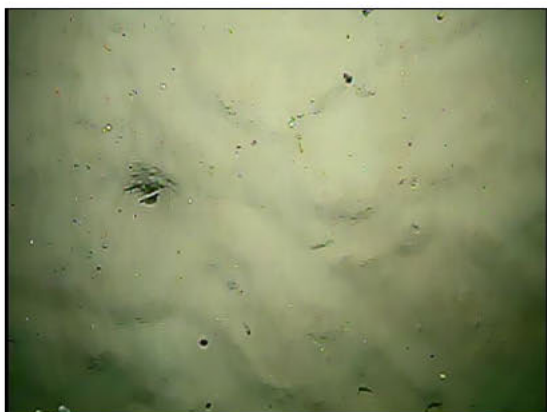


Photo site 4

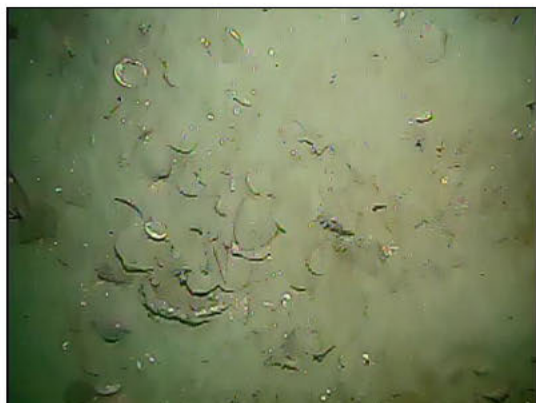


Photo 5



Photo site 6



Photo site 7

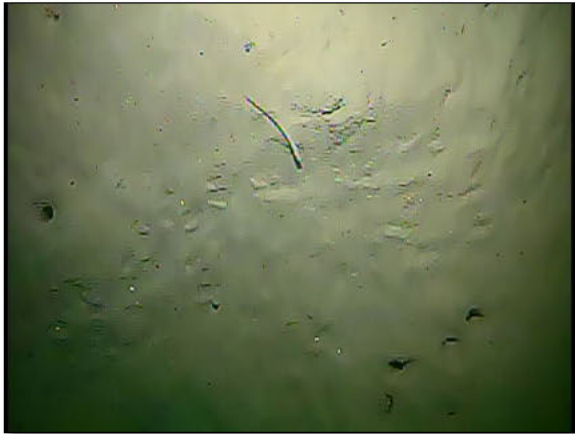


Photo site 8



Photo 9

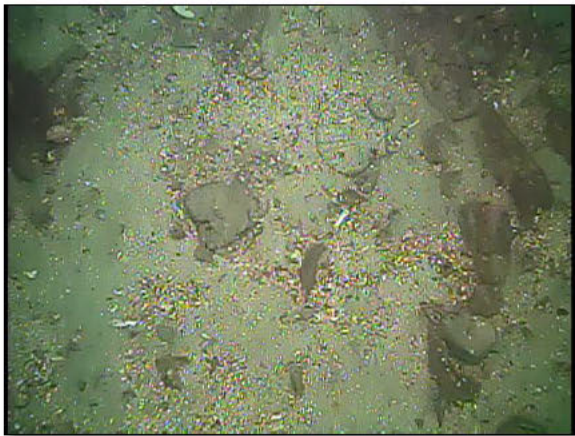


Photo 10



Photo 11

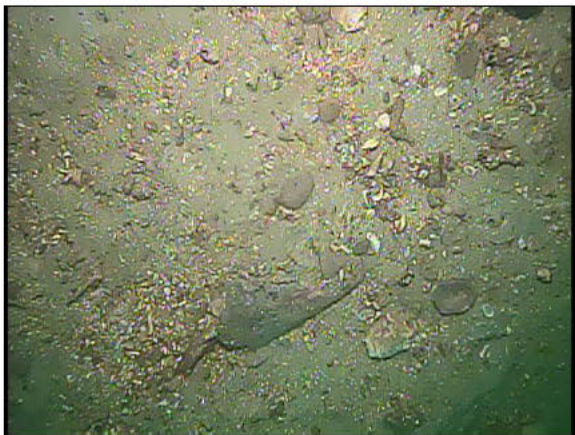


Photo 12



Photo 13



Photo 14



Photo 15



Photo 16

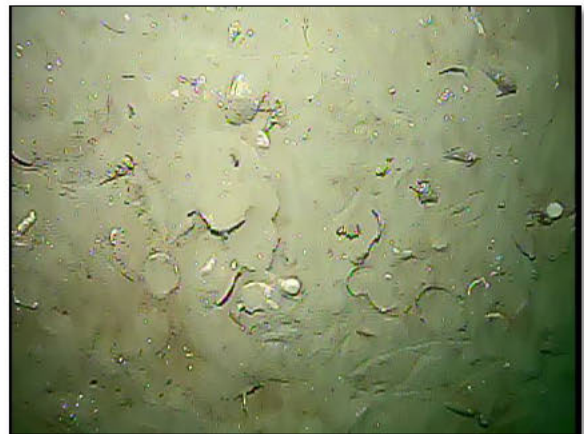


Photo 17



Photo 18





Davidson Environmental Limited

Diver sampled transects and high-definition video collected from a proposed new marine farm in Onapua Bay, Tory Channel

Research, survey and monitoring report number 1103

*A report prepared for:
Apex Marine Farm Limited
C/O PALMS Ltd.
15 Purkiss Street
Blenheim*

September 2021

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1.0 Introduction and identification of information gaps

The present report provides additional information for a proposed new marine farm located in Onapua Bay, Tory Channel (Figure 1).

This additional information was collected in response to a review of all biological data conducted for the MDC by Hilke Giles of Pisces Consulting Ltd. The review documents identified some gaps in knowledge and identified several areas of uncertainty (Giles 2021a, b, c). The present study aims to provide additional information to fill those gaps in knowledge and to provide additional comments on the uncertainties raised in the Giles (2021a, b, c) review (see gaps below).

New field-collected data:

- **Gap 1, 2.** Diver collected transect data describing major habitats and community types and their depth range at three sites (1 per farm block).
- **Gap 1, 2.** Diver collected handheld high-definition videos of representative habitats and community types.
- **Gap 2.** Remotely collected high-definition video from five sites extending from inshore of the consent to areas well into the consent areas.
- **Gap 1, 2.** Sonar profiles from representative transects extending from the shore into the application.

Additional comments provided:

- **Gap1.** Description of the reef, comments on the potential for adverse effects, comments on the appropriate buffer.
- **Gap 2.** Description of habitats and communities within and inshore of the application areas.
- **Gap 2.** Comments on the sensitivity of habitats and communities located within and adjacent to the application areas.
- **Effect nutrient uptake of algae.** Comments on the potential effect of nutrient uptake by farmed macroalgae.
- **Effect biosecurity.** Comments on biosecurity aspects of the species being farmed and their sources.



Figure 1. Location of proposed farm blocks in Onapua Bay, Tory Channel.

2.0 Methods

The study area was investigated on 2nd September 2021. Before fieldwork, the proposed marine farm boundary and the NIWA shapefile for “rock outcrops” provided by Draughting Plus Limited were plotted onto mapping software (TUMONZ Professional). The shapefile data were initially obtained from the MDC smart maps database.

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 fieldwork collected data including the diver sampled and remote video sampled transects. This GPS system has a maximum error of +/- 5 m.



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2.1 Diver transects and hand-held video

Divers collected profile data from three sites (one per proposed farm block) including a transect sampled at the reef (TR1) described in Davidson (2019) (Figure 2).

At each diver sampled site, a 100 m long lead-line transect was deployed from the survey vessel perpendicular to the coastline. The start and endpoint of each transect were plotted into Tumonz software.

Divers swam each transect from the low tide mark in an offshore direction. Divers stopped sampling where the low gradient mud seafloor became a consistent feature. Divers also recorded depths and distance along the transect at the points where habitat types changed (i.e. habitat transitions). It is noted that these delineations are where visually obvious transitions occur, however, it is noted they are transitions where overlaps in biotic and abiotic features remain common to both shore types. Within each zone or shore type, divers recorded dominant substrate and species as well as collecting representative bursts of high definition video using a GoPro7.

2.2 Remote high definition video

A total of five remote video sites were sampled (Figure 2). Each remote transect started inshore of the proposed farm blocks and extended variable distances into the farm blocks. At each site, a remote Paralens HD camera attached to a low definition cable camera was lowered to the seafloor. The low definition cable-equipped camera allowed real-time viewing of footage to ensure the camera remained close to the sea-floor. All footage was collected with a Sealife 5000 video light running at quarter strength.

The survey vessel was slowly reversed in an offshore direction. It is noted that the path was not directly straight due to winds and currents that caused the track to be jagged at times. Video footage was compiled into movies and presentative frame grabs were collected and presented in the report.

2.3 Sonar imaging

Sonar (side and down-scan) investigations of shore profiles were conducted using a Humminbird Solix 15 SI+ mega imaging unit. This unit provides right and left side imaging as well as down imaging used to collect profiles. A Lowrance HDS 12 Gen2 unit fitted with a



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high definition 1kw Airmar transducer was used to collect traditional sonar data from the site.

Subtidal profiles and habitat descriptions were collected at the three diver-sampled transect sites. Sonar was used to collect profiles at several other sites in each farm block (Figure 2). For sonar collected profiles, the survey vessel sampled a transect installed perpendicular to the coastline.

2.4 Video and photos

Video footage was compiled into movies using DaVinci Resolve software. Diver transect footage was compiled from short videos collected at intervals along each transect, while remote footage was continuously recorded from the point the camera reached the sea-floor to when it was raised. No footage of the seafloor was cut or removed from the final rendered videos. Representative frame grabs were collected from footage and presented in the present report.

Completed videos have been made available to the MDC and will be stored on their database.

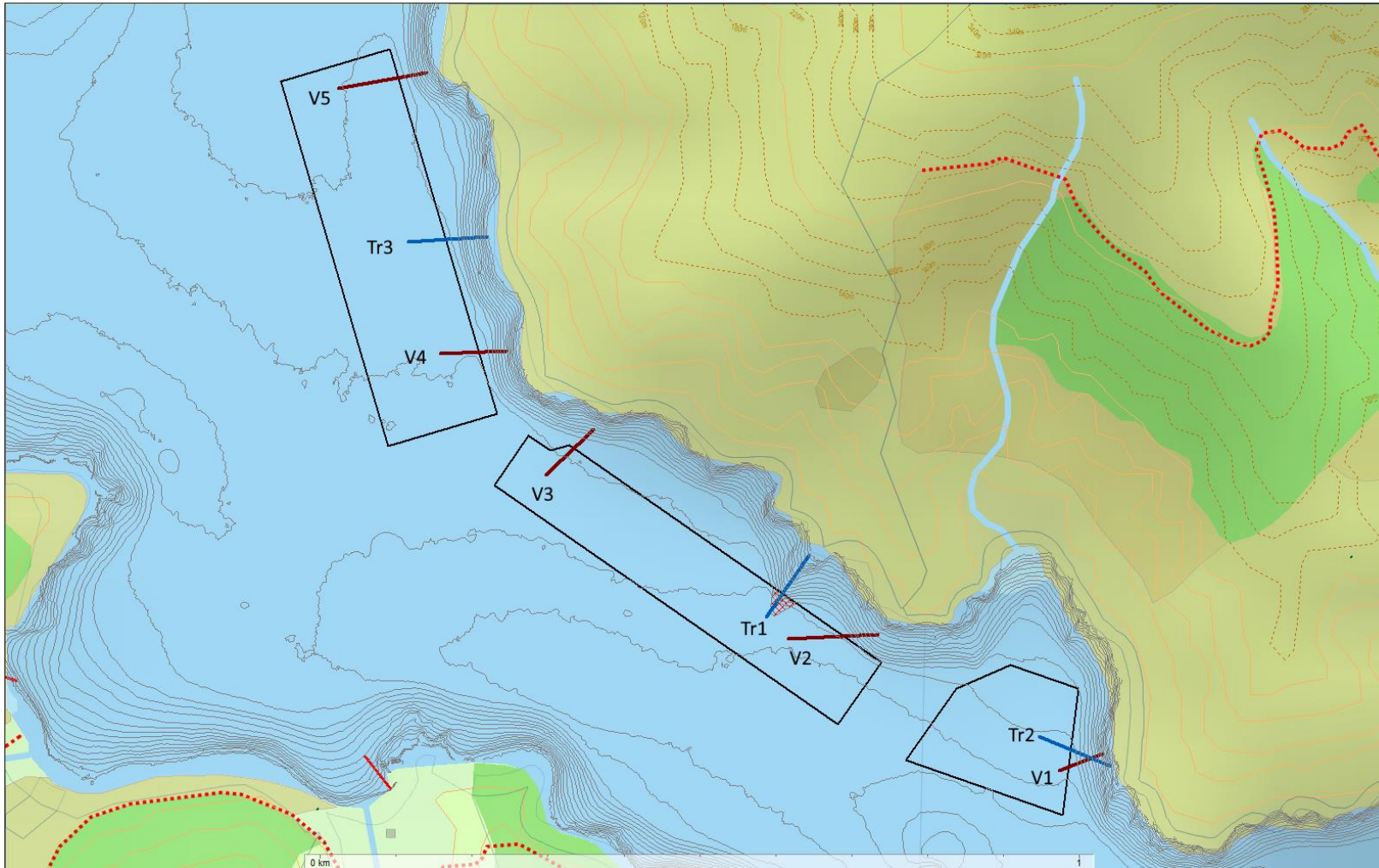


Figure 2. Location of the proposed marine farm (3 blocks) located in Onapua Bay, Tory Channel with diver sampled transects (blue) and remote video sites (red) shown relative to the proposed blocks. NIWA multibeam 1m depth contours are shown in grey.

3.0 Results

3.1 Diver collected transect descriptions

Three diver-sampled transects were collected, one per application block. One diver transect was installed along the reef previously surveyed by Davidson (2019).

3.1.1 Diver transect 1 (reef, middle application block)

Substrata

A bedrock dominated reef extended to 84m distance from low tide into the middle application block. The reef proper was characterised by combinations of bedrock, boulders, cobbles, sands, silt and natural shell (Table 1) (Plates 1 & 2). At the foot of the reef, soft substrata dominated by silt, fine sand, and natural shell were present (Plates 2 & 3). At 90 m distance from low tide and 15.4 m depth, the benthos became flat and dominated by silt and clay (mud) (Plate 4).

Flora and fauna

A typical range of reef-dwelling species associated with sheltered side bays of Tory Channel were observed from the reef. Sparse macroalgae (*C. flexuosum*) and *Codium adherens* were observed from the shallow subtidal zone. In the shallows, blue mussels were common and dead mussel shell was observed over the nearshore areas of the reef. Invertebrates on the reef were dominated by several gastropods (e.g. cats-eye, several topshell species) and echinoderms (11 arm seastar, kina, cushion star, sea cucumber). Small hydroids were also common on rock surfaces.

Galeolaria hystrix tubeworm individuals were present on the reef. Of note were *Galeolaria* mounds, some of which were relatively large (Plate 5). It was noted that some mounds were becoming smothered in *Chaetopterus* worms. It is unclear if *Chaetopterus* sp. is introduced or is native and going through a population boom.

New knowledge

The diver sampled reef transect was characterised by the same substrata, habitats and associated communities described by Davidson (2019), however, the present survey showed *Galeolaria* mounds were more common than originally described. It is unlikely *Galeolaria*

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mounds have become more abundant between the surveys. This result is therefore most likely explained due to the two sampling techniques used. Drop camera sampling records data from points with gaps between, while diver sampling gathers information from the entire reef structure.

Table 1. Summary of main habitat community types from the reef diver sampled transect located in the middle application block.

Distance (m)	Depth (m)	Habitat/community type	Characteristic species
0	0	Bedrock ridges, sand, natural shell	Blue mussels. <i>C. flexuosum</i> , gastropods, kina, sea cucumber, cushion star
25	4.7	Bedrock, boulder, cobble, sand, natural shell	<i>Galeolaria</i> mounds (occasional), gastropods, kina, sea cucumber, cushion star, 11 arm, hydroids
45	6.7	Fine sand, natural shell, occasional boulder & cobble, patchy bedrock	<i>Galeolaria</i> mounds (large mounds), gastropods, kina, sea cucumber, cushion star, red branching algae, <i>Chaetopterus</i> sp (abundant), scallop, horse mussel
55	10.3	Fine sand, silt, natural shell, occasional boulder & cobble, patchy bedrock	<i>Galeolaria</i> mounds (large, occasional), gastropods, kina, sea cucumber, cushion star, red branching algae, <i>Chaetopterus</i> sp (sparse), scallop, horse mussel
85	14.7	Silt, natural shell	Scallop, kina
90	15.4	Silt and clay	Diatom film, horse mussel (rare)



Plate 1. Bedrock reef at approximately 25 m distance from low tide and 5 m depth.

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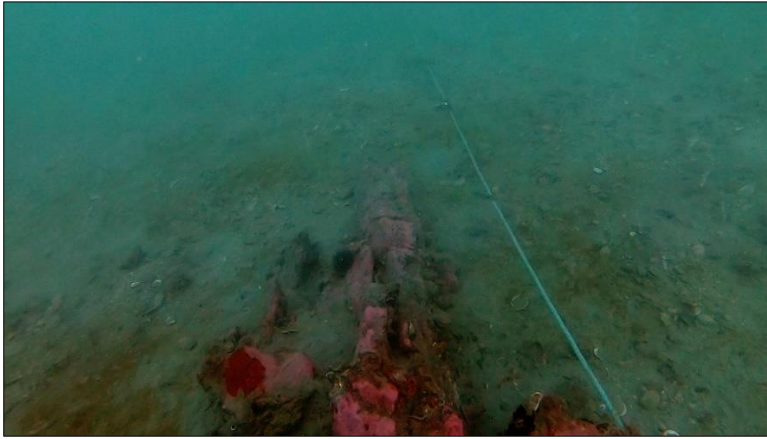


Plate 2. Offshore tip of the reef at 84 m distance from low tide and 14.7m depth. Soft substrate characterised by silt, fine sand and natural shell surrounds the foot of the reef.



Plate 3. Silt, fine sand and natural shell located immediately offshore of the bedrock reef 84m to 90m distance from low tide (14.7m to 15.4 m depth).

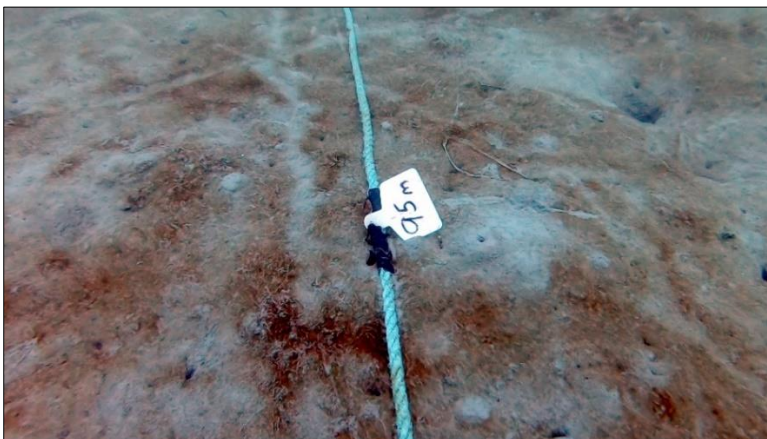


Plate 4. Silt and clay with a diatom film located offshore of the silt and shell zone extending from 90m distance from low tide (15.4 m depth).



Plate 5. Large *Galeolaria* mound on the reef being smothered by *Chaetopterus*.

3.1.2 Diver transect 2 (southern application block)

Substrata

Bedrock, cobbles and boulders dominated shallow areas of this diver collected transect. Rocky substrata extended to 27 m distance from shore and to 8.3 m depth (Table 2. Plates 6 & 7). These rock dominated shores were then replaced by silt, fine sand and natural shell substrate (Plate 8). With increasing depth and distance from shore, the fine sand and shell components declined (Plate 9). At 55 m distance from shore and 14.2m depth, the benthos transitioned to silt and clay (Plate 10).

Flora and fauna

A range of typical rock-dwelling species usually associated with sheltered side bays of Tory Channel were observed at diver transect 2. Sparse macroalgae (*C. flexuosum*) and *Codium adherens* were observed from the shallow subtidal zone. In the shallows, blue mussels encrusted with barnacles were common but patchy. Invertebrates on the reef were dominated by several gastropods (e.g. cats-eye, several topshell species) and echinoderms (11 arm seastar, kina, cushion star, sea cucumber).

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Chaetopterus worms were common on the shore slope below approximately 7m depth. Scallop, ostrich-foot whelks and horse mussels were present with most being observed on the low shore slope. Scallops and occasional horse mussels were observed on the mud benthos further from shore. A diatom film was widespread on the surface of offshore mud habitats (Plate 10).

New knowledge

The substrata, habitats and communities at this location are mostly comparable to those described by Davidson et al. (2016). *Chaetopterus* was not present in 2016 and scallops appeared more widespread in the present survey compared to 2016.

Table 2. Summary of main habitat community types from the reef diver sampled transect located in the middle application block.

Distance (m)	Depth (m)	Habitat/community type	Characteristic species
0	0	Bedrock, boulder, cobble, sand, natural shell	Blue mussels, <i>C. flexuosum</i> , gastropods, hydroids, kina, sea cucumber, cushion star, <i>Codium</i>
10	1.7	Bedrock, boulder, cobble, sand, natural shell	<i>Galeolaria</i> , <i>ga</i> stropods, kina, sea cucumber, cushion star, 11 arm, hydroids, solitary ascidian
27	8.3	Fine sand, silt, natural shell	Kina, sea cucumber, cushion star, red branching algae, <i>Chaetopterus</i> sp (common), scallop, horse mussel
40	11.7	Silt, natural shell	Kina, sea cucumber, cushion star, red branching algae, <i>Chaetopterus</i> sp (rare), scallop, horse mussel
55	14.2	Silt & clay	Diatom film, horse mussel (rare), scallop, solitary ascidian



Plate 6. Bedrock reef fringe terminating on cobbles near low tide. Note blue mussels and encrusting barnacles.

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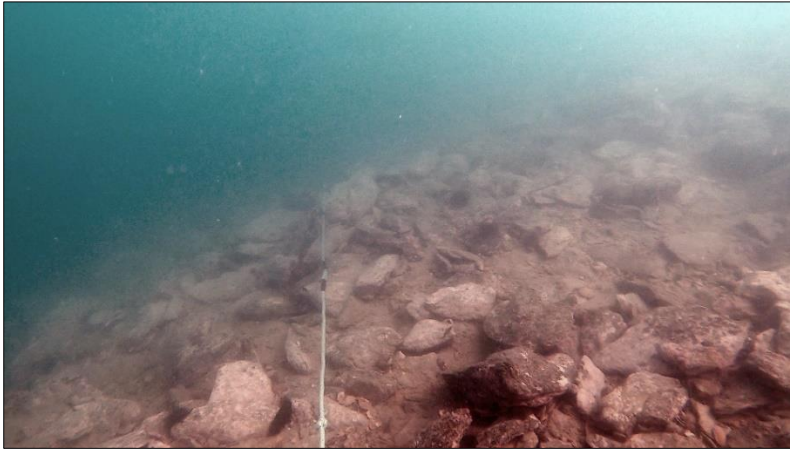


Plate 7. Cobble bank located below the fringe of bedrock (0 to 27 m distance from low tide).



Plate 8. Silt, fine sand and natural shell located below rocky substrata between 27m to 40m distance from low tide (8.3m to 11.7 m depth).

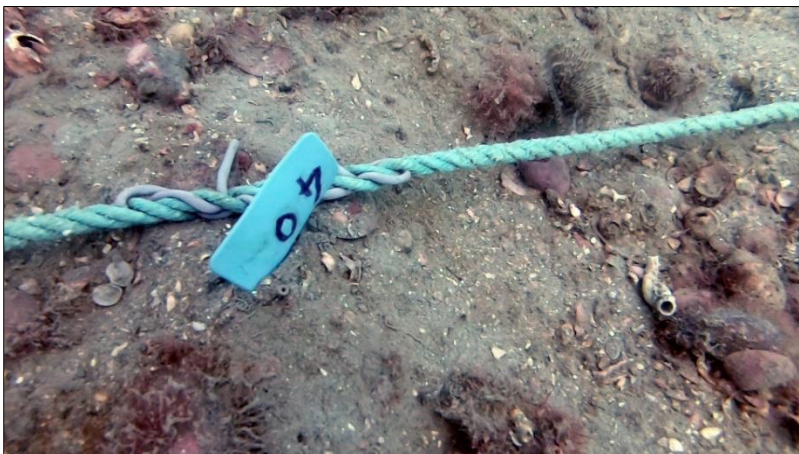


Plate 9. Silt and natural shell extending from 40m to 55m distance from low tide (11.7 m to 14.2m depth).

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Plate 10. Silt and clay from 55 m distance from low tide (14.2 m depth).

3.1.3 Diver transect 3 (northern application block)

Substrata

Cobbles dominated shallow areas of this diver collected transect (Table 3, Plates 11 & 12). With increasing depth and distance from shore the fine sand, silt and natural shell components increased (Plate 13). Rock and coarse soft-sediment shores were then replaced by silt, fine sand and natural shell substrate from 30m to 45m distance from shore (Plate 14). In this soft-sediment dominated zone on the shore slope, *Chaetopterus* and branching red algae were abundant. At the foot of the shore slope, the benthos transitioned into silt and clay at 45m distance from low tide and 11.2m depth. (Plate 15).

Flora and fauna

A typical range of rock-dwelling species usually associated with sheltered side bays of Tory Channel were observed at diver transect 3 (northern application block). Sparse macroalgae (*C. flexuosum*) and *Codium adherens* were observed from the shallow subtidal zone. In the shallows, blue mussels encrusted with barnacles were common in distinct patches. Invertebrates on the rocky substrata were dominated by several gastropods (e.g. cats-eye, several topshell species) and echinoderms (11 arm seastar, kina, cushion star, sea cucumber). The orange coloured compound ascidian (*Aplidium benhami*) was common down to approximately 7.5m depth.

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Chaetopterus worms were abundant in a distinct zone on the shore slope approximately 7m to 10.5 m depth. Scallops and occasional horse mussels were observed on the mud benthos further from shore. A diatom film was widespread on the surface of offshore mud habitats (Plate 10).

New knowledge

The substrata at this location were mostly comparable with that described by Davidson et al. (2016). *Chaetopterus* was not present in 2016 and is now very abundant in a distinct zone on the shore slope where soft sediments have a component of coarse material. Branching red algae were abundant in this zone and these were not abundant in the 2016 survey. Overall the communities on the mid to lower slope appeared very different in 2021 due to the effect of the biogenic *Chaetopterus* zone.

Table 3. Summary of main habitat community types from the reef diver sampled transect located in the middle application block.

Distance (m)	Depth (m)	Habitat/community type	Characteristic species
0	0	Cobble, boulder, sand, natural shell	Blue mussels. <i>C. flexuosum</i> , gastropods, hydroids, kina, sea cucumber, cushion star
10	1	Cobble, fine sand, natural shell	<i>Galeolaria</i> , gastropods, kina, sea cucumber, cushion star, 11 arm, hydroids, solitary ascidian, branching red algae, <i>Aplidium</i>
20	5	Cobble, fine sand, natural shell	Kina, sea cucumber, cushion star, red branching algae, <i>Chaetopterus</i> sp (common), scallop, horse mussel, <i>Aplidium</i>
30	7.5	Fine sand, silt, natural shell	Kina, sea cucumber, cushion star, red branching algae, <i>Chaetopterus</i> sp (abundant), scallop, horse mussel
45	11.2	Silt & clay	Diatom film, horse mussel (rare), scallop, solitary ascidian, wire worms, ostrich foot whelk



Plate 11. Bedrock reef fringe terminating on cobbles near low tide. Note blue mussels and encrusting barnacles.

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Plate 12. Cobble bank located below the fringe of bedrock (0 to 30 m distance from low tide).

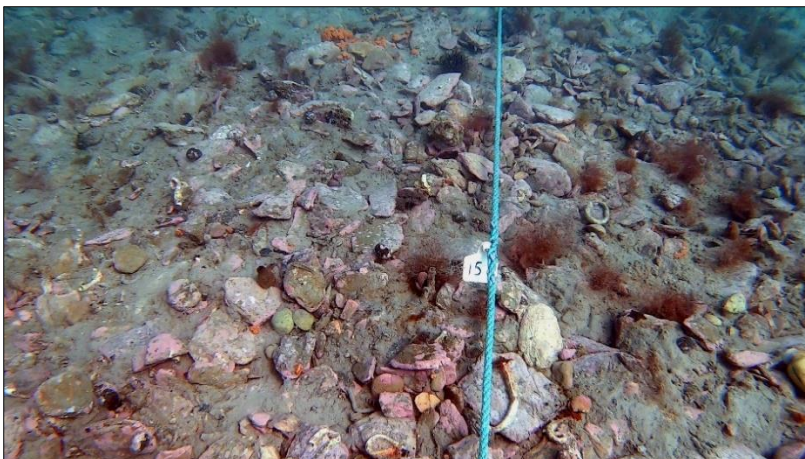


Plate 13. Cobbles, fine sand, silt and natural shell located on the shore slope to 30 m distance from shore (to 7.5 m depth).



Plate 14. Silt, fine sand and natural shell extending from 30m to 45m distance from low tide (7.5 m to 11.2m depth). Note the high density of *Chaetopterus* and abundant branching red algae.

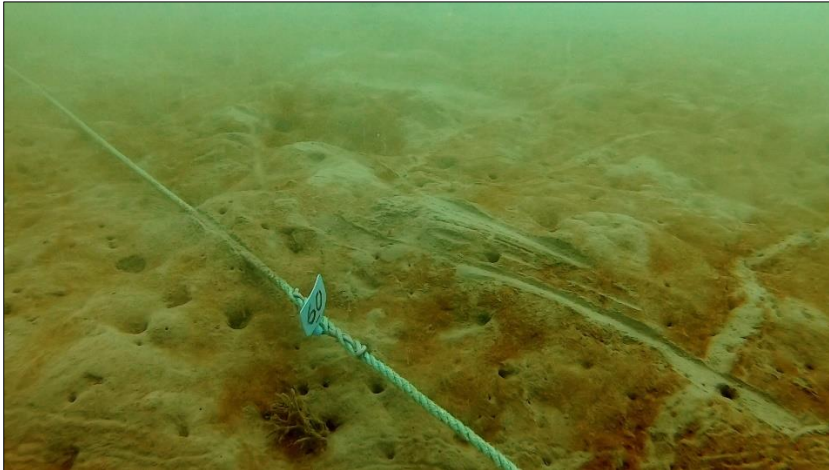


Plate 15. Silt and clay starting at 45 m distance from low tide (11.2 m depth onwards). Note the diatom film on the mud surface.

3.2 Remote video transects and sonar profile descriptions

Five remote HD video transects between 60m and 120m in length were sampled from the three application blocks (Figure 2). Transects were started at approximately 6-8 m depth and inshore of the application blocks. The boat was controlled to travel slowly into the application blocks. The camera continuously recorded depths onto footage collected along these transects. The tide was approximately 1 m higher than low water during sampling, therefore 1 m should be substrated from depths imprinted into footage by the camera.

All five remote video profiles showed a comparable range of substrata, habitats and flora and fauna. Excluding the diver transect 1 from the reef, diver collected profiles were also comparable to remote video footage.

3.2.1 The reef profile

Bedrock outcrops were visible across and down the submerged ridge (Figure 3 & 4). Bedrock was interspersed by cobbles, boulders, sand and shell. Both reef and coarse soft substrata extended a sufficient distance from shore to penetrate the middle application area.

Davidson (2019) suggested an exclusion zone to ensure these substrata and habitats were avoided by the proposed marine farm structures (see red area in Figure 4).

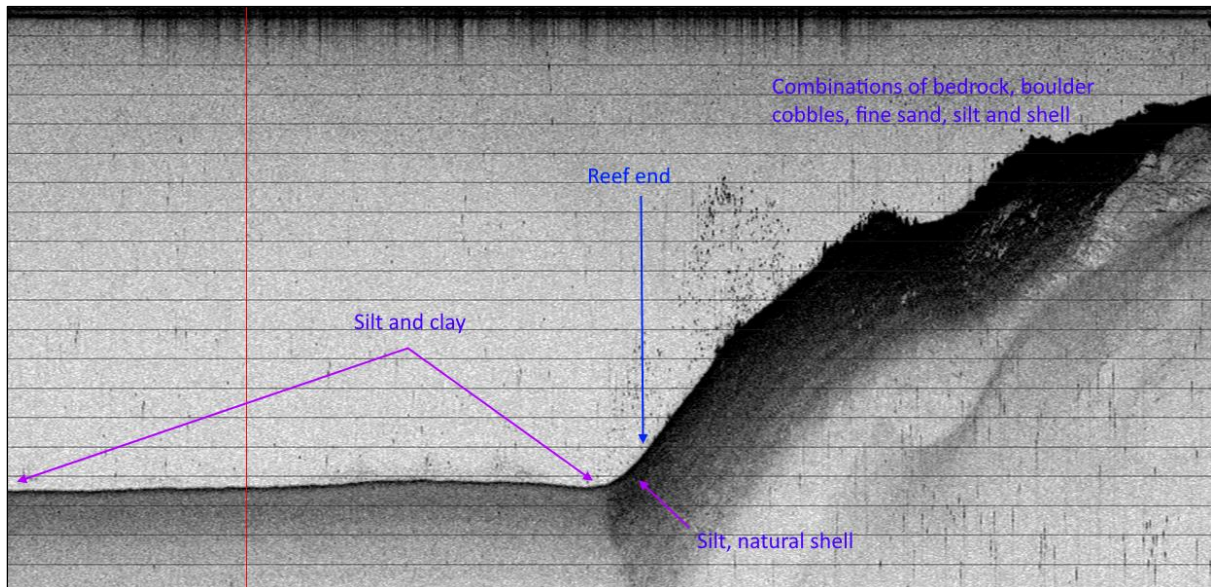


Figure 3. Sonar down-scan profile of the reef (profile 1). Horizontal lines are 1 m contours collected at 1.3 m above low tide.

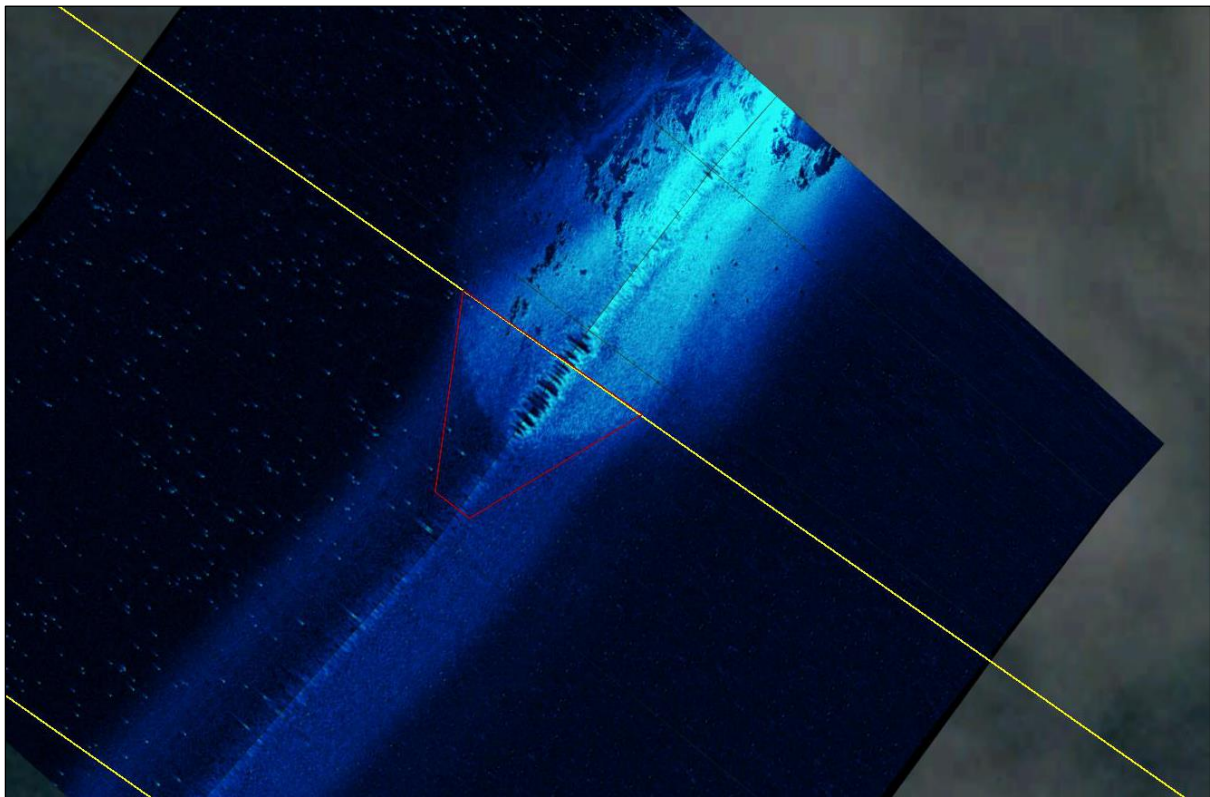


Figure 4. Sonar scan from Profile 1 (the reef), the application boundaries (yellow) and the exclusion area suggested by Davidson (2019). The shoreline is at the top of the image.

3.2.2 Profiles 2 to 10 and associated biotic features

Nine additional sonar profiles were collected extending from near low tide to the offshore edge of the application blocks (i.e. perpendicular to the shoreline) (Figures 5 & 6).

Based on diver sampled transects (N=3), the remote video transects (N=5) and the sonar profiles (N=10), the substrate and associated flora and fauna (communities) were compared between sample sites. Overall these features remained remarkably similar at all sites along this coast, however, there were some patterns observed differentiating the southern area from the middle and northern stretches of this coast. This pattern was mostly due to the abundance of *Chaetopterus* being moderate in the south and abundant in the middle and northern stretches of coast (i.e. *Chaetopterus* was not sufficiently abundant in the south to form a biogenic habitat).

Transitions between each habitat/community type appear to be strongly influenced by depth and substrata. The following zones patterns were common to all sites excluding the reef (diver transect 1).

(1) Upper shore slope (0 to 4m depth):

This area of the shore is dominated by rocky material and a small component of coarse soft substrata. Fringe zones often support bedrock outcrops surrounded by small boulders and cobbles.

A range of rocky dwelling species were present in these areas. Dominant surface-dwelling species were dominated by gastropods, echinoderms, hydroids, and ascidians. The species and communities recorded in this zone were characteristic of sheltered bays subjected to low wave and current energies.

(2) Middle shore slope (4m to 8m depth):

As depth increased soft sediments, mostly fine sands, silt and broken and whole dead shell also increased. With increasing distance from shore, bedrock and boulders were the first to disappear. With increasing depth, cobbles decrease in size and become a declining component, while soft-sediment cover generally increases.

A range of rocky and soft sediment-dwelling species were present in these areas. Dominant surface-dwelling species were dominated by gastropods, echinoderms,

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hydroids, and ascidians. The species and communities recorded in this zone were characteristic of sheltered bays subjected to low wave and current energies. *Chaetopterus* was usually present but not at high densities.

(3) Lower shore slope (8m to 11-15m depth):

Silt, fine sands and broken and dead whole shells dominated the lower shore slope.

Species characteristic of this zone were scallop, horse mussels, solitary ascidians, red algae, and tubeworms. *Chaetopterus* often formed dense beds in this zone, particularly adjacent to the middle and northern application blocks. Branching red algae and numerous juvenile spotty were usually associated with *Chaetopterus* beds in this zone.

(4) Low gradient soft bottom (11-15m plus depths):

From the foot of the slope seawards the benthos was characterised by silt and clay (i.e. mud). Apart from the exclusion zone, this habitat extended over all of the application blocks and likely dominates most of the offshore areas of the wider Onapua Bay.

Occasional horse mussels and scallops were observed from this habitat. Occasional clumps of non-calcareous worms likely to be *Spiochaetopterus* spp. and *Acromegalomma suspiciens* were observed in these offshore areas within the application (Plate 16). Non-calcareous tubeworms can become colonised by a variety of species including sponges, ascidians, algae and bivalves (Anderson et al., 2020). At this site, clumps of these worms are sparse and patchy and not at an abundance level that could be considered a bed.

Both *Spiochaetopterus* spp. and *Acromegalomma suspiciens* are found on mud bottoms in the Marlborough Sounds (Anderson et al., 2020). In Port Underwood they have formed dense beds and have themselves been colonised by a variety of species, particularly sponges and colonial ascidians (Davidson et al. in prep.). They appear to be tolerant of high turbidity environments.

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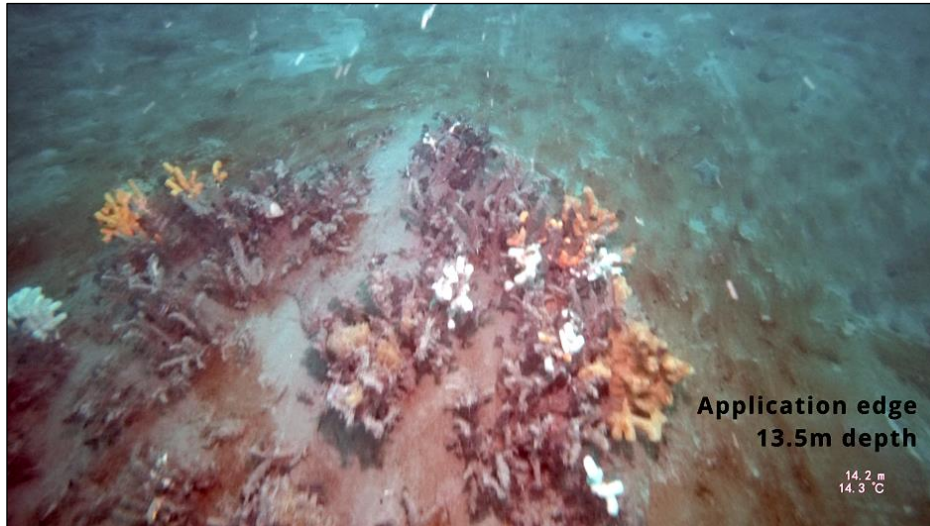


Plate 16. Occasional patches of non-calcareous tubeworms inside the middle and northern application blocks in Onapua Bay.

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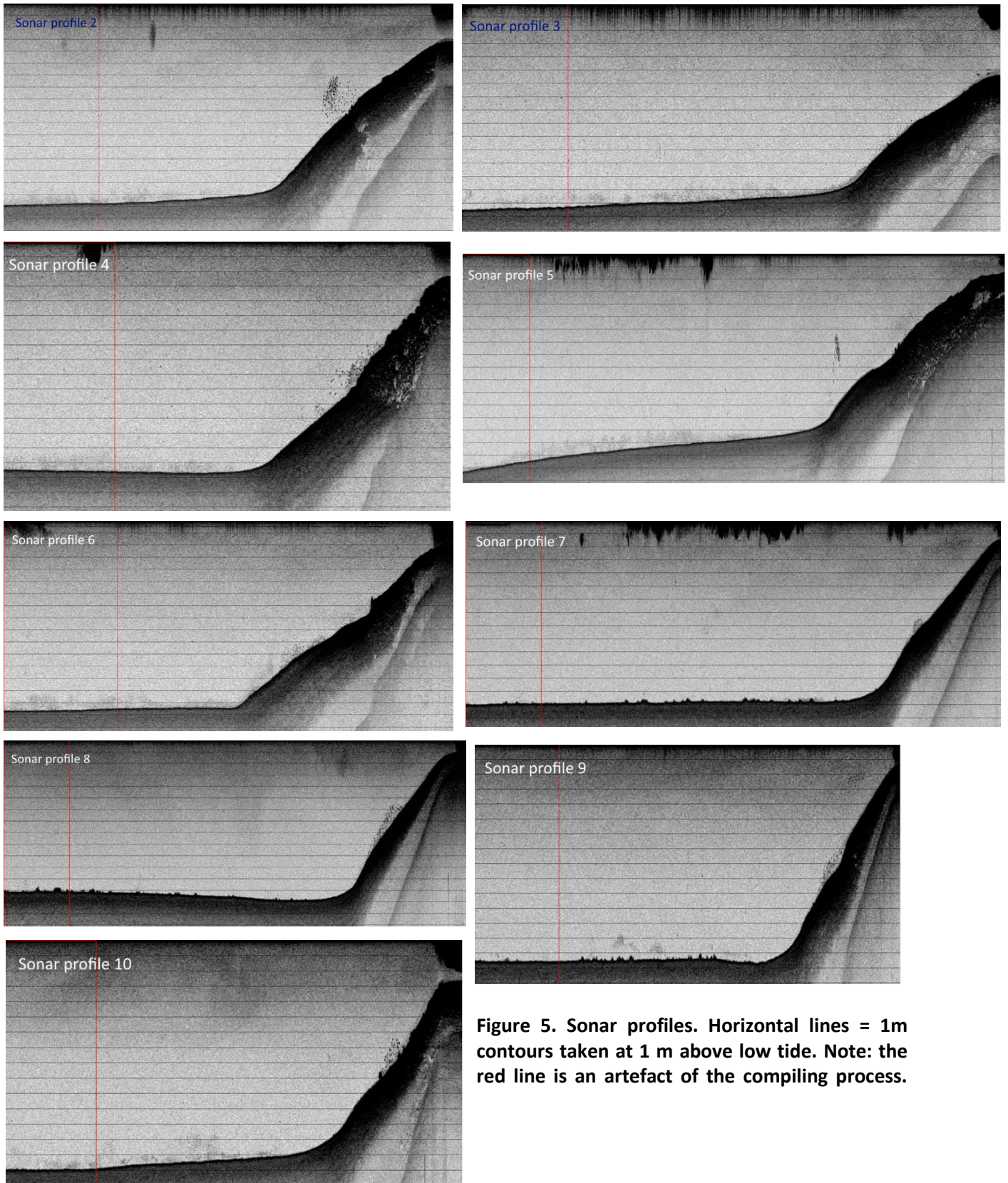


Figure 5. Sonar profiles. Horizontal lines = 1m contours taken at 1 m above low tide. Note: the red line is an artefact of the compiling process.



Figure 6. Location of shore sonar profiles (blue). Yellow = application blocks, red area = exclusion zone.

4.0 Discussion

4.1 Habitats and communities

Apart from the exclusion zone located in the middle application block, the three application areas were located over a low gradient mud dominated benthos. The infauna have been described by Davidson et al. (2016) as typical of mud dominated areas in the sheltered bays of the Marlborough Sounds and New Zealand. The author described the epifauna in these areas as relatively sparse. Occasional scallops, horse mussels, ostrich-foot whelks, hermit crabs and sparse small patches of wireworms and their associated encrusting species were observed in the present study from within the applications.

The present study confirms low gradient habitat under the application blocks have changed little between sample events. Some changes between 2016 and 2021 were obvious. The shore slope has been colonised by large numbers of *Chaetopterus* tubeworms. These have in turn provided habitat for other species such as branching red algae that were also common to abundant during the 2021 survey.

Chaetopterus are sufficiently abundant in places on the mid to lower shore slope to constitute a bed and thereby act as a biogenic habitat. These beds are now widespread in the Sounds, however, it is not known if they are native or introduced. It is concerning to see some *Galeolaria* mounds on the reef were being smothered by *Chaetopterus* (Plate 5). This phenomenon has also been observed at Long Island-Kokomohua Marine Reserve (Davidson et al., 2020).

4.2 The reef and farm-related threats

The present study confirmed the presence, location, extent and biotic attributes of the reef located adjacent to the middle application block. Giles (2021) raised concerns that the reef and its associated flora and fauna could be threatened by a new marine farm if placed nearby.

An exclusion zone was suggested by Davidson (2019) that encompassed the reef structure (see red area in Figure 7). The suggested exclusion encompasses the narrow terminal foot of the reef and also provides a buffer area around the rock substrata (Plate 17). An additional buffer zone is also established across the warp and anchor zone (Figure 7). In the alongshore direction, warps provide 25m distance separation on each direction between droppers and

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the edge of the exclusion. Davidson and Richards (2014) conducted an 11-year study looking at the recovery of a mussel farm in East Bay. The authors reported at the start of the study that impacts under warps was very low compared to production areas and the epifauna and substrata under warps were little-different to control sites. Based on the existing knowledge around the detectable impact of marine farming (see Keeley et al 2009 for review), it is therefore unlikely that impacts would be detected a sufficient distance from production droppers to threaten the reef. No change to the exclusion zone recommended by Davidson (2019) is therefore suggested.

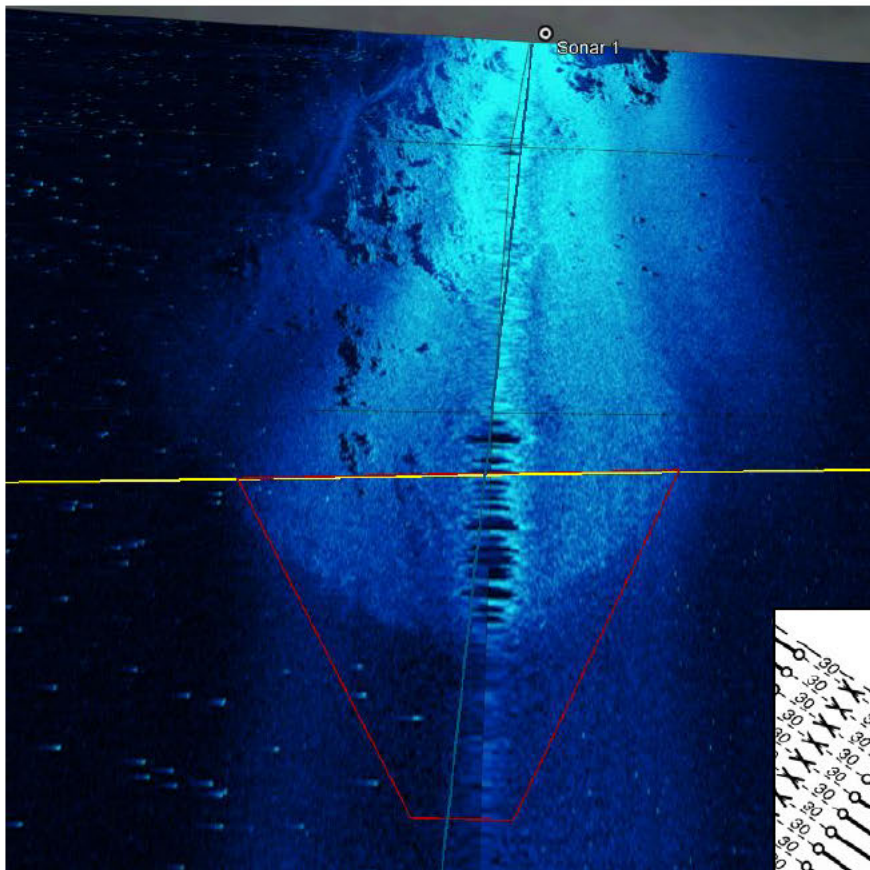
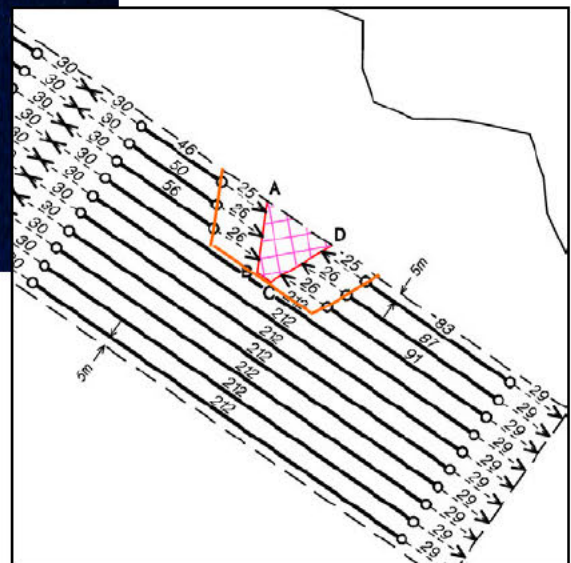


Plate 17. Sonar of the reef relative to the exclusion zone (red) and application boundary (yellow).

Figure 7. Proposed marine farm layout, exclusion zone (red hatched) and the buffer established by the warp and anchor zone (orange).



4.3 The benthos under and inshore of the application blocks

The present survey aimed to address benthic information gaps and uncertainties outlined in Giles (2021). Diver collected transects, high definition video combined with sonar have allowed description of the main habitats and communities relative to the application blocks. The locations of these biotic features have been accurately determined using these methods (i.e. diver recorded profiles combined with remote video and sonar shore profiling).

Based on these data, the application blocks are located over a very low gradient mud dominated sea bed. Mud is colonised by a widespread diatom film. All other surface-dwelling biota were relatively uncommon, patchy and sparse including scallops, horse mussels, non-calcareous tubeworms, whelks and hermit crabs. In contrast, the shore slope located around the edge of the bay supports a wide variety of surface-dwelling species. Since the Davidson et al. (2016) survey, *Chaetopterus* tubeworms have become very abundant on the lower shore slope. These have formed a biogenic habitat that supports a range of epibenthic species including beds of branching red algae.

Mead and Davis-Campbell (2021) surveyed 34 sites inside, offshore and inshore of the application blocks and provided a set of mostly low quality unlabeled frame grab images in their Appendix B. The authors stated:

“With respect to the Ecological Assessment (Davidson et al., 2016), it was concluded that the proposed marine farm is located over mud substrate and that the surface dwelling species in the area were sparse and recorded in low abundances. However, some 34 underwater drone surveys inside and outside the area of the proposed marine farm found evidence of extensive biogenic seabed structure, and algal mats where this was absent”.

“Interestingly, many of the surveys identified relatively complex 3-dimensional biogenic habitats (i.e., biogenic (or ‘living’) habitats important for biodiversity), which by contrast are not evident in the 44 drop camera photographs presented in Appendix 1 of Davidson et al. (2016) that generally show only flat muddy seabed with algal mats/mats.”

Unfortunately, Mead and Davis-Campbell (2021) have not provided details (depth, distance from shore, location) where their low definition frame-grabs were collected. It is possible to

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differentiate deep versus shallow by colour with shallow having a blue hue and deeper areas having a green hue. Another clue is the presence of shells, cobbles and *Chaetopterus* in photos that indicate a photo may have been collected from the shore slope. Other than those clues, it is difficult for the reader to relate described features relative to the application blocks. The authors have also failed to identify the main reason for the community changes observed between the Davidson et al. (2016) survey and their 2021 survey. These unexplained differences between the studies have resulted to a level of uncertainty by the reviewer (Giles, 2021). One of the main aims of the present report was to clearly describe habitats and communities and where they are located relative to the applications.

One of the major differences between the reports has been due to the *Chaetopterus* formed beds that have formed on the shore slope. Their presence in often high densities has established a biogenic habitat that has been colonised by a variety of species. The poor quality imagery combined with poor descriptions of photo locations in the Mead and Davis-Campbell (2021) survey has further muddied the waters. In their imagery, it is possible to make out the diatom film but it is difficult to determine other features from photos that appear to have been collected from offshore mud areas. In response, the present study provides HD imagery from several transects collected inside the application blocks.

4.4 Onapua Bay environment

4.4.1 Historical studies

Relatively little biological information is known from Onapua Bay. An early survey of the benthos in Tory Channel and adjacent bays occurred as part of a PhD study (Lauder, 1987). The author investigated coastal landforms and sediments detailing several aspects of sediment distribution in the Marlborough Sounds. The author also stated that sediment trapping was a distinctive attribute of the coastal landscape in the Sounds. The study included sampling in Onapua Bay, Tory Channel. Lauder (1987) stated:

“Three elements of pattern are significant. First, the dominance of silt at the bay head; secondly, the notable increase in clay and the decrease of sand in the inner-mid bay region and thirdly, the overall coarsening of the samples, especially in sand and coarse silt, towards the bay-mouth. Concentration of fine materials in the middle reaches of Opua Bay is interpreted as evidence of a mobility trap operating to retain and concentrate the finer materials. Silt-rich

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sediments in the bay-head are related to stream inflows, and to the retention of this material in a confined coastal site”.

Annual surveys of coastal seabed habitats and sediments below logged and unlogged catchments occurred between 1992 and 1995 in Onapua Bay (McMahon *et al.*, 1996; Fransen *et al.*, 1998). Fransen *et al.* (1998) concluded:

“Measurements at two near-shore sampling sites within Onapua Bay showed a significant decrease in fine sediments and benthic animals over the three years. This contrasted with Missionary Bay, which showed significant fine sediment accumulation in the near-shore region. The lack of observed near-shore fine sedimentation at Onapau Bay and the stronger change in seabed animal associations at Missionary Bay, indicated that factors other than logging, such as natural sediment input and flushing of fine sediments, were responsible for the observed changes over time. Despite the absence of near-shore sedimentation related to logging, it is recognised that accumulation of fine sediments within central Onepua Bay may occur over the longer-term, particularly as more of the catchment is logged”.

Fahey and Cocker (1992) conducted a survey looking at sediment production from forest roads in Queen Charlotte Forest, including a plot on Baldicks Road 70 m above Opua Bay. For Opua Bay, Fahey and Cocker (1992) found:

“There are c. 70 stream crossings by forest roads and access tracks within the Opua Bay catchment, about a third of the total for the forest. If this ratio is applied to the 550 t of fine sediment thought to be removed from the road system each year, up to 200 t could enter Opua Bay annually. If this sediment remained in the headwaters of Opua Bay (estimated volume of water, 250 000 m³) the suspended sediment concentration could be as high as 1000mg l⁻¹.

Once the sediment reaches seawater, it quickly flocculates in a shallow zone extending no more than a few tens of metres off-shore. Disturbance by wave action may bring it back into suspension periodically, but overall, a significant or sustained increase in turbidity levels is unlikely. However, in many sheltered near-shore areas in the vicinity of Farnham Forest, a surface layer of silty material exists and is mostly devoid of marine life (Johnston *et al.* 1981). Thus,

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while flocculation may be beneficial in keeping turbidity levels down, the additional sediment accumulating on the seabed may adversely affect benthic communities.”

Between 2004 and 2007, the benthic environment of three bays in Onapua Bay were surveyed on SCUBA. During these surveys, no logging operation was occurring in Opua Bay, however scattered debris was noted on the seabed and a plentiful abundance of whelks, flatfish and stingrays was recorded (Perano, 2007). The substratum was described as fine sand and earth from surrounding hills at shallow depths, before becoming gravel size and larger, then dominated by mud >6m depth (Perano, 2007). In comparison, Missionary Bay was described as having a zero population of marine life and no debris, while in Onapua Bay where logging was in operation was described as having plentiful active marine life (Perano, 2007). This study was limited to qualitative and descriptive information.

A long-term, and ongoing monitoring study of intertidal and shallow subtidal sites in Tory Channel and Queen Charlotte Sound investigated the impacts of ferry passage (Davidson *et al.* 2017). Monitoring began the summer of 1994/95 and continues today on a biannual basis, providing information on intertidal and shallow subtidal impacted and reference sites. Invertebrate presence and densities were recorded from bedrock and cobble/boulder intertidal and subtidal habitats, including one site at the mouth of Onapua Bay. The biological recovery at most impacted sites following a speed restriction bylaw in 2000, showed wave effects from fast ferries were impacting the biological communities at many of the intertidal and shallow subtidal sites (Davidson *et al.* 2017).

The benthic substratum and depths of Queen Charlotte Sound were described by Davidson *et al.* (2011), in the significant marine site inventory report for Marlborough Sounds:

“Maximum depths through most of the area range from approximately 30-45m. Depth reaches 75m off Dieffenbach Point at the entrance to Tory Channel, and there is a large depression 50-80m deep along the western side of Blumine Island. There are also holes up to 58m deep either side of Patten Passage. Unlike Tory Channel, maximum depths in the marginal bays and inlets are similar to those in the main body of the Sound. The surrounding land is steep and most of the shoreline is fringed by cobbles and boulders. There are bedrock outcrops off points and on some pinnacles and shoals. Rocky shores extend to a maximum depth of 33m and average 12.4m maximum depth. Coarse, silty, shelly sand

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usually covers the lower slopes of the Sound and marginal bays below the rocky shores. Most of the floor of the Sound is covered by soft mud. The sandy margin meets the mud floor at an average depth of approximately 18.4m but may be as deep as 39m at steep sites. Sand and pebble beaches occur at the head of many bays and there are extensive sand flats at the head of the Sound in Okiwa Bay”.

Assessing marine sites for ecological significance began in the Marlborough Sounds in 2010 and subsequent surveys have been conducted (Davidson *et al.* 2011, 2017; Davidson and Richards 2015,2016). Tory Channel has the highest concentration of marine significant sites in Marlborough, with most sites located in the main channel. No significant sites have been identified within Onapua Bay. A review of existing scientific literature in Tory Channel was conducted by Rayes and Davidson (2016).

In 2014 a report produced for the Marlborough District Council collated information on the natural character of the Marlborough Coast, including a section on marine areas (Bentley *et al.*, 2014). Tory Channel marine area was described by Bentley *et al.*, 2014) as:

“Very sheltered; cold waters; strong currents; a narrow rock/cobble reef fringe bordered by well-sorted sands; silty sands and calcareous gravels in the bottom of the main channel; shallow muddy side bays; rich and abundant seaweed and invertebrate communities along channel margins.

Reef areas in the side bays support an array of invertebrates and algae similar to sheltered areas of Queen Charlotte Sound. Horse mussel and cockle beds occur in some side bays.”

A biophysical model of Queen Charlotte Sound and Tory Channel was used to assess the influence of aquaculture (Hadfield *et al.*, 2014). The model highlighted the relatively low current speeds present in Onapua Bay.

Urlich (2015) produced a review identifying the cause and consequences of adverse effects from forestry in the Sounds. The review highlighted the release of fine sediment into the marine environment because of forestry, particularly due to high-intensity rainfall events and underlying lithology and soils (Urlich, 2015). Options to reduce fine sediment were outlined in that report.

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A multibeam seabed survey of Queen Charlotte Sound and Tory Channel was conducted (Neil *et al.*, 2018). Multibeam data highlighted notable features of the marine area and assessed a range of seabed attributes. Maps show bathymetry, seafloor classification and ecology data in QCS and Tory Channel including Onapua and Opuia Bays (Neil *et al.*, 2018).

Monitoring work concerning the toxic dinoflagellate *Alexandrium catenella* has been conducted in Onapua and Opuia Bays (MacKenzie *et al.* 2012, 2013).

Recently a quantitative intertidal and shallow subtidal survey was conducted in the Opuia and Missionary Bays area as part of a consent monitoring of a log handling and barge area (Davidson *et al.*, 2020a). The authors stated:

“Subtidal shores at both the impact and the reference site have been exposed to terrestrially derived material in the form of pinecones and wood. Fine sediment would also likely have been transported into these areas during rain events. Based on diver observations, the level of fine sediment at the impact site appears to be a more dominant feature compared to the reference site at Missionary Bay (as indicated by higher levels of coarse substrata at Missionary Bay). Both sites are, however, dominated by silt and clay substrata. Fine sediments entering the subtidal environment likely persist for much longer periods compared to intertidal shores due to the lower energy regime in these very sheltered bays. There is little doubt that terrestrially derived material has historically entered and remained in the subtidal environment at both impact and reference sites. The timing of the arrival of this material is unknown, but it is likely to have been exacerbated by large rainfall events during of following forest harvests. The present study suggests that both Opuia Bay and the reference site subtidal shores exhibit an impact from fine sediment deposition. This was more pronounced at the Opuia Bay site.”

4.4.2 State of the Onapua subtidal environment

Onapua Bay is a relatively shallow, narrow and long bay. Its catchment is relatively large, steep and composed of erodible material. Much of the catchment is clad in production forestry and is intermittently cleared exposing sediments and this combined with heavy rainfall events has led to the introduction of fine sediment into the marine environment. Because of the semi-enclosed structure of the bay, most of this terrestrial material likely

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accumulates on the sea-floor within the bay. Existing studies suggest most of the flat areas of the bay are characterised by mud, while steeper bay sides remain dominated by coarser material such as cobbles, shells and sands.

In the periods between harvest events, it is probable species living in and on these offshore mud bottoms recover and trend towards longer-lived slower-growing species. Unfortunately, this recovery is likely to be reversed after future harvest events when offshore benthic communities are subjected to sediment deposition and/or high turbidity. Most sediment will settle out relatively close to its source, therefore areas in the bay with stable catchments will likely support a healthier benthic community compared to subtidal areas close to streams and forestry catchments.

4.5 Biosecurity

Many human structures and the associated activities act to increase the risk of the spread and establishment of unwanted species. Marine farms, moorings, jetties, and the movement of boats all increase the risk of new incursions and the spread of species from other locations into new areas.

Marine farmers in New Zealand are aware of the risks of unwanted species as these species can cause major issues for farming operations. In response, the industry runs 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.

The applicant has listed a variety of farmable species: *Macrocystis pyrifera*, *Ecklonia radiata*, *Gracilaria* spp., *Pterocladia* sp., *Gigartina* sp., *Grateloupia* spp., *Aeodes nitidissima*, *Callophyllis* spp, *Gelidium* sp., *Ulva* spp., *Porphyra* sp., *Asparagopsis armata*. The list also includes the exotic species *Undaria*.

Subtidal monitoring of Tory Channel since 2000 has shown *Undaria* is well established, grows down to 6-8 m depth year-round and appears stable in the Channel (Davidson et al., 2017). There it grows in spaces between native species but does not appear to have

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displaced the native species. In contrast, in central and inner QCS it is usually limited to the first 2 m depth and is usually small in stature.

Apart from *Undaria* and *Grateloupia turuturu*, the other genus groups on the farm list are native and are found throughout most New Zealand where conditions are suitable. It is noted some species in the genus groups are restricted to offshore islands. Other species in the genus *Grateloupia* are also native (e.g. *G. intestinalis*). It is recommended *Grateloupia turuturu* be excluded as it is an exotic species and has only recently been found in NZ (D'Archino et al., 2007). It is unlikely any native species grown on the farm would pose a risk to algae growing in Onapua Bay and Tory Channel.

Apex source oysters from locally caught spat and 35-40% of mussels are obtained from the Nelson hatchery with the remainder like most of the mussel industry obtain mussel spat from Kaitaia.

4.6 Nutrient uptake by macroalgae

MPI (2013) states:

“The cultivation of seaweeds such as *Undaria* will generally have minor ecological effects on the seabed and water column as they function at a lower trophic level and use dissolved nutrients (mainly dissolved inorganic nitrogen) for growth. Based on overseas studies, the only potential water column effect is nutrient extraction, with a possible flow-on effect of reduced nutrient availability for natural phytoplankton populations”.

The report also notes macroalgae farming may absorb excess nutrients in the water column.

The main reach of Tory is a highly dispersive environment due to regular and strong tidal currents. These current carry nutrients from a variety of sources including the Wairau, Tory Channel and QCS catchments.

Nutrients are also inputted into the system from three salmon farms located in the area. Nutrients combined with currents and cold water have provided ideal growing conditions for macroalgae in the main reach. Only areas close to the main Reach in the side bays of

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Tory Channel have large beds of macroalgae. Further into these bays macroalgae becomes dramatically less diverse and abundant.

Giles (2021) raised concerns over the depletion of ambient nutrients by farmed macroalgae. The applicant proposes to farm combinations of shellfish and algae. Polyculture of shellfish and algae provides the opportunity to balance farm effects. For example, shellfish produce nutrients through excretion, while macroalgae take up nutrients directly. Further, additional nutrients from the salmon farms would also potentially be balanced (to a very small degree) by additional farmed macroalgae.

Historically, the Marlborough Sounds was likely an oligotrophic system. Presently enrichment levels are at higher levels. Therefore, the removal of nutrients from the system by farmed macroalgae could be argued as taking the system towards a more natural state. It is noted, however, that the scale of macroalgae at the proposed site would likely make little difference to the overall enrichment levels of the Sound.

4.7 Shading of the benthos

There are very few studies that have investigated this potential effect. Newcombe et al. (2015) used a CTD inside (4 stations) and at 50 m distance (4 stations) away from a mussel farm located in Admiralty Bay. The authors measured photosynthetically active radiation (PAR) with increasing depth (Figure 8).

The authors reported PAR readings were highly variable likely due to wave action near the water surface ranging from 957 to 4,315 $\mu\text{mol s}^{-1} \text{m}^{-2}$. Newcombe et al. (2015) stated PAR levels rapidly declined beyond ~3m depth reaching values close to zero (16.2 $\mu\text{mol s}^{-1} \text{m}^{-2}$ within and 20.3 $\mu\text{mol s}^{-1} \text{m}^{-2}$ outside) at 20m depth. The authors also stated PAR patterns were consistent for all stations both within and away from the existing marine farm area.

The authors concluded there was a “slight impact that was barely discernible”.

Figure 8. PAR data from Newcombe et al. (2016).

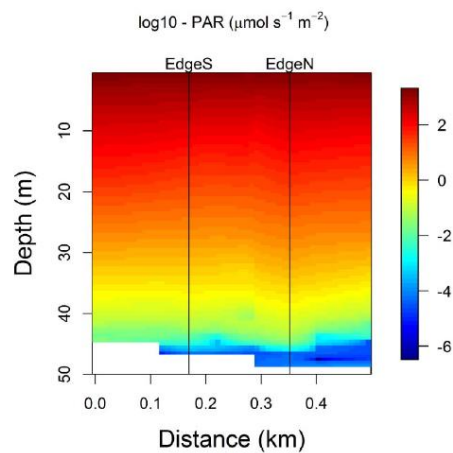
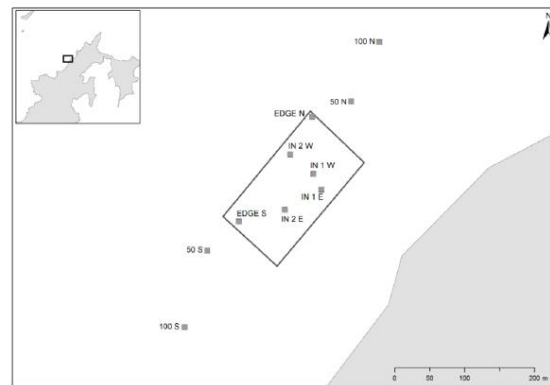


Figure A2.1. Log PAR (photosynthetically active radiation) interpolated across all stations surveyed as part of the assessment of light levels in an existing mussel farm. Sites are arranged from southern-most to northern-most. 'Edge' sites are marked with black lines to define the farmed area. The log scale is used to reduce the degree of apparent change in PAR with depth, thereby increasing the ability to detect horizontal change (*i.e.* that associated with potential shading by the mussel farm). Distances on the x-axis are measured from the southern-most sampling station.

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