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Project South, Stewart Island New Zealand

Volume 1 – Seabed Survey

Project South Sanford Benthic Report

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Report prepared by

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For

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1 SUMMARY

Sanford is seeking to expand salmonid production in an area to the south of Ruapuke Island. The Ruapuke Island / Project South application area contains five (5) proposed finfish farm blocks each with an approximate area of 20 hectares. The closet farm to Ruapuke Island is approximately 11 km away.

ADS Environmental Services *Sdn. Bhd.* (ADS) were commissioned to scope and then conduct a survey of the seabed characteristics in the vicinity of this area

Several seabed habitat assessment methods were conducted including side scan sonar, Van Veen grabs, underwater camera still shots and video, and continuous single bean echo sounder surveys. The surveys occurred from the 19th to 24th of August 2019 on a Sanford crewed vessel (*San Braz*).

In addition, 29 benthic stations were sampled, of these stations. Five stations (5) were located at each of the proposed fish farm sites with two of the stations located within the proposed farm area and 3 located perpendicular to the farm. Between the farm sites four (4) additional sampling stations were also chosen.

Results show that the seabed is comprised mostly of medium to coarse sandy sediments occasionally mixed with mud or shell hash. The seabed surface morphology is low relief (a few cm) sand waves. No acute changes in the seabed bathymetry were observed, nor were there any major features (biogenic reefs, large rocks, derelict fish pots, pipelines *etc*.) detected.

Video surveys observed a few crinoids (sea stars) and *Ophiopsammids* (brittle stars). Infauna surveys showed that the infaunal diversity and abundance varied between samples and that the seabed is relatively devoid of benthic organisms.

Overall the benthic habitat to the south of Ruapuke Island is not ecologically diverse. Nor is it comprised of ecologically sensitive habitats that are typically found in the Foveaux Strait such as bryozoan reefs, oyster reefs, and red algal reefs.

2 INTRODUCTION

Currently Sanford limited is growing Pacific (Chinook) Salmon (*Oncorhynchus tshawytscha*) only in Big Glory Bay, Stewart Island, and is seeking to expand salmonid production in an area to the south of Ruapuke Island. The proposed area shown in **Figure 1** contains five (5) proposed finfish farm blocks each with an approximate area of 20 hectares. In **Figure 1** these blocks are indicated by yellow boxes and labelled (A, B, C, D, and E).

This site experiences moderate to strong wind and tidal driven currents (peak speeds of >0.7 m/s, mean current speeds approx. 0.1 – 0.15 m/s), and potentially large waves of up to 10m waves (average significant wave height >1m). A rich epibenthic community has been reported in the literature throughout Foveaux Strait (containing sensitive suspension feeding organisms in some places), but few observations have made in the east and no detailed observations have been made in the specific area Sanford is considering for farm placement.

This lack of information warranted a more detailed investigation of the site to the south of Ruapuke Island, which it was determined needed direct observations of the seabed epibenthic and infaunal communities, observations of currents and direct observations of sediment physical characteristics.

This report summarizes the seabed habitat in the proposed farm area and vicinity and reports the presence and abundance of any sensitive environmental receptors identified.

It is important to note, that no previous ecological survey reports are available for this area, nor are there any previous hydraulic surveys that directly measure or describe water currents in the area. Thus, our approach was not only to quantify how abundant and rich the epifauna and infauna communities were at the proposed farm area, but also to identify whether there are any sensitive ecological elements (biogenic reefs or rare fauna), regardless of abundance or richness.

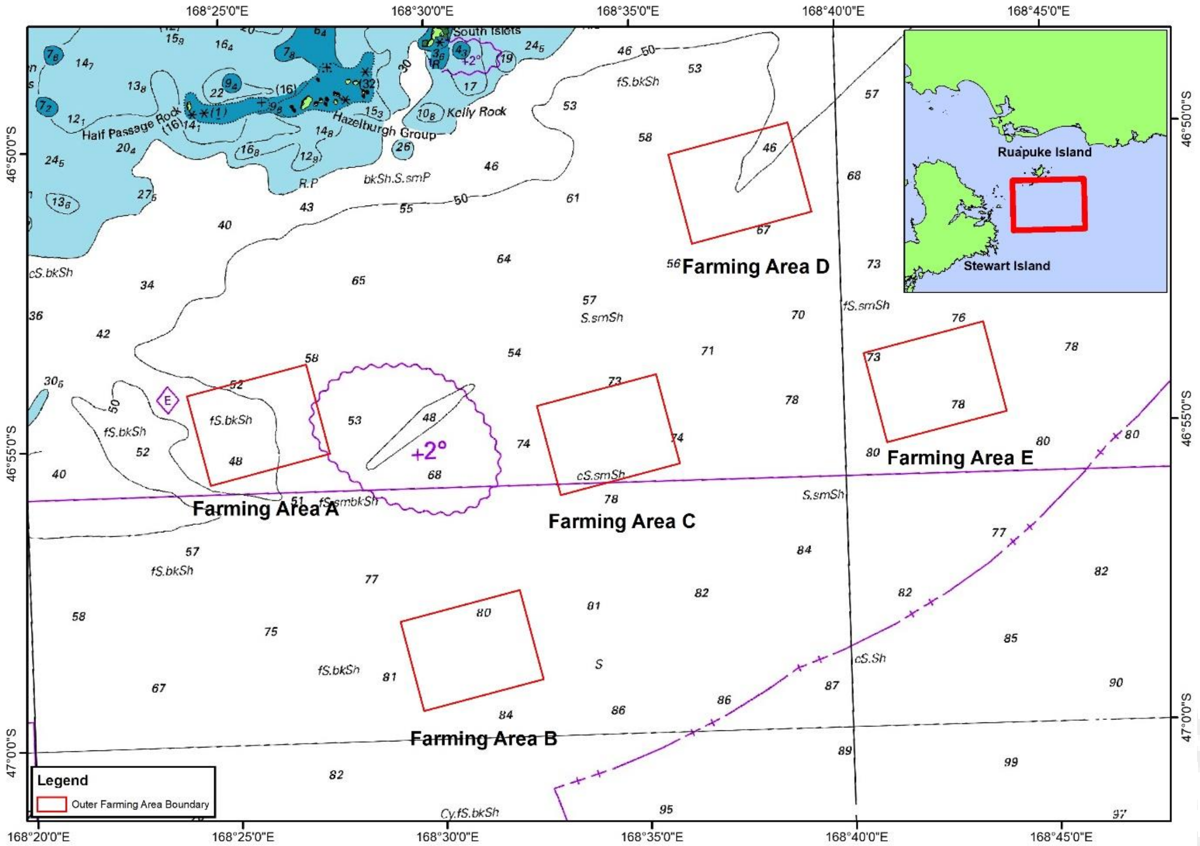


Figure 1: Site South of Ruapuke island

3 Methods

The survey method employed in this assessment comprised:

- Side scan sonar surveys to give a broad, generalized indication of seabed morphology
- Van Veen Grabs for site specific seabed benthic sampling
- Drop camera still shots and video survey (transect lengths of 30 to 120m depending on current flow = to a 4-minute bottom time at each site) for visual identification of seabed characteristics.
- Single beam echo sounder surveys to detect the presence of significant morphological / ecological seabed structures as well as a general idea of site depths.

The site surveys were undertaken from the 19th to the 24th of August 2019 on a Sanford Ltd, crewed vessel. The weather was rough with sporadic rain, strong winds (in excess of 20-25 knots), and waves up to 3m with periods of less than 10 seconds. It was interesting to note though that while we observed waves and wind there was little or no current flow. Current flow during the 4 days of survey was estimated to average less 0.1 meters second (10 centimetres per second) and were predominately from the north east and west. Much of the sampling effort focused on each of the proposed farm areas, however additional information was also collected at sites located between each lease.

Benthic sampling using a Van Veen grab was conducted from the 21st to 22nd of August 2019. On the 21st the sea was rough with waves of between 2-3 meters at times and moderately strong winds >20 knots. On the 22nd winds were generally 10-20 knots and there was a rolling swell of 1.5 meters. On both days a single beam echosounder built into the survey vessel was continuously monitored to help determine seabed habitat type as well as water depth at all sites.

On the 23rd to 24th of August of 2019 Side Scan Sonar and Drop Camera surveys were conducted. Again, the sea was rough (waves of between 2-3 meters at times and winds over 20 knots). This adverse weather impeded the use of the Side Scan Sonar to a few short periods due to the large waves causing considerable roll inside the vessel. Fortunately, the drop camera surveys were successful and provide adequate seabed surface characterization.

3.1 Monitoring Stations

In total 29 benthic sampling stations were sampled (**Table 1, Figure 2**). Of these stations, five (5) were located in and around each proposed farming area (A, B, C, D and E) see **Figure 2** & **Figure 3**. Additional samples were collected between the farm sites R1, R2, R3 and R4. Table 1 shows the coordinates of each sampling location.

Table 1: Co-ordinates for the benthic sampling stations (GCS NZGD 2000 UTM 59S) South of Ruapuke Island. Coordinates are in NZGD2000 UTM 59S datum and given as x and y, longitude and latitude in decimal degree.

Stations	**GCS NZGD 2000 UTM 59S** (Meters)		**GCS NZGD 2000 UTM 59S** (Degree Minute Second)	
	X	**Y**	**Latitude (S)**	**Longitude (E)**
Proposed Farming Area A				
A1	304230	4802503	46°54'7.44"S	168°25'45.73"E
A2	303013	4801483	46°54'39.154"S	168°24'45.037"E
A3	304066	4801417	46°54'42.479"S	168°25'37.825"E
A4	304428	4801483	46°54'42.758"S	168°25'50.27"E
A5	305414	4801483	46°54'43.977"S	168°26'44.717"E

Proposed Farming Area B				
B1	310907	4795596	46°57'56.16"S	168°30'51.219"E
B2	309624	4794543	46°58'28.95"S	168°29'48.893"E
B3	310677	4794510	46°58'31.137"S	168°30'40.243"E
B4	311039	4794576	46°58'32.508"S	168°30'54.211"E
B5	312162	4794585	46°58'34.754"S	168°31'48.678"E
Proposed Farming Area C				
C1	316140	4802282	46°54'27.235"S	168°35'11.591"E
C2	314948	4801165	46°55'1.166"S	168°34'10.884"E
C3	315991	4801202	46°55'3.32"S	168°35'2.183"E
C4	316289	4801128	46°55'3.681"S	168°35'19.298"E
C5	317407	4801165	46°55'5.761"S	168°36'7.486"E
Proposed Farming Area D				
D1	319083	4808988	46°50'51.467"S	168°37'35.032"E
D2	317928	4807908	46°51'22.255"S	168°36'36.115"E
D3	318934	4807982	46°51'24.39"S	168°37'27.357"E
D4	319232	4807908	46°51'24.68"S	168°37'41.346"E
D5	320275	4807833	46°51'26.774"S	168°38'31.036"E
Proposed Farming Area E				
E1	323851	4803996	46°53'36.11"S	168°41'18.164"E
E2	322585	4802879	46°54'11.1"S	168°40'14.378"E
E3	323702	4802879	46°54'13.208"S	168°41'5.669"E
E4	324000	4802841	46°54'12.456"S	168°41'21.272"E
E5	325081	4802841	46°54'14.556"S	168°42'12.564"E
R1	306894	4797997	46°56'35.234"S	168°27'44.868"E
R2	322363	4805804	46°52'37.083"S	168°40'9.112"E
R3	320424	4802320	46°54'28.156"S	168°38'29.309"E
R4	312551	4798358	46°56'28.325"S	168°32'14.753"E

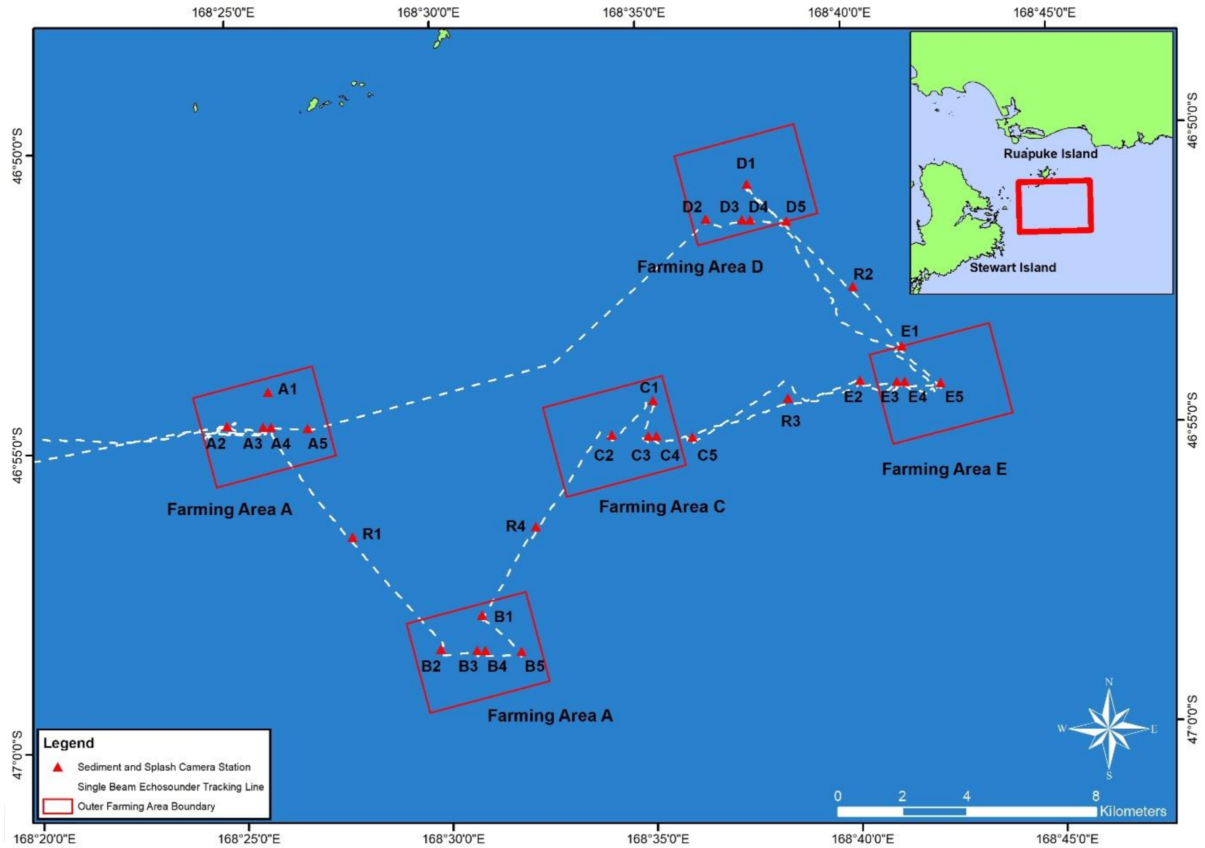


Figure 2 Sampling stations South of Ruapuke Island along with the single beam echo sound tracking data (White dotted line).

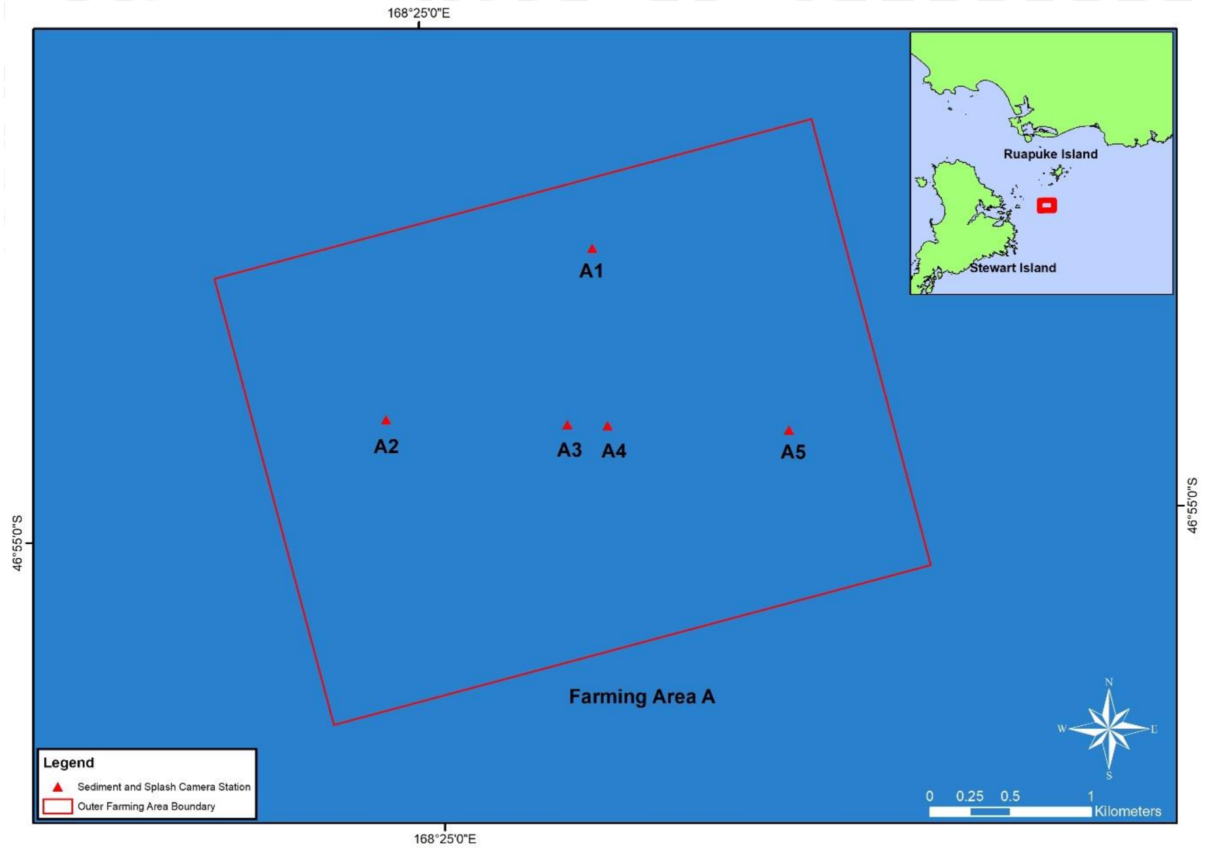


Figure 3 Sampling locations at Proposed farming area A, South of Ruapuke.

3.2 Sampling Methodology

3.2.1 Benthic Sampling and seabed still shots and video collection (drop camera)

At each benthic station the following sampling methods were employed:

- Drop camera footage was recorded at each sampling station to visually assess the seabed and identify epifaunal communities;
    - If the field drop camera footage was found to show no epifauna within the 35cm by 50cm quadrat, 4 min video transects were also collected to gain a better idea of what fauna were present, which resulted in transect length approx. 30 to 120 m.
- Van Veen grabs (bite area ca. 0.1 m^2, max bite depth 16 cm) were collected. Each grab sample was subsampled to a final volume of 4000cm^3 for infaunal analysis. If the volume of the sample in the grab did not reach 4000cm^3 subsequent grabs were taken.
- Seabed features and water depths were observed using a single beam echo sounder.

All benthic infauna were identified and the data were analysed using the statistical analysis software (PAST3). Measures (or indices) of community structure of infaunal data were calculated using the DIVERSITY feature in PAST.

To assess the similarity between infauna assemblages from the different stations, species density data were square-root transformed to de-emphasise the influence of the dominant species and comparisons made using clustering (Bray-Curtis similarities) (Clarke and Warwick 1994) and nonmetric multidimensional scaling ordination (MDS; Kruskal and Wish 1978). Analyses of similarity (ANOSIM) tested the significance of differences between infauna assemblages from different stations.

Table 2: Methodologies employed to analyse benthic samples

Core for:	Measure	Method
	Fauna	
Epifauna	Presence/absence on the surface of the sediment Identification of surface features such as sand etc.	Drop camera video footage was recorded at each station to describe the presence of conspicuous epifauna. The presence of other seabed features and characteristics such as the presence / predominance of sand and shell debris were also recorded.
Infauna	Numbers and taxa per grab Number per taxon	Each grab was used to collect the sediment. Sediment samples were sieved though a 4mm, 2mm and 0.5 mm mesh. Retained infauna counted and taxa identified

3.2.2 Acoustical Seabed Survey and Ground Truthing

To examine the seabed surface, to determine the extent of sand / mud deposition, and to locate reef and rubble a side scan sonar survey was utilised. Side scan sonar is a marine geophysical technique that is used to image or “see” the ocean seabed using sound waves instead of light waves (which is used in video surveys). Since it uses sound rather than light, side scan sonar works even in turbid water.

The method uses pulses of sound shot sub-horizontally across the sea bottom from a towed transducer or “tow-fish”. The sound pulses reflect off relief or objects on the seabed (and fish in the water column), and the strength and travel time of reflected pulses are recorded and processed into an image of the seabed.

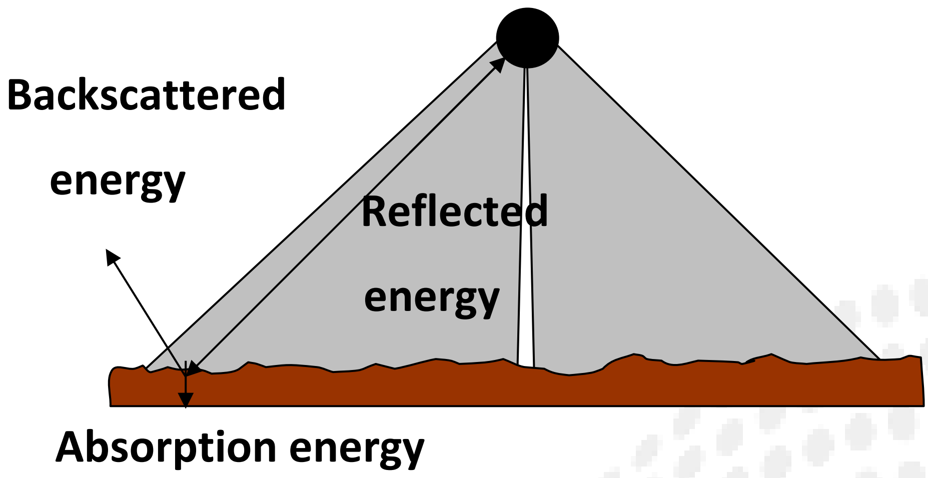
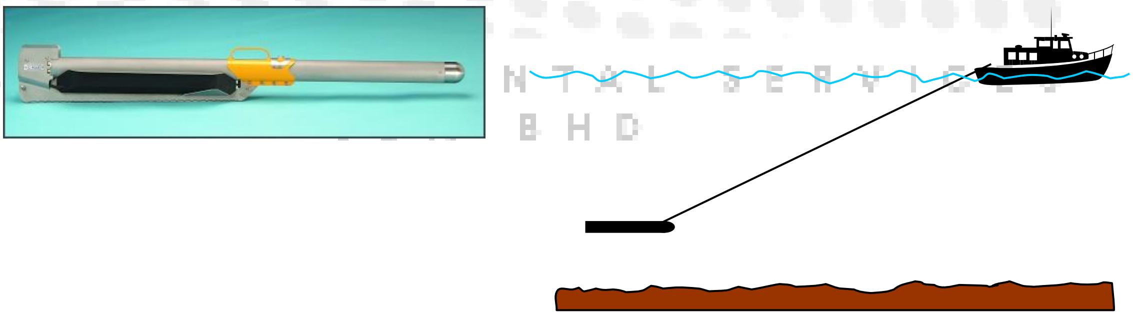


Figure 4 Schematic showing side scan sonar pulse

For the current survey, a C-Max CM2 side scan sonar was used and deployed off the back of the 60-foot survey vessel and was conducted at a frequency of 325khz and a swath width of 100m – meaning that a 200m wide section of seabed is surveyed along each survey line. At this swath width and resolution sand, rocky areas can be distinguished while at the same time maximizing the size of the survey area covered. Lines were spaced 150m apart to ensure there was an overlap, meaning that 100% of the seabed was assessed.



(a) (b)

Figure 5 CM2 Side scan sonar (a) and deployment off boat in relation to the seabed (b).

In this survey the side scan sonar was gently lowered to the sea surface by its umbilical cable off the vessel’s stern while the boat was stationary in the water. The boat then gradually accelerated to a final cruising speed between 3-5 knots, with approximately 50-100m of cable lowered out the back of the boat (**Figure 4** to **Figure 6**). Once the cable was lowered, it was locked in place and the length adjusted with changes in water depth to keep the instrument between 5-10m above the seabed.

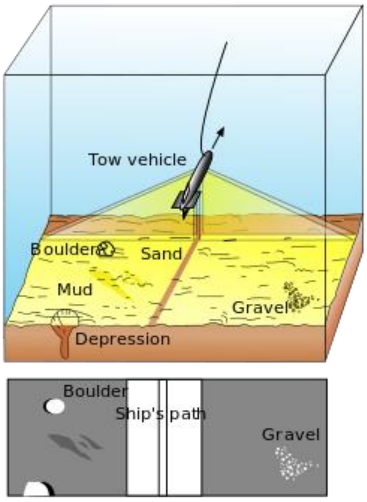


Figure 6 Diagram of side scan sonar

Global Positioning System (GPS)

A Differential Global Positioning System (DGPS) was used to record the location of the scan sonar as it was being towed behind the vessel. A single beam echo sounder was used together with the side scan sonar to verify seabed depth and to check for unknown navigation hazards and mooring lines.

Field verification/ground-truthing of the sonar images was conducted by collecting sediment grabs for visual analysis and by taking underwater video footage of the seabed. Sediment quality data (*Table 3*) were collected with the Van Veen sediment grab while, video footage was collected with an underwater video drop camera on a 35cm by 50cm frame for size reference.

Time, position and water depth of the ship, and the height of the side scan above the seabed was logged every second.

Table 3 Sediment Quality Data (parameters)

Sediment Quality Data	
1.	Presence or absence of hydrogen sulphide (H_2S)
2.	Redox Condition (mm)
3.	Presence or absence of Beggiatoa matting
4.	1st order of grainsize
5.	Sediment colour

3.2.3 Data Processing

The acoustic survey data were processed using Hypack mosaicing and data acquisition software. A mosaic is a blending of the side scan data from one or more data files and is means to present a map of the seabed. Using the Hypack software, georeferenced Tiff files were produced. These are included in Section 4 of this report.

4 RESULTS

4.1 BENTHIC ENVIRONMENT

4.1.1 Side Scan Sonographs

Side Scan Sonographs were collected along 3 lines south of Ruapuke Island (**Figure 7**) that varied in length between approximately 2-8 km in. A swath width of 200 meters was utilised. The seabed to the south of Ruapuke Island can be seen in the sonograph as grey scale images (**Figure 8**). Despite poor weather conditions, the side scan imagines collected were adequate to determine that the seabed surface is comprised of sand. There were no reefs observed.

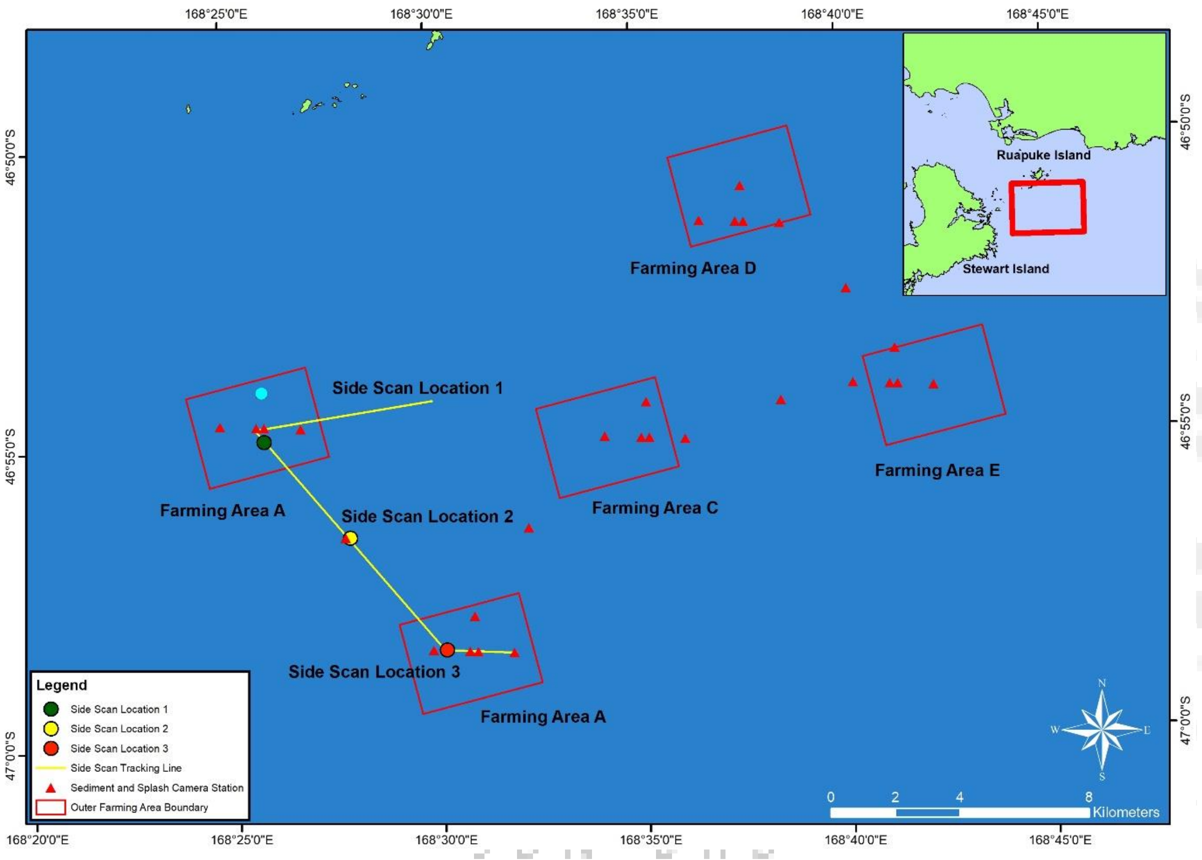
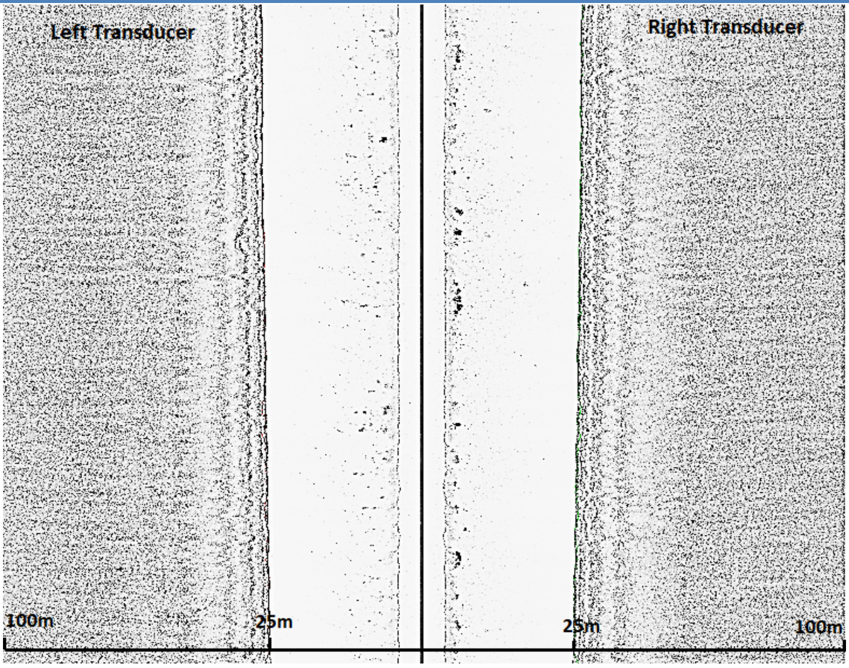
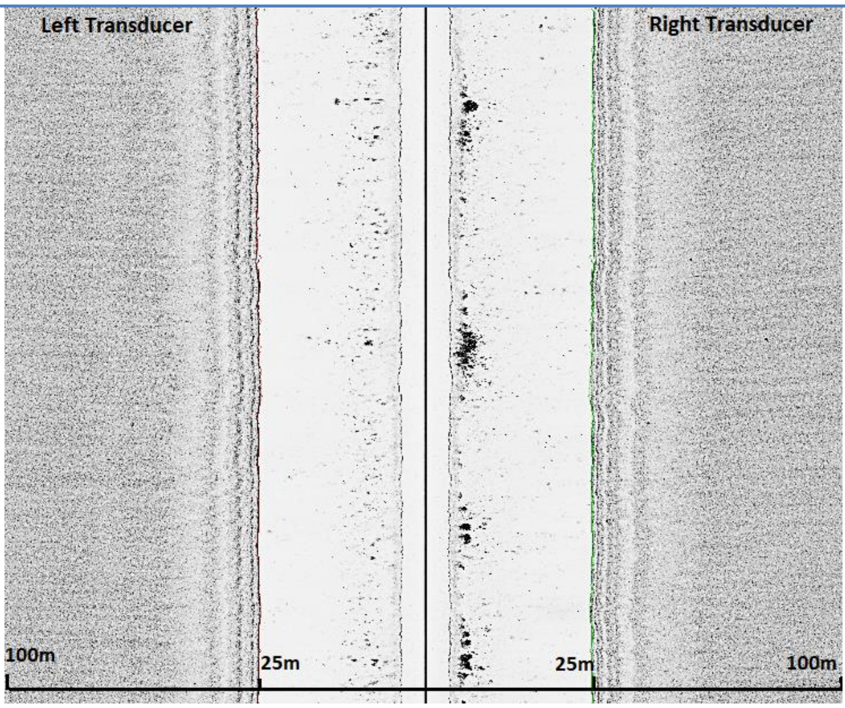


Figure 7 Side Scan Sonar sampling sonograph locations South of Ruapuke Island.

Location	Image
Side Scan Location 1	
Side Scan Location 2	

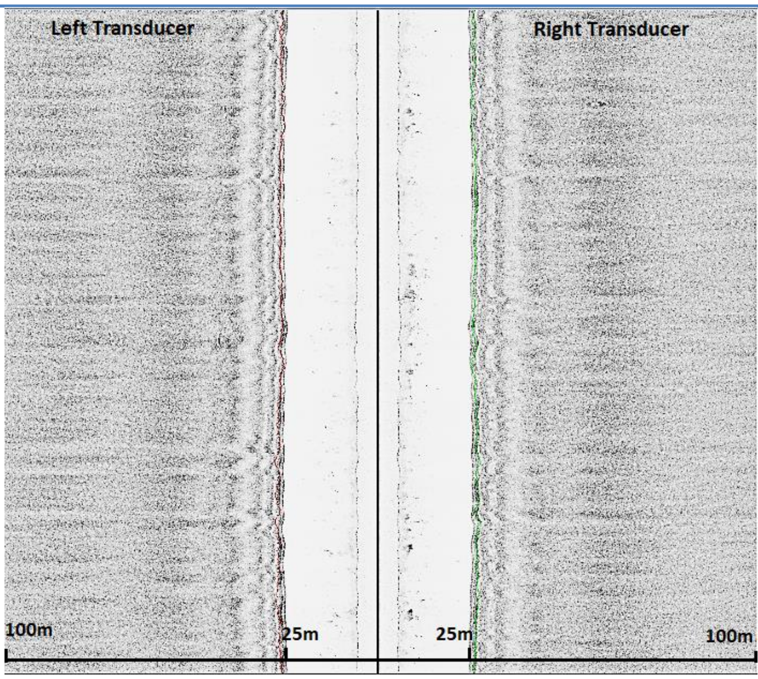
Side Scan Location 3	

Figure 8 Examples of Side Scan Sonographs collected from each location

4.1.2 Single Beam Echo Sounder Survey

A single beam echo sounder detected broad scale seabed morphology, structural features, and water depth along the survey route shown in **Figure 9**. This survey corroborated the data from the side scan survey, showing no significant structural features or acute changes in seabed relief along the entire survey route. The seabed consisted of sand along the entire tracking line within the proposed farming area. The single beam echo sounder was purely a verification tool used by the vessel captain for navigation purposes. At the same time it was monitored for seabed characters and any changes noted and saved as waypoints in a GPS.

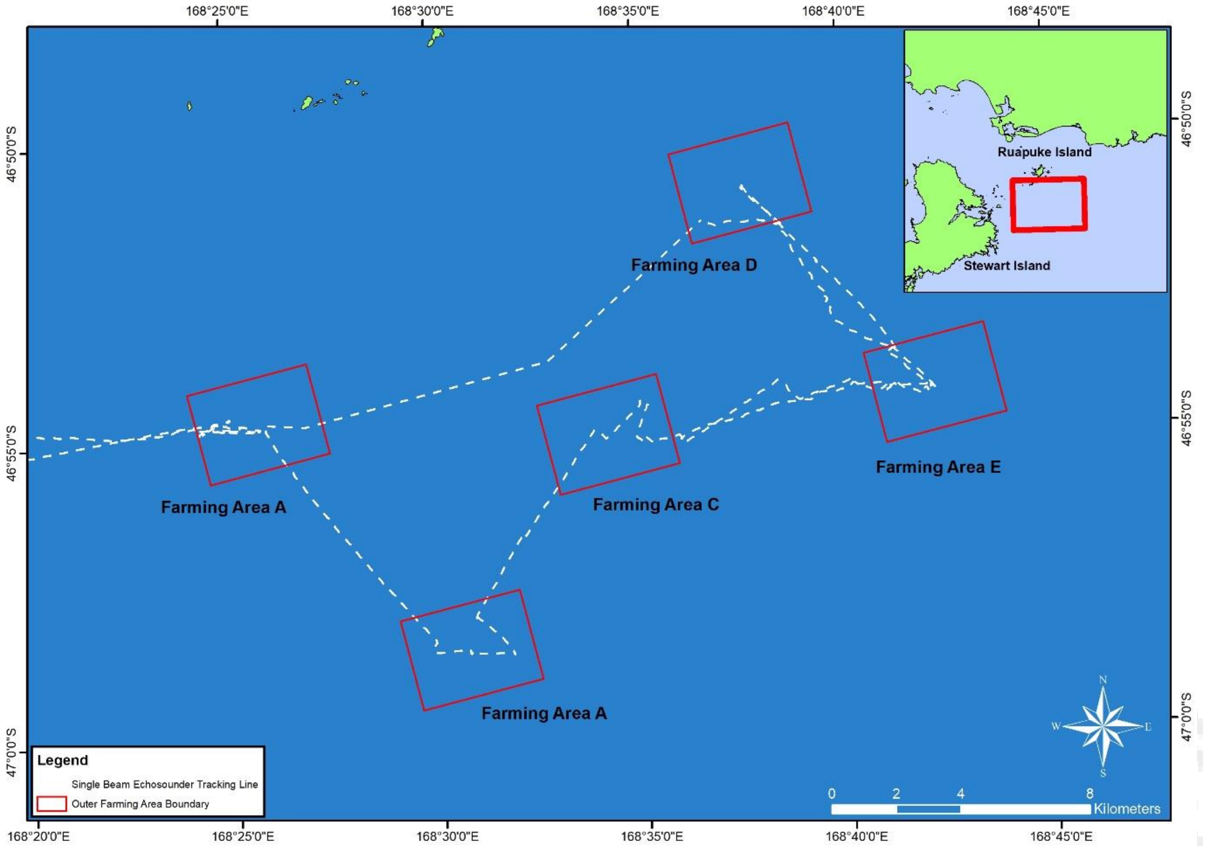


Figure 9 Single Beam Echo Sounder Tracking Line

4.1.3 Benthic Seabed Features and Epifauna (Splash Camera Still Shots and Video Survey)

Drop Camera still shots showed few if any conspicuous epifaunal features at most sites. Consequently, video transects were also undertaken. From these transects a total of 2 distinct seabed features, 14 conspicuous epibenthic taxa, and presence or absence of finfish were identified and recorded from video surveys (approx. 30 meters in length per site was assessed) (including invertebrates and benthic algae) (*Table 4* - Table 6). All sites were comprised of sandy sediments, shell hash, with a little mud, corroborating observations made by the side scan and single beam echosounder surveys. The predominance of sand and shell hash indicates that the site experience moderate to strong seabed flows (**Komar and Miller 1973, Pethick 1984, Hartstein and Dickinson 2006**), which is corroborated by the hydraulic model results (see **Vol 2**).

Drop camera video footage showed a paucity of finfish in the area with only two small finfish observed, at stations D3 and B2. It is worth noting that the drop camera had lighting fixed to the frame, which tends to attract finfish in our experience. The lack of finfish activity in this area was surprising and suggests this area may not be an important habitat for fin-fish. From the video surveys a few notable observations were:

- *Ophiopsammus maculate* (brittle star) were observed on the seabed at stations A2, A3, A4, A5, Z1, D1, D2, Z2, E1, E5 and E4. Unidentified sea stars were found in station A5, D3, D4, E5, E4, E3, C2 and Z4.
- Oyster shells were found in stations E2, C2 and Z4, with only stations Z1 and E2 observed with *glycymeris* shells. These shells were taken as an indication of the presence of these taxa.

- Crinoids were found in three stations: A4, A5 and Z4. Sea urchins were observed at stations A2, A3, A4 and A5. What appeared to be solitary ascidians were observed in four stations: A4, D3, D1 and Z2.
- Anemones were also found at many of the stations except for stations A2, A3, A4, A1, Z1, D5, E3, Z3, C3, C5 and C4.

Table 4 Seabed features seen in the video. 0 = absent, 1 = present.

Location	A2	A3	A4	A5	A1	Z1	D2	D3	D4	D5	D1	Z2	E1	E5	E4	E3	E2	Z3	C5	C4	C3	C1	C2	Z4	B1	B5	B4	B3	B2
Sand	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Shell hash	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 5 Finfish seen in the video. 0 = absent, 1 = present.

Location	A2	A3	A4	A5	A1	Z1	D2	D3	D4	D5	D1	Z2	E1	E5	E4	E3	E2	Z3	C5	C4	C3	C1	C2	Z4	B1	B5	B4	B3	B2
Small finfish	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 6 Conspicuous epibenthos seen in the video. 0 = absent, 1 = present

Location	A2	A3	A4	A5	A1	Z1	D2	D3	D4	D5	D1	Z2	E1	E5	E4	E3	E2	Z3	C5	C4	C3	C1	C2	Z4	B1	B5	B4	B3	B2
Bivalvia shell (Oyster shell)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0
Rhodophyta (Red algae)	0	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	1	1	1	1	0	1	0	0
Crinoidea (Crinoid)	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Echinoidea (Sea Urchin)	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ophiopsammus maculata (Brittle star)	1	1	1	1	0	1	1	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asteroidea (Sea star)	0	0	0	1	0	0	0	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0
Solitary ascidians (sea squirts)	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycymeris shells (Bittersweet clams)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

***Pecten novaezelandiae* (New Zealand scallop)**	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bryozoan (moss animals)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Actiniaria (Sea Anemone)	0	0	0	1	0	0	1	1	1	0	1	1	1	1	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1
Macroalgae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Unidentified algae	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0
Crustacean (Crab)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

4.1.4 Seabed Sediments Images from Van Veen Grab Samples and Drop Camera

Photographs of grab samples were taken at each station during the sediment sampling campaign and still shots of the video surveys, along with descriptions of the sediments are provided in **Figure 10**. The sediment collected was mostly comprised of medium-coarse sand and shell hash corroborating data from side scan, drop camera surveys, and grain size data collected at Site A (see **James *et al.* REPORT**).

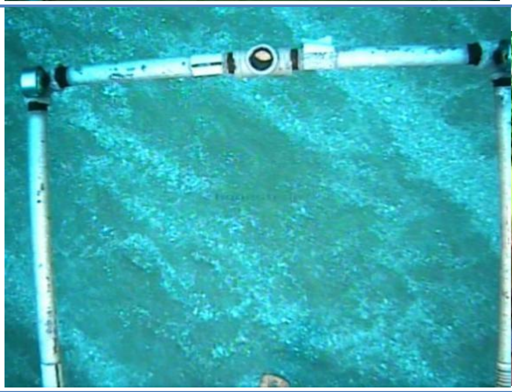
There was no oyster or biogenic reef habitat detected at any station. Sometimes shell hash was collected in the grab sample and captured on the video survey, however no living oyster shells, bryozoan reefs, or algal reefs were detected.

Note that video still shots presented in **Figure 10** were taken during the initial phase of each video survey which was designed to allow the epibenthic analysists to observe the seabed with more context spatially by hovering the camera approx. 2m from the seabed. The frame for these shots does not function to provide a size reference for the images presented in Error! Reference source not found. (the frame only provides a size reference when in contact with the seabed).

Stations	Image	Description
A1	 	Fine to medium sand
A2	 	Shell hash and medium/coarse sand
A3	 	Shell hash and coarse sand

A4	 	Mud and sand
A5	 	Sea horse, shell hash and and medium sand
B1	 	Mud and sand
B2	 	Fine/medium sand

B3			Medium sand
B4			Medium sand
B5			Medium sand, mud and shell hash
C1			Coarse sand and and shell hash

C2	 	Coarse sand and shell hash
C3	 	Fine to medium sand and shell hash.
C4	 	Medium to coarse sand, alittle mud and some shell hash
C5	 	Fine to medium sand and shell hash

D1	 	Fine sand and shell hash
D2	 	Fine to medium sand
D3	 	Rubble, coarse and medium sand
D4	 	Fine to medium sand

D5	 	Rubble, sand and mud
E1	 	Medium sand and shell hash with a little mud
E2	 	Medium/coarse sand and shell hash
E3	 	Medium sand and shell hash

E4	 	Medium sand and shell hash
E5	 	Medium sand
RI	 	Coarse sand and shell hash with a little mud

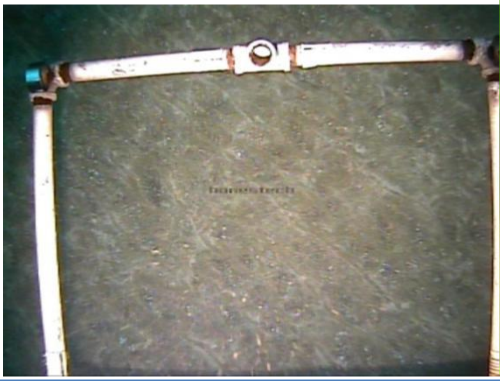
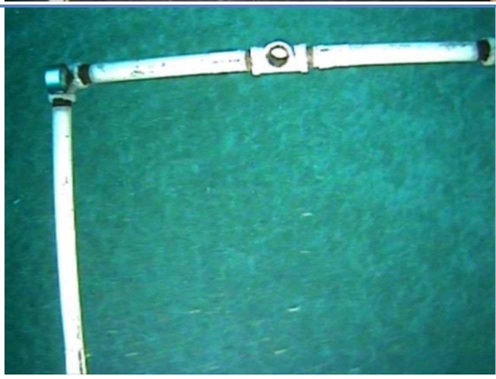
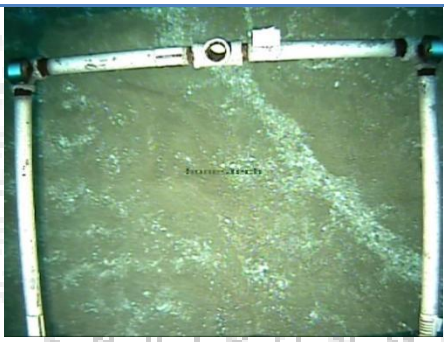
R2			Coarse sand and shell hash
R3			Fine to medium sand, a little mud and shell hash
R4			Coarse sand and shell hash

Figure 10 *Sediment sampling image, still image from video survey, and description at each sampling station.*

4.1.4.1 Benthic Seabed Habitat

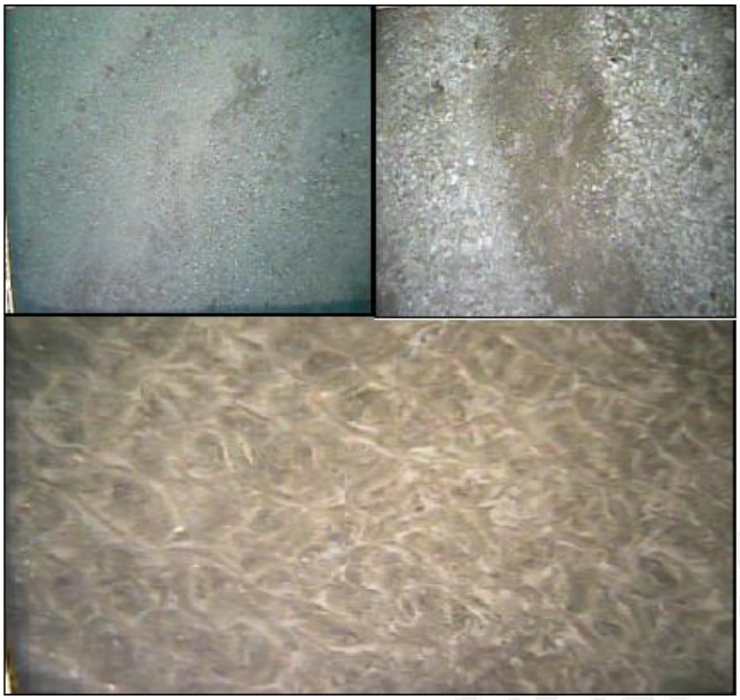


Figure 11 Seabed photographs, captured from the Drop Camera. TOP LEFT: Flat sand (sand wave), TOP RIGHT: Shell Hash, BOTTOM: Hard sand.

Seabed sediment observations were categorized based on the splash camera footage (**Figure 11**). The seabed consisted of a relatively flat sandy seabed, with patches of shell hash, and shallow subtle sand waves.

4.1.5 Benthic Infauna

A list of the infauna taxa and their densities per station and replicate is given in the Appendix.

4.1.5.1 Infauna structure

The maximum number of taxa observed was 11 (**Figure 12**), and mean infauna density or abundance (N, individuals/grab) ranged from 1 individual to 37 individuals (**Figure 13**). The species richness index (Margalef's, *d*) varied widely from 0 to 2.769 (**Figure 14**). This indicates that the infaunal community across the entire sampling area was not particularly diverse, especially compared to more coastal and nearshore environments such as Big Glory Bay and Marlborough Sounds (**Hartstein and Rowden. 2004, NIWA 2015, Davidson *et al.* 2014, Davidson *et al.* 2017, Hartstein *et al.* 2018**). No particularly unique taxa were observed in the samples.

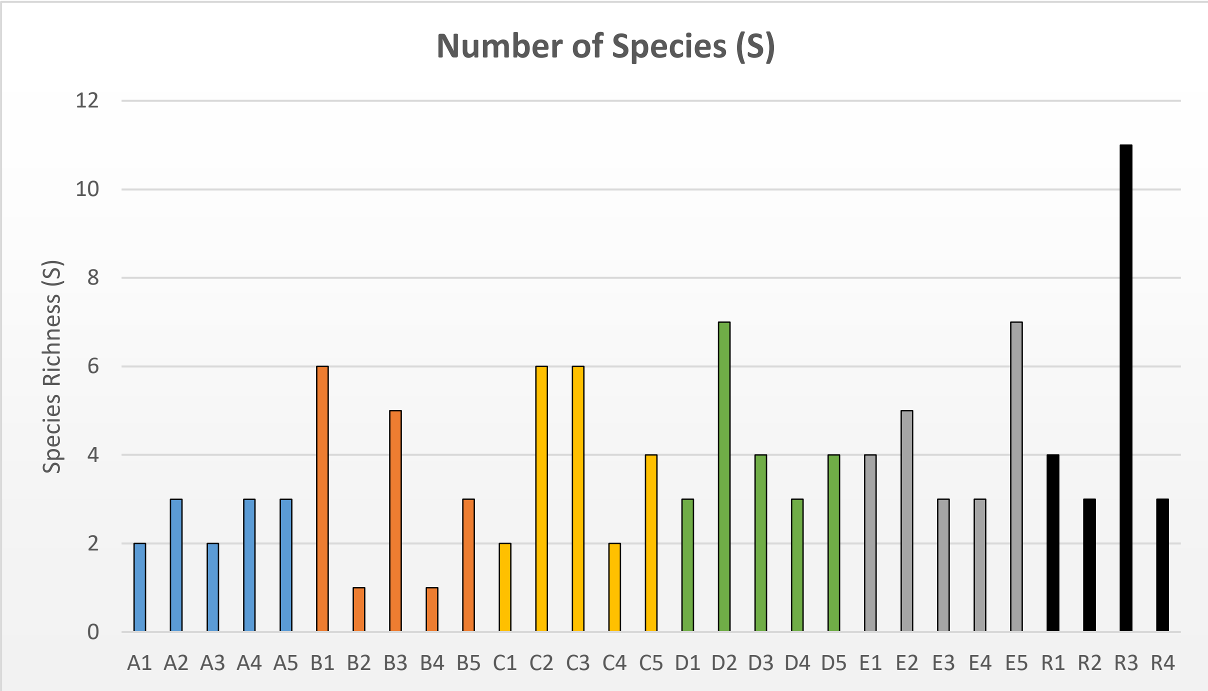


Figure 12 Mean number of species/core (S) from sediments across all sampling stations.

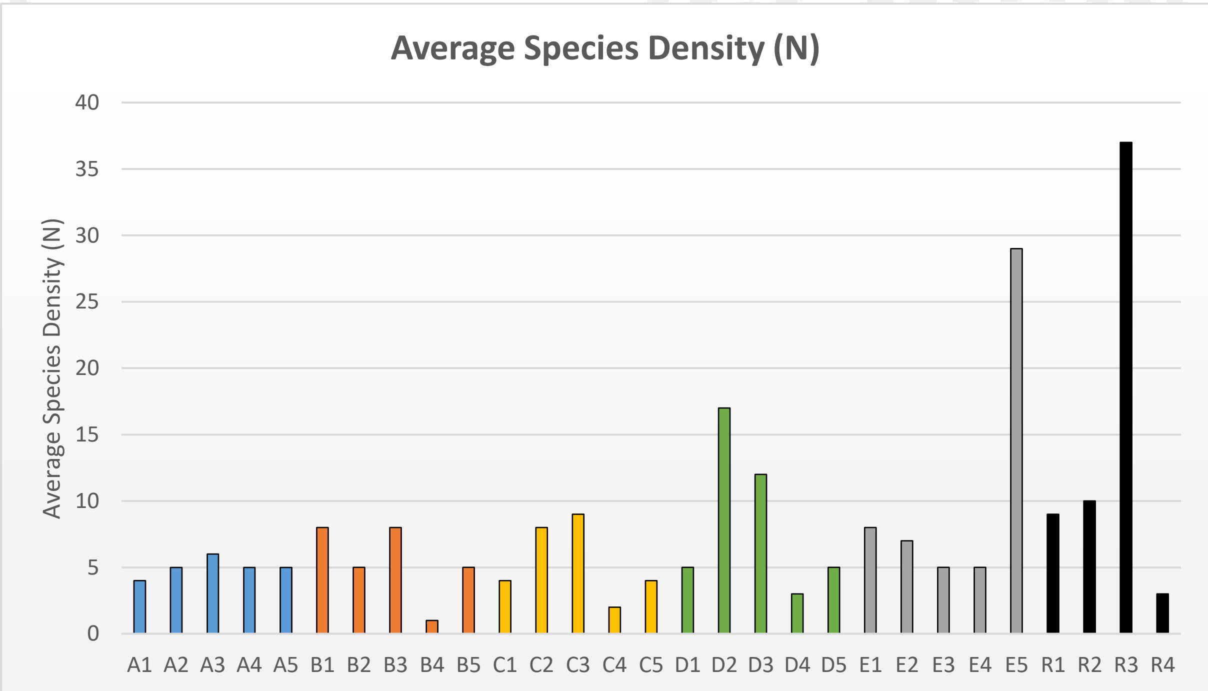


Figure 13 Mean density of individuals/grab (N) from sediments at all sampling stations.

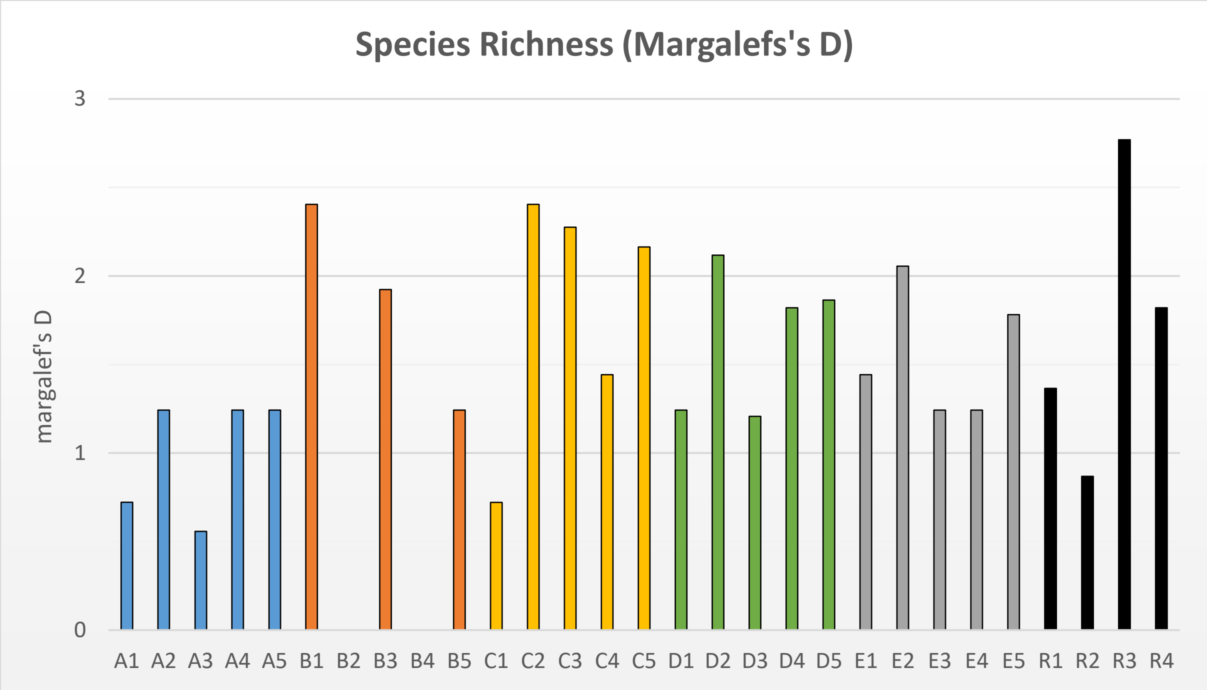


Figure 14 Species richness index (Margalef's d) from sediments at all sampling stations.

4.1.5.1.1 Infauna community composition

Figure 15 shows the composition matrix comparing between the sampling stations.

A Bray-Curtis Similarity Index was used to investigate the similarity of infauna between the sampling stations. **Figure 16** indicates that the infauna varied widely between farm sites. Similarity (0-90%) with the value of 0.7102 was observed between sampling stations. Most sampling stations had a reasonable amount of similarity (10-60%), suggesting that the seabed is similar across the entire proposed farm area.

An MDS (Multiple Dimensional Scaling) plot corroborates this trend of similarity (**Figure 17**). The MDS plot shows most of the sampling stations tending to cluster together toward the centre of the plot again indicating that most samples are similar.

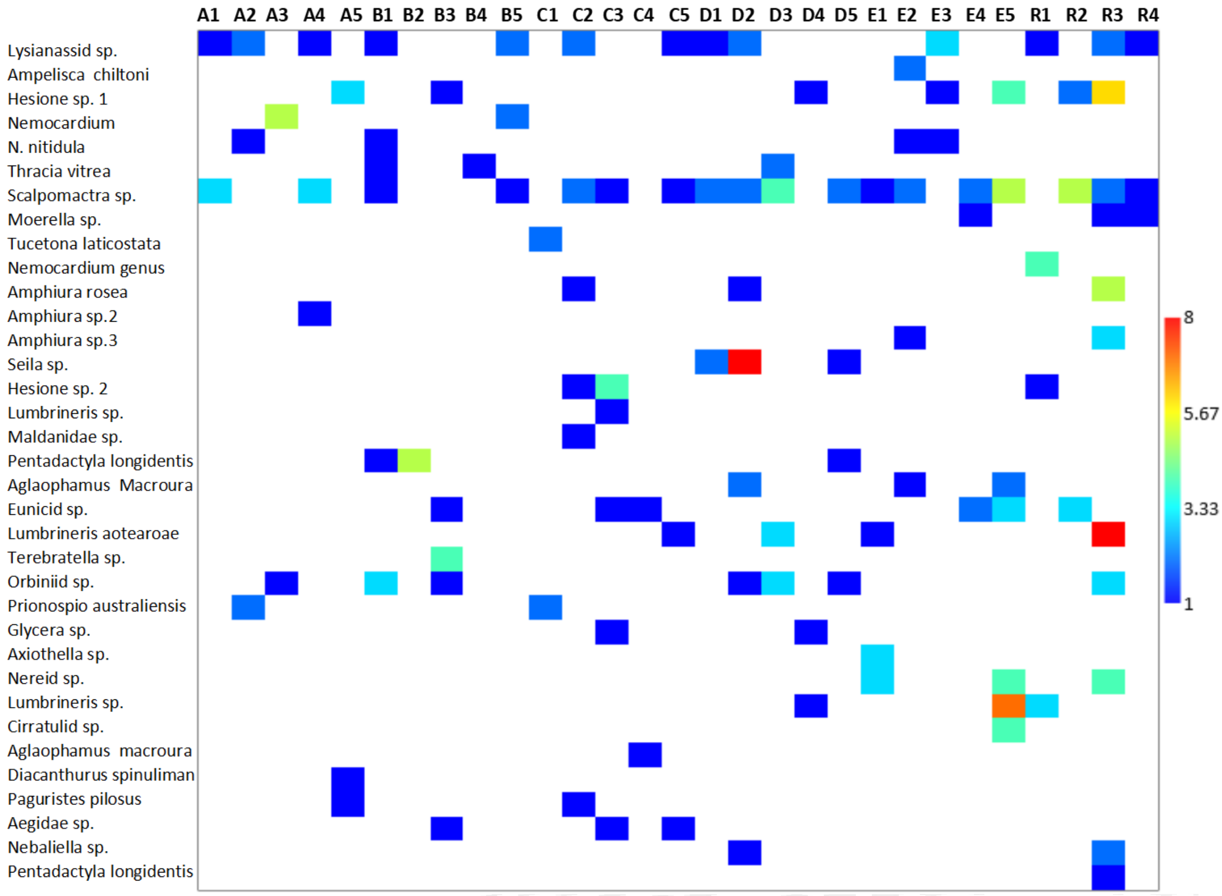


Figure 15 Abundance matrix of infauna species at each sampling station. The vertical colour bar indicates numbers/grab.

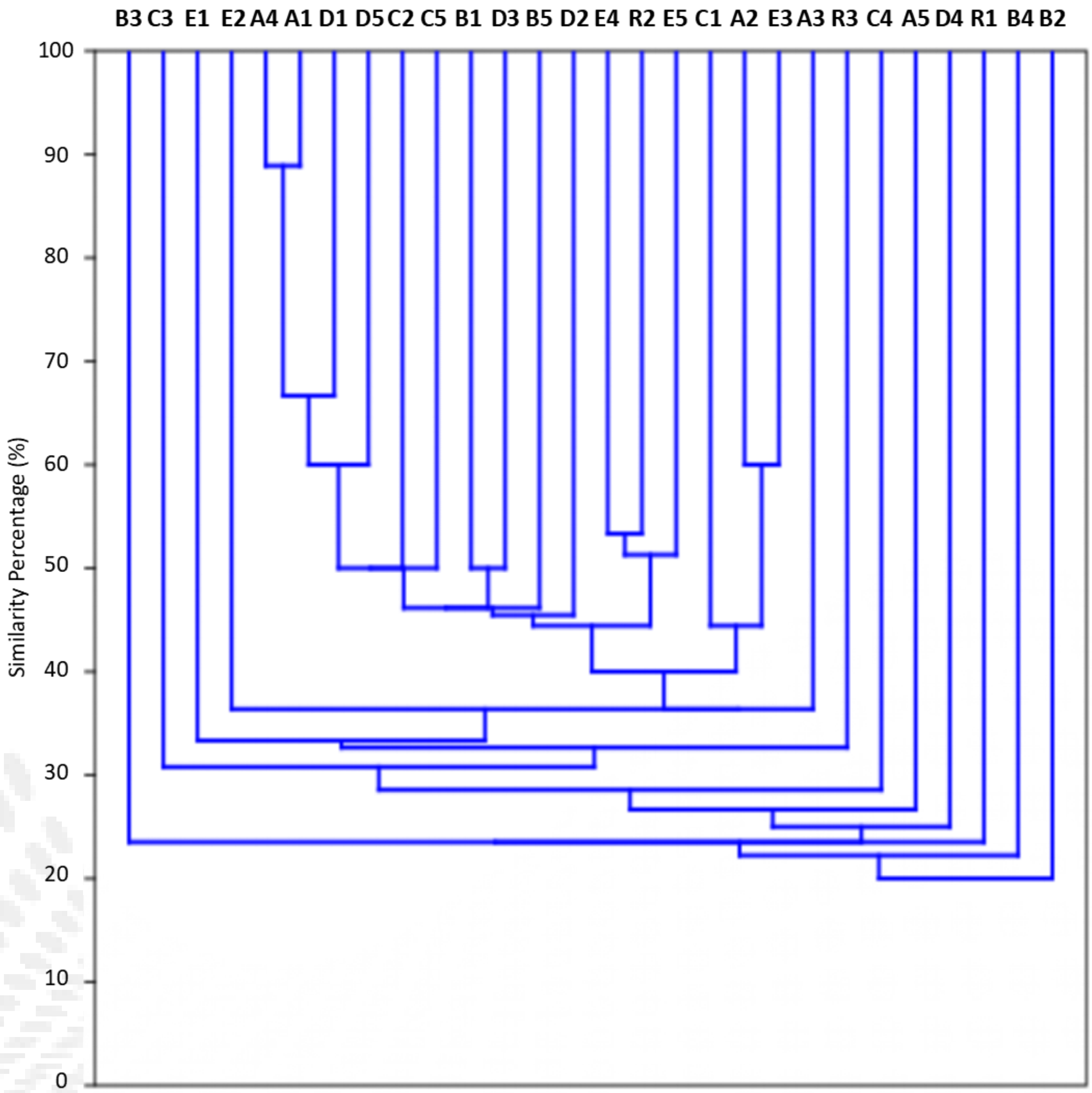


Figure 16 Cluster analysis dendrogram based on Bray-Curtis similarities between infauna composition at each sampling stations.

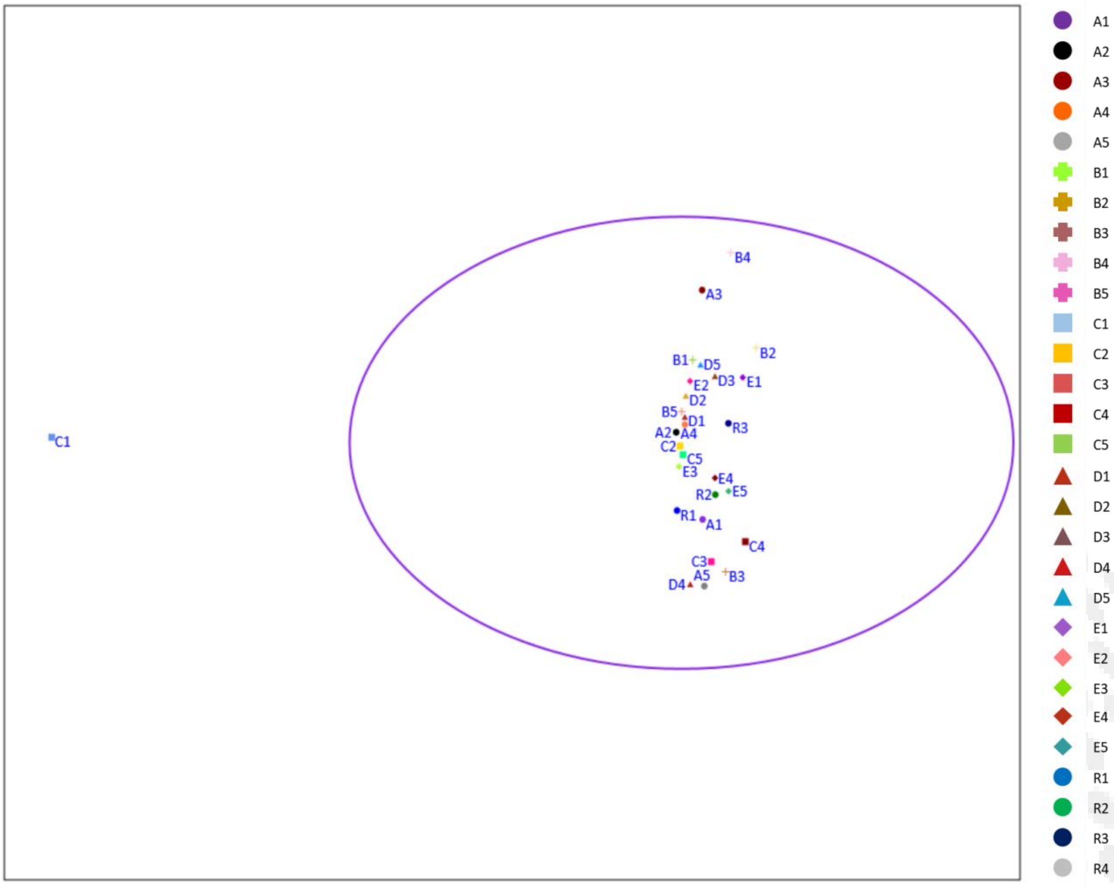


Figure 17 MDS (Multiple Dimensional Scaling) analysis plot of sampling stations based on Bray-Curtis similarities between infauna composition at each sampling station.

5 DISCUSSION

The benthic habitat was characterised by sampling using acoustical surveys, video surveys, and sediment grabs was undertaken at five sampling sites to the south of Ruapuke Island in Foveaux Strait. *In-situ* samples were collected using the Van Veen Grab, and acoustical and still shot/ video samples were collected to observe seabed surface composition, seabed morphology, and epibenthic ecology.

The approach taken was to note epifauna presence and infauna abundance and composition across the proposed site, and to identify the presence of any sensitive ecological elements (biogenic reefs or rare fauna)

The results of the seabed sampling and observations indicate that the seabed is comprised mostly of medium to coarse sand mixed with a little mud and/or shell hash. The seabed surface morphology can be described as low relief (a few cm) sand waves with mud or shell hash deposits in the troughs.

There were no acute changes in the seabed bathymetry detected at any point during the single beam acoustic survey, nor was there any major features (biogenic reefs, large rocks, derelict fish pots, pipelines *etc*.) detected during the side scan acoustic survey or during the video surveys. Camera still shots showed almost no epibenthic features within the 35cm x 50cm quadrats, moreover with nearly 145 minutes of video footage from around the proposed site, only two finfish were observed in the video survey. The most common epibenthic organisms identified in the video surveys were crinoids (sea stars) and Ophiopsammids (brittle stars).

Analyses of the sediment grab surveys showed that the infauna communities varied little between farm sites and that the ecological diversity of this community was poor.

Overall the seabed in the proposed farming area to the south of Ruapuke Island does not appear to be especially ecologically diverse nor does it contain ecologically sensitive habitats that are typically found in the Foveaux Strait such as bryozoan reefs or oyster reefs.

6 REFERENCES

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7 APPENDIX

7.1 APPENDIX A BENTHIC INFAUNA TAXA AND ABUNDANCE

TAXA					Sampling Stations																												
					Proposed FIsh Farm A					Proposed Fish Farm B					Proposed Fish Farm C					Proposed Fish Farm D					Propsoed Fish Farm E								
Phylum	Class	Order	Family	Species	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	D1	D2	D3	D4	D5	E1	E2	E3	E4	E5	R1	R2	R3	R4
Arthropoda	**Malacostraca**	**Amphipoda**	**Amphipod**	***Lysianassid* sp.**	1	2	0	1	0	1	0	0	0	2	0	2	0	0	1	1	2	0	0	0	0	0	3	0	0	1	0	2	1
Arthropoda	**Malacostraca**	**Amphipoda**	**Ampeliscidae**	***Ampelisca chiltoni***	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Annelida	**Polycheate**	**Phyllodocida**	**Hesionodae**	***Hesione* sp. 1**	0	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	4	0	2	6	0
Mollusca	**Bivalve**	**Cardiida**	**Cardiidae**	***Nemocardium***	0	0	5	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	**Bivalve**	**Nuculida**	**Nuculidae**	***N. nitidula***	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Mollusca	**Bivalve**	**Anomalodesmat**	**Thraciidae**	***Thracia vitrea***	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Mollusca	**Bivalve**	**Venerida**	**Mactridae**	**Scalpomactra *sp.***	3	0	0	3	0	1	0	0	0	1	0	2	1	0	1	2	2	4	0	2	1	2	0	2	5	0	5	2	1
Mollusca	**Bivalve**	**Cardiida**	**Tellinidae**	***Moerella* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
Mollusca	**Bivalve**	**Arcida**	**Glycymerididae**	***Tucetona laticostata***	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	**Bivalve**	**Cardiida**	**Cardiidae**	***Nemocardium genus***	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
Echinodermata	**Ophiuroidea**	**Ophiurida**	**Amphiuridae**	***Amphiura rosea***	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	5	0
Echinodermata	**Ophiuroidea**	**Ophiurida**	**Amphiuridae**	***Amphiura* sp.2**	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinodermata	**Ophiuroidea**	**Ophiurida**	**Amphiuridae**	***Amphiura* sp.3**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0

Mollusca	**Gastropoda**		**Cerithopsidae**	***Seila* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0	1	0	0	0	0	0	0	0	0	0
Annelida	**Polycheate**	**Phyllodocida**	**Hesionodae**	***Hesione* sp. 2**	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Annelida	**Polycheate**	**Eunicida**	**Lumbrineridae**	***Lumbrineris* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	**Polycheate**		**Maldanidae**	***Maldanidae* sp.**	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinodermata	**Holothuroidea**	**Dendrochirotida**	**Phyllophoridae**	***Pentadactyla longidentis***	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Annelida	**Polycheate**	**Phyllodocida**	**Nephtyidae**	***Aglaophamus Macroura***	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	2	0	0	0	0
Annelida	**Polycheate**	**Eunicida**	**Eunicidae**	***Eunicid* sp.**	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2	3	0	3	0	0
Annelida	**Polycheate**	**Eunicida**	**Lumbrineridae**	***Lumbrineris aotearoae***	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	1	0	0	0	0	0	0	8	0
Annelida	**Polycheate**	**Terrebratulida**	**Terebellidae**	***Terebratella* sp.**	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	**Polycheate**	**Orbiniida**	**Orbiniidae**	***Orbiniid* sp.**	0	0	1	0	0	3	0	1	0	0	0	0	0	0	0	0	1	3	0	1	0	0	0	0	0	0	0	3	0
Annelida	**Polycheate**	**Spionida**	**Spionidae**	***Prionospio australiensis***	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	**Polycheate**	**Phyllodocida**	**Glyceridae**	***Glycera* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Annelida	**Polycheate**		**Maldanidae**	***Axiothella* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Annelida	**Polycheate**	**Phyllodocida**	**Nereidae**	***Nereid* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	4	0	0	4	0
Annelida	**Polycheate**	**Eunicida**	**Lumbrineridae**	***Lumbrineris* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7	3	0	0	0
Annelida	**Polycheate**	**Spionida**	**Cirratulidae**	***Cirratulid* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Annelida	**Polycheate**	**Phyllodocida**	**Nephtyidae**	***Aglaophamus macroura***	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthropoda	**Malacostraca**	**Decapoda**	**Paguridae**	***Diacanthurus spinulimanus***	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthropoda	**Malacostraca**	**Decapoda**	**Paguristes**	***Paguristes pilosus***	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Euarthropoda	**Malacostraca**	**Isopoda**	**Aegidae**	***Aegidae* sp.**	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthropoda	**Malacostraca**	**Leptostraca**	**Nebaliidae**	***Nebaliella* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0
Echinodermata	**Holothuroidea**	**Dendrochirotida**	**Phyllophoridae**	***Pentadactyla longidentis***	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0