19 The Crescent, PO Box 1262,
Invercargill 9840, NEW ZEALAND
Telephone: 03 218 2546
Facsimile: 03 214 4285
Email: admin@bonischenvironmental.co.nz
Web: www.bonischenvironmental.co.nz

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2 May 2018

The Consents Manager
Environment Southland
Private Bag 90116
Invercargill 9840

Dear Michael

Zane Smith & Jim Maass-Barrett – application for consents for three marine farms in Big Glory Bay, Stewart Island

Please find attached to this letter and application and assessment of environmental effects for three new marine farming sites at Big Glory Bay, Stewart Island. Mr Maass-Barrett of Maass Mussels & Oysters Ltd, is an existing consent holder for a farm in the Bay and is now working in partnership with Mr Smith to establish some new sites.

The type of marine farming proposed is for shellfish, mainly Green-lipped mussels, and it will in the same manner as it is carried out on other shellfish farms in the Bay. In assessing the effects of the proposal, the applicants rely on recent scientific studies in other locations that is, within reason, transferable to Big Glory Bay; the results of monitoring in the Bay; a benthic survey of the seabed under the proposed site locations; and the lack of any significant effects from the existing farms, particularly in regard to water quality and the seabed under the mussel farms.

The overall finding of the assessment of environmental effects is that adverse effects will be no more than minor. It is also considered that the application is not contrary to, or inconsistent with, the relevant national and regional planning documents.

It is therefore submitted that the application can be processed without notification and granted.

Yours sincerely,

John Engel
Manager, Bonisch Environmental

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Invercargill 9840, NEW ZEALAND
Telephone: 03 218 2546
Facsimile: 03 214 4285
Email: admin@bonischenvironmental.co.nz
Web: www.bonischenvironmental.co.nz

bonisch environmental

Applicants: **Zane Morgan Smith and Terrence James Maass-Barrett**

Report: **Assessment of Environmental Effects**

Subject: **Application for a coastal permit for three marine farming sites for shellfish**

Date:

1. Introduction

Zane Smith and Jim Maass-Barrett (the Applicants) are applying for a coastal permit to establish three new marine farming sites in Big Glory Bay. The sites will be farmed for shellfish, namely, mussel varieties, oysters and scallops.

The sites include two of three locations that were granted resource consent in April 1997 to Mr Maass-Barrett. However, two of those consents lapsed when a marine farming permit could not be obtained for those sites from the former Ministry of Agriculture & Fisheries[1]. The third was granted a marine farming licence and is currently being farmed.

The application forms are attached as Appendix 1. The site localities within Big Glory Bay are shown on the maps in Appendix 2, one of which shows the locations in relation to the existing marine farms and the navigation lane located through the middle of the Bay.

Sites 2 & 3, as shown in Appendix 2, are the previously consented sites. The only activity on them when previously granted consent was the storage of some salmon cages for a period of time after Regal Salmon Ltd ceased farming in the Bay. There has never been any actual marine farming on the sites.

The consent required for each site is a coastal permit for marine farming under Rule 15.1.7 of the Regional Coastal Plan. "Marine Farming" is defined as:

1 The reason for the permits not being granted by MAF were contentious and resulted from using the same information that Environment Southland relied on to grant resource consents, but in a different way. The applicant at that time was not in a position to challenge the Ministry's decision in the High Court and the two consents eventually lapsed.

> *"the activity of breeding, hatching, cultivation, rearing, or on-growing of fish, aquatic life, or seaweed for harvest; but does not include ... [the exclusions are not relevant to this application] ... and "to farm" has corresponding meaning which includes any operation in support of, or in preparation for, any marine farming."*

This definition includes all of the activities associated with establishing the farm, rearing the shellfish and harvesting them, i.e. disturbance of the seabed and placement of structures on and over the seabed; occupation of the coastal marine area; deposition of shell, pseudofaeces (mussel excreta); and discharge of crop washing water. Each activity that makes up the overall activity of "marine farming" is discussed in more detail below.

2. The application

The application is for coastal permits to establish three marine farm in Big Glory Bay, one of 6 ha and two of 5 ha, and the marine farming activity required to manage and operate them. The application forms are attached as Appendix 1.

The species to be farmed are:

Common name	Latin name	Culture method
Green lipped mussels	Perna canaliculus	Mussel rope
Blue mussels	Mytilus galloprovinciallis	Mussel rope
Ribbed mussels	Aulacomya ater	Mussel rope
Scallop	Pecten novaezelandiae	Baskets
Oysters[2]	Ostrea chilensis	Mussel rope, baskets, trays

The specific activities associated with establishing the marine farms and carrying out marine farming of shellfish that require a consent are:

1. placement of structures on and over the seabed. The structure consists of:
   - mooring blocks and steel Danforth anchors, or screw anchors;
   - backbone ropes and buoys;
   - suspended ropes, baskets and trays attached to the backbone; and

2 The applicants acknowledge that oysters cannot currently be farmed in Big Glory Bay due to the *Bonamia Ostreae* outbreak that was detected in this area. However, if the problem is resolved in the future and Bluff (flat) oysters are able to be farmed, the applicants want to be able to do so on these proposed farms.

- navigation lights/aids.

2. disturbance of the seabed during the placement of the structure;

3. occupation of the coastal marine area with the structure. Exclusive occupation is not applied for but the effect of the farm on access is discussed below in the section on "Consideration of Adverse Effects";

4. occasional mooring of a vessel and barge within the site for set-up, harvesting and maintenance work; and

5. deposition of shell, sediment and organic material (pseudo faeces from shellfish excretions) on the seabed, and the discharge of water associated with the harvesting of the shellfish.

The site co-ordinates and dimensions are set out in Table 1 below.

	Location	Co-ordinates (NZTM)		Depth at middle (m)	Area (ha)	Dimensions (m x m)	Shape
Site 1	Centre	4786551.3	1229123.7	26	6	300 x 206.2	Parallelogram
	NE corner	4786556	1228942				
	SE corner	4786719	1229194				
	SW corner	4786S46	1229306				
	NW corner	4786383	1229054				
Site 2	Centre	478S069.1	1228697.1	27	S	200 x 2S0	Rectangular
	NE corner	478S191	1228S94				
	SE corner	4785143	1228839				
	SW corner	4784947	1228801				
	NW corner	478499S	1228SSS				
Site 3	Centre	4785210.7	1229089.0	27	S	200 x 250	Rectangular
	NE corner	478S330	1228994				
	SE corner	478S283	1229240				
	SW corner	478S086	1229201				
	NW corner	478S134	1228956				

Table 1 Site locations and dimension information. The site locations are shown on a map in Appendix 2.

The structure of the farming system will be based on a conventional long-line system on each site. Ropes and/or baskets/trays would be suspended from standard double back bone lines of 24, 28, or 32mm diameter polypropylene rope that would be moored to the seabed with either screw anchors or large concrete blocks, coupled to large steel Danforth style anchors. The water depth at the three sites is approximately 26m and most of the culture is grown in the top 10 to 12m of water. The lines are generally laid in an east west direction in Big Glory Bay in order to align with the prevailing wind.

A number of sketches of the farm structures are attached in Appendix 3.

The ropes used are generally manufactured in NZ where experience in mussel culture is world leading. The floats used by most Stewart Island marine farmers are made on the island. New materials are favoured to eliminate the risk of bringing in any marine pests.

Shellfish will either be grown on ropes or in trays/baskets suspended from the backbone. While mussels are best grown on ropes, scallops are grown in baskets in order to contain them. Oysters can be grown on either ropes or trays and the method used will depend on how they best respond in terms of health and growth rates. The harvesting activity requires a barge and vessel to be on the site. When harvesting the mussels, sediment and pseudo faeces can be temporarily suspended in the water column causing some discolouration in the immediate vicinity but this effect is very minor and short-lived. This effect is discussed in more detail below.

The Applicants are seeking a term of consent to expire on 1 January 2040. They are aware that other consents in the bay have a common expiry date of 1 January 2025, and have assumed that any replacement consents would be granted for a further 15 year term. The 2025 expiry date is close and, if applied, would be too short a term to provide security for a new development, particularly given that it will take some time to get the sites set up and seeded with mussels. The Applicants require sufficient time to establish farming on all sites, gather information associated with their farming activity, and to get a reasonable return on the investment required for the proposed development.

The effects associated with farming shellfish are reasonably well known and significantly less than those from finfish farming, i.e. there is not a high degree of uncertainty that would require a short term consent to be granted. Shellfish farming, mainly mussels, has been occurring in Big Glory Bay for about 30 years, and in that time a considerable amount of monitoring data has been gathered and reported to the Council. Adverse effects are considered in more detail later in the application.

3. Description of the locality and existing environment

A map of Big Glory Bay that shows the main features is included in Appendix 2

Big Glory Bay is a semi enclosed arm of Paterson Inlet, located in its south east corner, and has a surface area of approximately 12 km^2. The main axis of the bay, which is approximately 5.5 km long, runs north east to south west, and the bay is approximately 2.7 km wide at its widest mark. The land surrounding the bay is part of Rakiura National Park on the northern side and Glory Cove Scenic Reserve on the southern side. The land cover is predominantly Indigenous forest, with small areas of Broadleaved Indigenous Hardwoods at the head of the bay and at the entrance.[3]

The shoreline includes a number of small bays with sandy beaches. There are no major inflows of freshwater into the bay. The largest stream by catchment area (approximately 580 ha) is at the head of the bay. Apart from some clearance and buildings (two cribs and a boatshed) on the west side of Bravo Island at the mouth of the bay, there is no other sign of human development on land in the vicinity of Big Glory Bay.

Water movement in the bay is controlled by tides and wind. There will be some variation with the stage of the tide but water flows into the bay at depth and travels up the middle, rising as it goes. The water then diverges and flows around the sides of the bay before coming together again and flowing out near the surface (0-10m depth)[4]. The surface flow is accentuated by the predominant westerly winds that push water towards Paterson Inlet. The residence time in the bay varies from 10 – 14 days depending on tide and wind conditions.

Development within the bay is from marine farming, of which there are 35 sites. By area, the greatest proportion is in mussel farming but there is a significant area available for salmon farming[5], which is the more visible of the two. There are a number of vessels in the bay at different times, mostly associated with marine farming activities, but private and charter vessels can enter the area for sightseeing, and for shelter in the bays and coves along the shoreline. There is also some storage of marine farm equipment on barges within the area.

A channel has been maintained through the middle of the bay to allow access through it (see Appendix 2 – the dots on the fairway boundaries are the points recorded in the Regional

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3 Source: Department of Conservation GIS map – Landcover Database v3.3.

4 Taken from 'Net flushing pattern, Big Glory Bay" – R Pridmore, Water Quality Centre, March 1991.

5 Although a significant area is available for salmon farming, only some of that area has cages on as other areas are left to "recover" or lie fallow. Shellfish maybe farmed on some of the fallowed sites.

Coastal Plan map that is also in Appendix 2). There is no marine farming in the upper part of the bay because it is too shallow and water movement is very slow.

The Coastal Values section of the RCP (Part B, Chapter 3) includes Big Glory Bay in Section 3.14 – Stewart Island and Islands Offshore. A lot of the information relating to natural character, landscape values, flora and fauna, and the general ecology is common to all parts of Stewart Island, apart from the more developed areas around Halfmoon and Horseshoe Bays. Big Glory Bay is the only area around this coastline that has not been identified as an area containing significant conservation values, presumably because of its use for marine farming.

The Coastal Landscape Assessment in the RCP does not include any specific reference to Big Glory Bay. It is part of the Eastern Bays Landscape Unit, which includes Halfmoon and Horseshoe Bays, and Paterson Inlet, the area with the most development on the island, but it is still given a naturalness rating of 3+ out of 5 (midway between modified (3) and semi-natural (4)). Semi-natural is described as having "… high inherent values and where indigenous characteristics are still dominant, but where some localised modifications have occurred to the original character." Big Glory Bay, even with the marine farming development present, would fit the definition of 'semi natural' so, on its own, would qualify for a naturalness rating of 4. By comparison, Halfmoon and Horseshoe Bays would more likely to have a naturalness rating of '3'.

The only signs of any development on land within Big Glory Bay are at the entrance on the western side of Bravo Island, and a house at the head of the bay, which is very difficult to see as it is in the forest area. All of the development of any significance in the bay is on the water. The existing environment includes 35 marine farm sites within the bay, the majority of which are used for shellfish farming (mainly mussels). About 10 sites are authorised for finfish farming (salmon) but at any one time, only two or three sites are likely to have cages on them.

The landscape information has recently been updated with the publication in October 2017 of a report entitled "Stewart Island – Landscape and Natural Character Study" by Boffa Miskell Ltd. The report was prepared for Environment Southland. It finds that most of the landscape and seascapes meet the standard of outstanding natural landscapes, the exceptions being the more developed areas of Halfmoon and Horseshoe Bays, part of the north side of Paterson Inlet and Big Glory Bay. The findings in regard to natural character are similar as those for landscape with the same exclusions.

Statements in the report relevant to Big Glory Bay are referred to in Section 4 below relating to the effects assessment.

Water quality, even with the marine farms present, is very high within the bay. The latest monitoring report available[6], identifies some seasonal variations but loss of some samples limited Aquadynamic Solutions (ADS) ability to analyse the seasonal patterns. However, Chlorophyll *a* levels and nutrient concentrations did "… indicate that there is variability between nutrient uptake and phytoplankton. …" that did appear to be seasonal.

Temperature stratification was noted but is "… purely related to climatic forcing …". No impact on dissolved oxygen levels as a result of marine farming activities was observed. ADS noted that "… Other water quality parameters indicate no detectable adverse water quality conditions within the bay."

The benthic conditions under the proposed farm sites were assessed by NIWA[7] and its report is attached as Appendix 4. Historical data from two designated control sites that are used for ongoing monitoring purposes within the bay were used as reference sites, so that the data from each of the proposed sites could be "… analysed for significant differences between the proposed sites and the controls." In its Conclusion, the report states:

> *In this study, the three proposed mussel farming sites align with the reference sites (CM and CH) as assessed by the suite of prescribed environment indicators. The areas are environmentally healthy and have complex community structures that accommodate predator-prey relationships.*

More information is in the complete report appended.

4. Assessment of Environmental Effects

The potential adverse effects that need to be considered for this application are in regard to impacts on landscape, water quality, seabed, interactions with marine mammals, noise, safety and navigation, high value areas, heritage, and amenity values.

One of the significant benefits of farming shellfish in conjunction with finfish is the "grazing" of excess nutrients in the form of phytoplankton. This effect is discussed further below in Section 4.3 and includes reference to scientific studies. Other potential positive effects are in relation to people and communities, and the economy generally.

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6 "Big Glory Bay Benthic and Water Quality Sampling 2016" – Aquadynamic Solutions, September 2016.

7 "Baseline benthic survey of three proposed mussel farm sites in Big Glory Bay, Stewart Island" – NIWA, December 2017.

In regard to the ecological effects of farming shellfish, a Cawthron report prepared for the Ministry of Fisheries is used as a reference[8]. Its full title is "Review of the Ecological Effects of Farming Shellfish and Other Non-finfish Species in New Zealand" and was published in April 2009. It is referred to as the "Cawthron Report" in the assessment that follows.

The effects assessed below are potential adverse effects but it is noted that the proposed development will have economic and social benefits through the sale of the product and the employment of local staff. There is potential for up to two additional staff initially and in a small community like Stewart Island, that is significant.

4.1 *Ecological carrying capacity*

Carrying capacity within Big Glory Bay has historically been determined by nitrogen allocation. It was developed in the 1990's but no update or recent review of the model and its assumptions has been carried out to take account of later studies that looked at how mussels fit into the nitrogen cycle in the bay, particularly in combination with finfish farming. The Cawthron report had the following to say about this matter:

> *So where does New Zealand sit currently in terms of meeting the objectives of ecological carrying capacity? Unfortunately, there are no definitive studies which provide a clear cut answer to this question, mostly because it is complex issue. In order to consider it, we first need to determine the temporal and spatial scales to be assessed. Typically the results of studies conducted as part of consent applications for individual farms (e.g. Pelorus Sound – unpublished Cawthron FRIA Reports, and the Coromandel - Stenton-Dozey et al. 2008) suggest that the current levels of production are presently low when compared to average levels of food in predominantly semi-confined growing regions (i.e. Embayments/Sounds). Despite the reduced production noted over 1999-2002 (Zeldis et al. 2008), the conclusions of these studies are supported by a generally consistent production of mussel culture over the longer term, suggesting New Zealand mussel farms are at least sustainable in a production sense."*

The report goes on to note that New Zealand's farming is significantly less intensive than in other countries where the main limitation is physical space. However, it doesn't mean that poor production years have not occurred but they are considered to have been as a result of climatic factors and variations in phytoplankton biomass.

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8 "Review of the Ecological Effects of Farming Shellfish and Other Non-finfish Species in New Zealand" – Cawthron Institute - April 2009

In Big Glory Bay, no monitoring has detected any wider bay impacts that extend significantly beyond the boundaries of each site, including the finfish sites. Mussel production is consistent and there does not appear to be any "competition" between the sites for that food supply. As noted in the Cawthron report, assessing carrying capacity is a complex issue.

Using the outdated nitrogen model prepared for Big Glory Bay, three mussel farming sites were granted consent in 1997 to T J & H E Maass-Barrett but two (Sites 2 & 3 in this application) were not granted a marine farming licence by the former Ministry of Agriculture and Fisheries (MAF) and their consents subsequently lapsed. MAF's methodology for assessing the application was disputed at the time due to its double accounting for sites that could farm finfish or mussels, but research since that time has also shown that some of the assumptions used in the nitrogen model were flawed. However, an updated model is not available.

Notwithstanding the lack of a working model, the assessment is that there is sufficient carrying capacity in the bay for the additional mussel farms. This assessment is based on the lack of any detectable impact from the existing farming on either the ecology of the bay away from the farm sites, or on mussel production on those existing sites. There are certainly some sites that perform better than others but it is believed to be due to other matters such as their location in the bay and suitability of the particular site.

The assessment is also based on the fact that even under the very conservative nitrogen model developed in the 1990's, consent could be granted for sites 2 & 3. Apart from the shifting of the salmon farm around the bay, nothing has changed that would affect that decision.

4.2 *Landscape and visual effects*

The quality of the landscape has already been described in Section 3 above. Notwithstanding the extent of aquaculture development within the bay, it still retains a high naturalness rating due to the ability of the landscape to absorb some development at sea level. Disturbance of the land and/or clearance of vegetation would have a far more significant impact in this environment.

The Boffa Miskell report notes that marine farming "… *has modified the central coastal waters of Big Glory Bay, however the coastal interface area adjacent to the land retains generally very high levels of naturalness due to the lack of modifications.*" In describing Paterson Inlet, the report states that despite "… *the modification (which is centred on only* *a few parts of the Marine Area the majority is relatively untouched, supporting an overwhelming sense of naturalness, notably within the more sheltered parts of the Inlet."*

However, the areas of Big Glory Bay, Halfmoon Bay and Horseshoe Bay are excluded from the area considered to be an Outstanding Natural Landscape because of the level of existing development. Similarly, while much of Paterson Inlet is deemed to have outstanding natural character, Big Glory Bay does not due to the presence of the marine farms.

Because of the existing effect on the landscape and natural character values by the marine farms in the bay at present, the addition of three further mussel farms will only have a cumulative effect. The new farms will not detract significantly from these values any further, and, because they will not be any different in nature to what is already present, i.e. they will blend in, the overall impact is assessed as no more than minor. This assessment is conservative in the absence of a specialist report as the cumulative effect may actually be less than minor.

The surrounding land is not as immense and dominant as the Fiordland landscape but it is still significant. Of the marine farming in the bay, the salmon cages and associated service vessels and barges are the most visually prominent but even they are small in the context of the landscape.

Mussel farms, excluding the vessels used for maintenance and harvesting, are most prominent when looking over the water surface from a vessel in reasonably close proximity – the dark-coloured buoys can be seen unless weather conditions have caused rough conditions to develop. However, for the most part, their dark colour is unobtrusive, making them difficult to notice from a distance, and they do not detract significantly from the natural character of the area. Each line has an orange buoy at its ends, but despite that brighter colour, they are not conspicuous from a distance. However, when mussels are being harvested, the vessels and barge used will be more prominent.

Aquaculture has been present in Big Glory Bay since the 1980's and the current number of sites has not changed for over 10-15 years. Marine farms are confined to this area and are an expected sight when visiting Big Glory Bay. The addition of three more farms to the 35 existing ones will have a cumulative effect but it is considered to be no more than minor. They will be consistent with other shellfish sites and similar in the way they will be laid out, i.e. they will not be distinguishable from other shellfish sites in the bay.

4.3 *Water quality*

The earliest marine farming started in Big Glory Bay in the late 1970's (a salmon farm) with mussel farming developing in the 1980's and significantly increasing through the 1990's. Following the introduction of the Resource Management Act and various amendments, marine farms had to get a resource consent and those consents have required both water quality and benthic monitoring to be carried out. The extent of the monitoring over the years has changed but the results have been reasonably consistent over that time.

The sampling methodology is in accordance with the monitoring requirements of the resource consents. Monthly water quality sampling is conducted at 6 stations. Temperature and dissolved oxygen levels are measured every 2 meters from the sea surface to the seabed with a water quality probe/sonde, while a Secchi disc is used to measure water clarity (note – the consent requirement for water quality monitoring was for the first two years only but the consent holders have decided to continue it). Monthly samples for the analysis of Chl-*a*, and dissolved nutrients are collected at 5 meters depth.

The most recent annual monitoring report (April 2016 to April 2017) for the bay continues to state that the "… *water quality survey indicates there are no detectable adverse water quality issues within Big Glory Bay.*" Dissolved oxygen (DO) levels were above 6 mg/l during all sampling periods and at all depths. There was no indication that marine farming was impacting on DO levels in the bay. Some thermal stratification was observed during the warmer months but the effect is related to climate rather than marine farming.

Chl-*a* and nutrient concentrations showed some seasonal variation, but from previous modelling work and wide-scale sampling, they are known to be affected by regional changes from outside of the bay.

The addition of three new shellfish farm sites can impact directly on water quality through the release of nutrients and/or indirectly by restricting water movement and wave action in the bay. As noted in the Cawthron report, the effects on the water column "… *are less well defined than for the seabed, because water column characteristics are more dynamic and inherently harder to quantify.*" However, as a general statement, the report concludes as follows:

> *"Bivalves and other associated fauna release dissolved nitrogen (e.g. ammonium) directly into the water column, which can cause localised enrichment and stimulate phytoplankton growth. Toxic microalga blooms may lead to ecological or health problems, but there is no evidence of this being exacerbated by mussel farming in*

> *New Zealand waters. Filtration pressure by mussels is sufficient to potentially alter the composition of the phytoplankton and zooplankton/mesoplankton communities through feeding, but the extent to which this occurs and its ecological consequences are poorly understood. Despite the recognised knowledge gaps, the fact that no significant water column related issues have been documented suggests that effects associated with traditional inshore farming practices are minor."*

The report goes on to state that the situation is likely to be the same for oysters and other bivalve species but species such as paua that require a feed input will be different.

Studies in the Firth of Thames[9] have shown that mussel farming is a net user of nitrogen, which is consistent with the view that mussel farming and salmon farming provide mutual benefits for both production and maintaining water quality. Earlier work on allocating space in Big Glory Bay was based on a nitrogen model developed by NIWA. At that time, mussels were considered to be a net nitrogen producer but subsequent work has indicated that that might not be the case.

The Firth of Thames study and other work done in the Marlborough Sounds[10] considered that mussels are a net consumer of nitrogen as they are harvested and do not stay in the environment. While no work has been done to see if this finding is transferable to Big Glory Bay, or to what extent salmon and mussel farming complement each other in regard to nitrogen removal, there is nothing to suggest that it would be different.

What is known is that the existing level of farming has not caused any measurable impact on water quality within the bay, and that there is more impact on nutrient enrichment from influxes of water from outside the bay than from the farming inside. Water residence time in the bay varies with the size of the tides, which is the most significant driver of water movement. Residence time can be from 5 to 14 days, and the water movement is the most significant towards the mouth of the bay close to Paterson Inlet.

No hazardous chemicals are stored on vessels or used on mussel farms. Vessels will have fuel aboard and minor amounts of detergent for washing, which is no different to any fishing, charter or recreational vessel.

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9 "Magnitudes of Natural and Mussel Farm-Derived Fluxes of Carbon and Nitrogen in the Firth of Thames" – J Zeldis, NIWA, for Environment Waikato – June 2005.

10 "Blowing the budget? Nutrient resources and the Marlborough mussel crop". MacKenzie L - Seafood New Zealand, March 1998: 41-44.

It is therefore considered that the effect of proposed new sites on water quality will be no more than minor.

4.4 *Benthic Effects*

The NIWA report prepared for this application describes the benthic conditions at the proposed sites. Under the proposed mussel lines, changes in the benthic conditions are anticipated over time and are expected to be the same or similar to the conditions under the existing farms as documented in the annual monitoring reports for the bay.

The 2017 annual report, which has been submitted to Environment Southland and is on record (a copy can be provided if necessary), includes the results of monitoring two mussel farm sites, namely, MF 244 and LI 340 (see marine farm location plan, which includes the proposed new sites, in Appendix 2). The benthic environment under the existing farms is affect by the marine farms, both mussel and salmon, and "*... is typical of that observed in several marine aquaculture impact studies including those undertaken in the Marlborough Sounds during the early 2000's.*" The results from the 2017 monitoring are summarised in the following extract from the report:

> *"Organic enrichment (when compared to the nearby central bay control station ConH) was observed beneath most farming stations (both mussel and fish farm), along with mussel shells (at both mussel farms and one of the salmon farms, which was once a mussel farm). Opportunist polychaetes (i.e.* Dorvilleid*) were also observed beneath both mussel farms and two of the three salmon farms. Similar species have been observed in and around many mussel farms in the Marlborough Sounds. Copper concentrations were observed to be elevated beneath both the 338 and 339 farm leases but copper quickly attenuated to background levels 50m from the edge of lease. At the new 246 salmon farm lease there was no sign of additional copper in the sediments.*
>
> *Both the mussel and salmon stations still retained a moderately high species richness and diversity. A wide range of polychaetes were found at these sites including grazers, detritivores, opportunists, and predators. Conditions were generally observed to improve (i.e. organic matter content decreased away from the site boundaries) with distance from the salmon farms (50 and 100m from the site boundary). The seabed under the new 246_F site looked to be almost un-impacted as there was no increase in metals and few if any opportunistic polychaetes. Currents at this site are also stronger (as it is at the mouth of the bay) and this will*

likely aid in reducing the impact beneath the farm. A recent storm may also have acted to help clean the seabed of farm related organic material.

During the 2016 survey, Beggiatoa[11] *matting was observed both beneath farm stations 249_50 and 249_1:OO and patchy* Beggiatoa *was also observed beneath mussel farm site 272. During the 2017 survey, no* Beggiatoa *was observed at any of the sites surveyed. Fish farm feed waste was observed under the farm at 339_F, however there was no sign of any feed waste 50 or 100m from the cage edge.*

Overall, the sediment quality in Big Glory Bay appears to have improved since the 2015 (no sign of Beggiatoa*) and does not appear to be badly impacted given that there are a large number (more than 30) farms scattered across the entire bay. Both control stations, one situated in the middle of the bay while the second is toward the mouth, appear to be un-impacted by farm debris."*

There is no indication from this ongoing monitoring that there are any significant cumulative effects extending out from the immediate area under the existing farm sites. This finding is particularly true in regard to the mussel farm sites where the adverse effects under the farms are considered to be no more than minor.

Although the monitoring shows significant variation across all sites, the analysis of the results indicated "*... that the mussel stations still retained a moderately high species richness and diversity. A wide range of polychaete species were observed (*Dorvilleid sp. Glycerid sp. & Polychoeta lJnidentified sp*). Filter feeding bivalves (*Solemya parkinsoni, Nuculidae sp, Nucula nitidula, Veneridae, Thracia vegrandis & Leptomya retioriia*) were also found in the mussel sampling stations. Amphipods were also collected beneath the mussel farm station 340, though in low abundance ...*". It is also noted that no tube worm (*Galeolaria hystrix)* species or mounds were observed on the proposed sites.

The proposed new farms will be set up and operated in much the same way as the existing sites, so the effects will be the same and the only cumulative effect will be from an additional 16 ha under marine farms. The potential adverse effects of the activity proposed is therefore assessed as no more than minor.

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11 *Beggiatoa* is a bacteria known to live in sulphur–rich environments, including hydrogen sulphide, which is often an indication of the breaking down of organic matter in the absence of oxygen.

4.5 *Wildlife Interactions*

Operating in this area means a lot of marine wildlife, including a number that are of conservation interest, come into contact with the marine farms. Species of conservation interest, including seals, sea lions, cetaceans, sharks, and seabirds, are all found around most of the coastline of Stewart Island. The most common interactions within Big Glory Bay are with seals (mainly fur seals), sealions (the New Zealand sea lion), dolphins (bottlenose), sharks (White Pointer, Broadnose Sevengill and the Porbeagle) and seabirds.

The larger predators are mostly attracted to the salmon farms. Fur seals are the most common but improvements in net and cage design have reduced interactions. They do appear around mussel lines, possibly seeking prey that may use the mussel structures as part of their habitat, but no issues have been noted.

In open water areas, some entanglement with mussel lines by cetaceans has occurred but it is rare and not something that has occurred in Big Glory Bay.

Interactions with sharks are not uncommon, but again, they appear to be attracted by the salmon and no issues have been noted around mussel lines.

Seabirds are common, including various species of shag, penguins and gulls, some of which are classified as vulnerable and, in the case of the yellow-eyed penguin and the black billed gull, endangered. Mussel farms are visited by penguins and, for the shags and gulls, are places to roost on. The Cawthron report provides the following overview of effects on seabirds:

> *"Several New Zealand and overseas studies discuss the potential ecological effects of shellfish aquaculture on seabird populations, but only a few direct studies have been conducted (Roycroft et al. 2004; Zydelis et al. 2006; Kirk et al. 2007). Based on these studies, mussel aquaculture potentially affects seabirds by altering their food resources, causing physical disturbances (e.g. noise) and/or being a possible entanglement risk. The structures associated with aquaculture may also provide benefits including additional perching and feeding opportunities. As several of New Zealand's seabird species are endangered or threatened, it is important that the shellfish industry remains up-to-date on any possible influences shellfish farming may have on these populations (Dowding & Murphy 2001)."*

There are no known problems associated with the Big Glory Bay mussel farms in regard to seabirds and most interactions appear to be positive. However, the applicants are open to new information and modifications that may avoid any impact on seabird species.

The overall assessment of the potential adverse effect of the new farms on seabirds is that they will be less than minor.

4.6 *Noise effects*

Sound from marine farming activity is generally low level. The main sources are vessels coming to the farm and leaving, smaller vessels operating in and around the farm, and from electrical generators. Generators are only an issue if a vessel moors at the site overnight. Unlike the salmon farms, mussel sites have no permanent presence on-site.

Harvesting mussel crop and reseeding lines are the busiest times on site. The noise is common in the bay now as it is a working environment. On the harvest vessel, there is mechanical noise that will vary in loudness over the day but it is unlikely to exceed the daytime noise standard at the landward boundary of the coastal marine area.

A specialist noise report has not been prepared because the activity is not new and believed to be consistent with other activity occurring in the bay that, to the applicants' knowledge, has not caused the issues in regard to noise.

4.7 *Navigation*

Big Glory Bay marine farms are shown on modern charts. Environment Southland has developed a navigational channel that carries from entrance to the bay, and extends in a sweeping arc to the head of the bay. This channel is shown in the Regional Coastal Plan with co-ordinates. It is lit by corner lights on some marine farms, red lights on port side, and green lights on starboard side of channel. It is accepted because of the pattern of farms in Big Glory Bay that it would be confusing to light all corners of all sites. In addition to the lights, these points have a radar reflector and reflectorised tape to cover all probabilities. During daylight hours, marine farm backbones are visually enhanced by orange floats on the ends of each line.

All sites must comply with the navigation and safety requirements of the regional Harbourmaster. Marking of sites is based on the *"Guidelines for Aquaculture Management Areas and Marine Farms"* booklet produced by Maritime New Zealand, the latest version of which is dated December 2005. The applicants agree to comply with these requirements.

The new farms are located adjacent to existing sites and will not be exceptional in any way or create any new hazard for the area. The bay is known to be a marine farming area and that extra care needs to be taken to navigate through it. There are seven anchorages in the bay identified in the Regional Coastal Plan, one of which is in the middle of the fairway provided for access. However, it is believed to be the site used by the Penrod oil rig and, because it is exposed to winds, is not used by vessels visiting the bay.

The potential effects on navigation and safety are therefore assessed as less than minor.

4.8 *Effects upon areas of significant indigenous vegetation and significant habitats of indigenous fauna and outstanding natural features and landscapes*

Big Glory Bay is not an area that is identified as an area containing significant values (ACSV) in the Regional Coastal Plan, due in part to the historic marine farming activity in this area. Values on the land, apart from the presence of the marine farms on the seascape, are not impacted by this activity. On the water, there is a level of activity that would not otherwise occur if marine farming was not present.

The seabed has been described in the appended NIWA report, which confirms that there are no particularly sensitive features present. In terms of wider impact on the bay, the marine farming is already present and spread throughout the bay.

Indigenous fauna are present but no specific habitat areas, such as breeding grounds, are impacted by the existing or proposed sites. The shoreline is, for the most part, unaffected by the farming activity – potentially, some vessel wake could occur, and some debris has washed up in the past. The latter is removed from time-to-time by the farm staff.

The landscape around Big Glory Bay is the same or similar to the landscape over most of Stewart Island – it has very high natural character and is, for the most part, pristine. It has not been formally identified as an outstanding natural landscape, nor is there any outstanding feature. The marine farming activity has no physical impact on the land but it is visible from many points around the bay. The mussel lines themselves are relatively unobtrusive when viewed from the shoreline but vessel and harvesting activity will be more visible. These structures will be present for the foreseeable future but once removed, impacts on anything that could be regarded as an outstanding feature or landscape will be removed and leave no residual impact.

Because there is an existing level of development with which the new sites will be consistent, potential cumulative effect of the three new sites is assessed as less than minor.

4.9 *Any effect an heritage or archaealagical sites*

As the activity is in the coastal marine area, no heritage or archaeological sites are directly affected by this proposal. There are two sites identified on Bravo Island and one on the south side of Big Glory Bay identified in the Southland District Plan but none are impacted by the proposal for the three new farm sites.

4.10 *The effect an sites ar areas af significance ta Tangata Whenua.*

Local Iwi have not objected to the marine farming activity in Big Glory Bay in the past and it is not anticipated that there will be any issue regarding this proposal. Iwi have an interest in the development of new marine farms under the provisions of the Ngāi Tahu Claims Settlement Act but that is addressed outside the provisions of the Resource Management Act.

Impact on Tangata Whenua is believed to be no more than minor based on previous consent processes, but no consultation has been carried out at this time.

It is also noted that there is one claim for Customary Marine Title under the Marine and Coastal Area (Takutai Moana) Act 2011[12]. The claim is by Te Rūnanga o Ngāi Tahu (TRONT) on behalf of the Ngāi Tahu Whānui. As required by the legislation, a copy of the application will be forwarded to this group.

4.11 *Waste*

The only solid waste that is deposited on the seabed is the pseudofaeces excreted by the mussels, dislodged shellfish, and the epibiota that can attach itself and grow on the mussel farm structures and the mussels themselves. Rope and other materials used to attach the mussels to the lines that may drop to the seabed are regathered for disposal on land. Any equipment or materials lost overboard accidently are recovered and disposed of appropriately on land.

4.12 *Biasecurity*

There is a risk of introducing or providing habitat for invasive marine species with marine farming activities. However, the risk can be minimised by adopting best management practices for sourcing and introducing mussel spat onto the site, and carrying out the

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12 Application by Cletus Maanu Paul on behalf of all Māori and Waitaha Nation were lodged for all of the coastline around New Zealand/Aotearoa but the Minister for Treaty of Waitangi Negotiations has declined to engage with them. The effect of that decision is that there is no longer any need to notify them.

appropriate level of monitoring. The applicants are also familiar with the information published by both Environment Southland and the NZ Mussel Industry Association (NZMIA). The NZMIA has developed a voluntary industry code of practice that includes transfer protocols for spat transfers, and the applicants will be guided by this document. The applicants are also familiar with the standard conditions relating to biosecurity matters on consents for this activity.

In Big Glory Bay, *Undaria* is present, as it is in other parts of the Southland coast. While efforts are made to keep boats and equipment clean, the applicants view is that *Undaria* can no longer be controlled in Big Glory Bay. However, to minimise the risk of introducing more plants, or other marine pests, spat will only be sourced from Kaitaia off 90 Mile Beach.

Managing biosecurity risks is an ongoing issue for farmers as the spat for Big Glory Bay cannot be sourced locally. Visual inspections of lines are carried out, but some pests are microscopic. Treatment processes are available, but they do not provide an absolute guarantee that no unwanted organisms are present. Big Glory Bay has some natural protection from some pest plants and organisms that are not viable in southern waters, but it cannot be taken for granted. The applicants therefore undertake to ensure they are fully informed on such matters, to adopt best management practices relating to all their activities associated with the farm sites, and to be vigilant.

Based on the existing farming activities in the bay and the applicants experience, the risk of a biosecurity issue is assessed as no more than minor.

4.13 *Consideration of alternative sites*

There are two aspects to the consideration of alternative sites. The first is the general area in which to establish the farms, and the second is the actual sites in that general area.

Big Glory Bay is selected because it is a discretionary activity to farm there, rather than prohibited as it is for many other areas, and it is an established marine farming area. It is also close enough to an urban area from which the farm can be serviced. Alternatives include Port Adventure and the open coastal waters around Stewart Island, and areas along the southern coast of Southland.

Port Adventure is an area with high natural values but it is a discretionary activity to farm there so it is available. However, developing a new area would be challenging in regard to obtaining resource consents. It is also more remote so logistically, there are issues in developing a viable farm.

Open coastal waters anywhere in the coastal marine area around Southland are, by their very nature, exposed and difficult to farm. While it may be possible, and that is not certain in southern waters, it would be challenging and costly, again making it difficult to establish a viable farm. There are some embayments around the Southland coast but they are either too exposed from one or more direction, or are too shallow, or have river inputs that cause water quality issues.

Big Glory Bay is therefore considered to be the best option, if not the only one due to the areas that are prohibited, because it is both available and environmentally sustainable.

In regard to the actual sites within Big Glory Bay, they were selected because there is sufficient depth and current to have viable farms, and they will not interfere with existing farms. The sites are also out of the fairway that is a prohibited area. It is possible to move the sites, but the scope is limited and potential adverse effects will be the same or similar. The sites have also been subject to an ecological survey and are not over any sensitive environments.

It is therefore considered that the sites that are the subject of this application are suitable and appropriate, and alternatives need not be considered further.

4.14 *Summary*

The overall assessment of the potential adverse effects of the proposed three new sites is that they will be no more than minor. Some are less than minor, but cumulatively, no more than minor is considered to be an appropriately conservative assessment.

Shellfish farming is not new to the bay and, apart from the recent *Bonamia* outbreak affecting oysters, there has not been any significant adverse effects identified. The farming has been good for the local, regional and national economy, providing employment and work for downstream industries.

5. Consideration of Statutory Documents

The documents that are relevant to this application are the Resource Management Act, New Zealand Coastal Policy Statement (NZCPS), Regional Policy Statement (RPS), and the Regional Coastal Plan (RCP). There is no National Environmental Standard relevant to this proposal. Te Tangi a Tauira, the Iwi natural resources and environmental management plan is also a document that should be considered.

The Stewart Island/Rakiura Conservation Management Strategy has some relevance, but it is mostly applicable to land-based activities. However, the Strategy does have a management policy of working with Environment Southland to ensure aquaculture activities "*... occur on a limited basis and that the adverse effects on the naturalness and natural character of the area, as well as adverse effects on indigenous biodiversity, public access and navigational safety, are avoided or mitigated.*" In the absence of any specific policies, the Strategy is not considered further but it is acknowledged that the Department of Conservation is a potentially affected party to this application.

The Resource Management Act 1991 is the over-riding statute and its provisions, in particular, the purposes and principles set out in Part II, are taken into account in the preparation of the other documents. For the most part, these matters are addressed in the NZCPS, RPS and RCP.

5.1 New Zealand Coastal Policy Statement

The New Zealand Coastal Policy Statement (NZCPS) is a high-level document, the objectives and policies of which are given effect to through the regional planning documents. However, while the matters of more general application are not repeated here, though they are relevant to any application associated with the coastal environment, there are specific matters that should be noted:

Objective 1	To safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land, by: • maintaining or enhancing natural biological and physical processes in the coastal environment and recognising their dynamic, complex and interdependent nature; • protecting representative or significant natural ecosystems and sites of biological importance and

	maintaining the diversity of New Zealand's indigenous coastal flora and fauna; and • maintaining coastal water quality, and enhancing it where it has deteriorated from what would otherwise be its natural condition, with significant adverse effects on ecology and habitat, because of discharges associated with human activity.
Objective 2	To preserve the natural character of the coastal environment and protect natural features and landscape values through: • recognising the characteristics and qualities that contribute to natural character, natural features and landscape values and their location and distribution; • identifying those areas where various forms of subdivision, use, and development would be inappropriate and protecting them from such activities; and • encouraging restoration of the coastal environment.
Objective 3	To take account of the principles of the Treaty of Waitangi, recognise the role of tangata whenua as kaitiaki and provide for tangata whenua involvement in management of the coastal environment by: • recognising the ongoing and enduring relationship of tangata whenua over their lands, rohe and resources; • promoting meaningful relationships and interactions between tangata whenua and persons exercising functions and powers under the Act; • incorporating mātauranga Māori into sustainable management practices; and

	• recognising and protecting characteristics of the coastal environment that are of special value to tangata whenua.
Objective 6	To enable people and communities to provide for their social, economic, and cultural wellbeing and their health and safety, through subdivision, use, and development, recognising that: • the protection of the values of the coastal environment does not preclude use and development in appropriate places and forms, and within appropriate limits; • some uses and developments which depend upon the use of natural and physical resources in the coastal environment are important to the social, economic and cultural wellbeing of people and communities; • functionally some uses and developments can only be located on the coast or in the coastal marine area; • the coastal environment contains renewable energy resources of significant value; • the protection of habitats of living marine resources contributes to the social, economic and cultural wellbeing of people and communities; • the potential to protect, use, and develop natural and physical resources in the coastal marine area should not be compromised by activities on land; • the proportion of the coastal marine area under any formal protection is small and therefore management under the Act is an important means by which the natural resources of the coastal marine area can be protected; and • historic heritage in the coastal environment is extensive but not fully known, and vulnerable to

	loss or damage from inappropriate subdivision, use, and development.
Policy 6 – Activities in the coastal marine area	… (2) Additionally, in relation to the coastal marine area: (a) recognise potential contributions to the social, economic and cultural wellbeing of people and communities from use and development of the coastal marine area, including the potential for renewable marine energy to contribute to meeting the energy needs of future generations: (b) recognise the need to maintain and enhance the public open space and recreation qualities and values of the coastal marine area; (c) recognise that there are activities that have a functional need to be located in the coastal marine area, and provide for those activities in appropriate places; (d) recognise that activities that do not have a functional need for location in the coastal marine area generally should not be located there; and (e) promote the efficient use of occupied space, including by: (i) requiring that structures be made available for public or multiple use wherever reasonable and practicable; (ii) requiring the removal of any abandoned or redundant structure that has no heritage, amenity or reuse value; and

	(iii) considering whether consent conditions should be applied to ensure that space occupied for an activity is used for that purpose effectively and without unreasonable delay.
Policy 3 – Precautionary approach	(1) Adopt a precautionary approach towards proposed activities whose effects on the coastal environment are uncertain, unknown, or little understood, but potentially significantly adverse. (2) In particular, adopt a precautionary approach to use and management of coastal resources potentially vulnerable to effects from climate change, so that: (a) avoidable social and economic loss and harm to communities does not occur; (b) natural adjustments for coastal processes, natural defences, ecosystems, habitat and species are allowed to occur; and (c) the natural character, public access, amenity and other values of the coastal environment meet the needs of future generations.
Policy 6 – Activities in the coastal marine area	(1) ... (2) Additionally, in relation to the coastal marine area: (a) recognise potential contributions to the social, economic and cultural wellbeing of people and communities from use and development of the coastal marine area, including the potential for renewable marine energy to contribute to meeting the energy needs of future generations:

	(b) recognise the need to maintain and enhance the public open space and recreation qualities and values of the coastal marine area; (c) recognise that there are activities that have a functional need to be located in the coastal marine area, and provide for those activities in appropriate places; (d) recognise that activities that do not have a functional need for location in the coastal marine area generally should not be located there; and (e) promote the efficient use of occupied space, including by: (i) requiring that structures be made available for public or multiple use wherever reasonable and practicable; (ii) requiring the removal of any abandoned or redundant structure that has no heritage, amenity or reuse value; and (iii) considering whether consent conditions should be applied to ensure that space occupied for an activity is used for that purpose effectively and without unreasonable delay.
Policy 8 - Aquaculture	Recognise the significant existing and potential contribution of aquaculture to the social, economic and cultural well-being of people and communities by: (a) including in regional policy statements and regional coastal plans provision for aquaculture activities in appropriate places in the coastal environment, recognising that relevant considerations may include:

	(i) the need for high water quality for aquaculture activities; and (ii) the need for land-based facilities associated with marine farming; (b) taking account of the social and economic benefits of aquaculture, including any available assessments of national and regional economic benefits; and (c) ensuring that development in the coastal environment does not make water quality unfit for aquaculture activities in areas approved for that purpose.

Although not included in the list above, Policy 11 – Indigenous biological diversity (biodiversity), Policy 12 – Harmful aquatic organisms, Policy 13 – Preservation of Natural Character, and Policy 15 – Natural features and natural landscapes are relevant to the consideration of this application, particularly in regard to cumulative effects. Other policies not mentioned have some indirect relevance but are not key to the consideration of this application.

Policy 8 recognises the importance of aquaculture as an activity that requires space in the coastal marine area and some protection from land-based activities that may impact on the ability to farm those areas. Policy 6 is also supportive of activities that have a functional need to be in the coastal marine area.

However, these policies do not carry any more weight than Policies 11 to 15 that require certain values to be protected or preserved. The supportive policies do not over-ride the other policies that seek to protect and preserve important values in the environment.

The NZCPS is a high level document and it is given affect to at the regional level in the RPS, which has only recently been made operative. The RCP also gives effect to these higher level documents but it is noted that its provisions pre-date both of them.

5.2 Regional Policy Statement

The relevant objectives and policies associated with aquaculture in the Proposed RPS are as follows:

Objective COAST.2 – Activities in the coastal environment	Infrastructure, ports, energy projects, aquaculture, mineral extraction activities, subdivision, use and development in the coastal environment are provided for and able to expand, where appropriate, while managing the adverse effects of those activities.
Objective COAST.3 – Coastal water quality and ecosystems	Coastal water quality, and ecosystems are maintained, or enhanced.
Objective COAST.4 – Natural character	The natural character of the coastal environment is restored, rehabilitated or preserved.
Objective COAST.5	Recognise the contribution of aquaculture to the well-being of people and communities by making provision for aquaculture in appropriate locations while: (a) protecting coastal indigenous biodiversity in accordance with Policy BIO.3; (b) protecting outstanding natural features, landscapes and natural character in accordance with Policy COAST.3; and (c) avoiding, remedying, or mitigating other adverse effects.
Policy COAST.3 – Protection of the coastal environment	Ensure that subdivision, use and development activities: (a) avoid adverse effects on areas of outstanding natural features and landscapes, and/or outstanding natural character; (b) avoid significant adverse effects, and avoid, remedy or mitigate other adverse effects on other natural features and landscapes and/or natural character in the coastal environment; (c) ...

Policy COAST.4 – Infrastructure, port, aquaculture and energy projects	Recognise and make provision for nationally significant, regionally significant or critical infrastructure that has a functional, operational or technical need to be located within the coastal environment, and appropriate port, aquaculture, mineral extraction activities and energy projects that must be located within the coastal environment.
Policy COAST.S – Management of effects on coastal water quality and ecosystems	Avoid, remedy or mitigate adverse effects of land-based and marine activities on coastal water quality and ecosystems.
Policy COAST.8 – Management of activities in the coastal marine area	Within the coastal marine area, provide a framework to avoid or mitigate adverse effects on the coastal environment for the following activities: a) the allocation, use and occupation of coastal space; b) the use and development of the natural and physical resources of the coastal marine area; c) the emission of noise; d) commercial activities on the water and on the foreshore and seabed.

The RPS provides more guidance through Policy COAST.8 but it also relies on the Regional Coastal Plan for implementation of the policies. While the RPS is generally supportive of aquaculture, its development is constrained by Policies COAST.3 and COAST.5.

Policy COAST.4 provides a direction to the Council to, amongst other things, make provision for "*… appropriate … aquaculture, … that must be located within the coastal environment*", subject to Policy COAST.8. Although the RCP pre-dates the RPS its objectives and policies go some way to implementing these policies.

5.3 Regional Coastal Plan

The following are the sections of the Regional Coastal Plan that are most relevant to this application:

Objective 4.2.1 – Need for coastal location	To ensure that only those activities and developments that have a functional need to be located in the coastal marine area or for which there is no practicable alternative location outside the coastal marine area are situated there.
Policy 4.2.1 – Justifying coastal location	Require that proposals for uses and developments in the coastal marine area justify the functional necessity for that location or demonstrate that there is no practicable alternative location outside the coastal marine area.
Policy 4.2.2 – Consideration of alternatives	Where the adverse effects of use or development are more than minor, require alternative sites and methods be considered to determine the option that best avoids, remedies or mitigates the adverse effects of the use and development of the coastal marine area.
Objective 4.6.1 – Concentrating use and development	To protect areas free from use and development by seeking, wherever practicable, to concentrate use and development into areas where those activities are already taking place.
Policy 4.6.1 – Concentrate compatible activities	Encourage concentration of compatible activities in areas of existing uses and developments, where adverse effects can be avoided, remedied or mitigated, in preference to using undeveloped areas in the coastal marine area.
Objective 4.7.1 – Avoid, remedy or mitigate cumulative adverse effects	To avoid, remedy or mitigate cumulative adverse effects.
Objective 4.7.2 – Obtain an appropriate level of use in the coastal marine area	To obtain a level of use which is appropriate in the coastal marine area, particularly in areas where remoteness, wilderness and tranquillity are significant components of the environment.

Policy 4.7.1 – Avoid remedy or mitigate adverse cumulative effects	To avoid, remedy or mitigate adverse cumulative effects of activities in the coastal marine area.
Objective 15.1.1 – Avoid, remedy or mitigate any adverse effects	Avoid, remedy or mitigate any adverse effects of marine farming operations.
Policy 15.1.3 – Avoid adverse effects of marine farms in specific areas	Avoid the adverse effects from the establishment of marine farms in Marine Reserves, Fiordland's internal waters, Lords River, Port Pegasus, Paterson Inlet (except Big Glory Bay and the Salmon Farming Refuge Zone), and Port William on Stewart Island, and that part of Awarua Bay that lies to the east of the Tiwai Causeway.
Policy 15.1.4 – Monitoring the effects of marine farming	To require monitoring of individual marine farm sites.
Rule 15.1.5 – Marine Farming(prohibited) – Stewart Island	Marine Farming in the Stewart Island waters of: • Port Pegasus; • Lords River; • Paterson Inlet, except Big Glory Bay and the Salmon Farming Refuge Zone; • Port William from Peters Point to the eastern most extremity of the headland enclosing the northern end of Port William is a prohibited activity.
Rule 15.1.7 -	Marine farming in areas other than those referred to in Rules 15.1.2 - 15.1.6 is a discretionary activity.

Definitions:	
- Marine Farm	a in relation to a leased area, all that part of the area that is being or has been developed into a farm for the farming of fish or marine vegetation; includes all structures and rafts used in the area in connection with the farm, and all boundary markings, and all fish or marine vegetation for the time being farmed in the area by the lessee; and b in relation to any licensed area, all that part of the area in which the licensee is for the time being carrying on the business of farming of fish or marine vegetation in accordance with [their] licence; and includes all structures and rafts used in the area in connection with the farm, and all fish or marine vegetation for the time being farmed in the area by the licensee: (Marine Farming Act 1971).
- Marine Farming	the activity of breeding, hatching, cultivation, rearing, or on-growing of fish, aquatic life, or seaweed for harvest; but does not include - a any such activity undertaken pursuant to regulations made under Section 91 of the Fisheries Act 1983; or b any such activity where fish, aquatic life, or seaweed are not within the exclusive and continuous possession or control of the holder of a marine farming permit issued under Section 67J of the Fisheries Act 1983; or c any such activity where the fish, aquatic life, or seaweed being farmed cannot be distinguished, or be kept separate from naturally occurring fish, aquatic life, or seaweed - and "to farm" has corresponding meaning which includes any operation in support of, or in preparation for, any marine farming.

As required by Policy 4.2.1, mussel farming is an activity that can only be carried out in the coastal marine area. While there may be alternative areas where the activity could be carried out, it can only be areas within the coastal marine area.

Developing new farms in Big Glory Bay is also consistent with Policy 4.6.1 because the activity is already occurring there, and it avoids the need to develop a new location that has not yet been used for that purpose. However, this policy is constrained by Policy 4.7.1, which seeks to limit the cumulative effects from multiple developments in the same area. The effects assessment considers that the cumulative effect of adding three new mussel farms will be no more than minor.

Policies 15.1.3 and 15.1.5 exclude marine farming from certain areas, leaving others that can be farmed as a discretionary activity. These policies are intended to achieve Objective COAST.5 of the RPS, and Objectives 4.6.1, 4.7.2 and 15.1.1 of the RCP. Much of the coastal areas that are ideal for marine farming are also areas with very high landscape and natural character values, as well as habitat to indigenous species. Big Glory Bay , as an area that has been used for marine farming since the 1980's, has been made available in the Regional Coastal Plan for marine farming, the extent of which is restrained by Policies 4.2.2 and 4.7.1, as well as a number of other general policies relating to cultural matters, landscape and natural character values, amenity values, and public access. As stated in the previous section, the cumulative effects relating to all of these matters is assessed as no more than minor.

Big Glory Bay is part of the Rakiura/Te Ara a Kiwa Statutory Acknowledgement Area but there are no known specific cultural sites in the coastal marine area. Three archaeological sites are identified in the Southland District Plan on land around Big Glory Bay but none will be affected by this application. As a Statutory Acknowledgement Area, Te Rūnanga o Ngāi Tahu must be notified.

In regard to amenity values, there has been some impact on these by the existing farms. Marine farming is not an inherently noisy activity but there will, at times be multiple vessel movements occurring, as well as harvesting of both shellfish and finfish. However, while the new sites will not add to noise levels in the bay but they may extend the time that noise is at a higher level. The existing farms do not breach the noise standards in the RCP, and the new sites will not cause that to change.

As for public access, the fairway through the middle of the bay, as marked on Map 12a of the RCP, is available for access to the head of the bay. Occupation of this space is a prohibited activity under Rule 11.8.1 of the Plan. All farms are required in their consents to have buoys and navigation on all sites that comply with the guidelines produced by Maritime NZ. Vessels can, with care, also navigate between the mussel lines on the farms as the consents do not authorise exclusive occupation of the sites. Farms do inhibit full public access to all areas of Big Glory Bay, but, for the most part, the public can navigate safely through it. The presence of the farms is noted on hydrographic charts.

Finally, the definitions for 'marine farm' and 'marine farming' are included for completeness. The definitions make it clear that these terms include a variety of activities that are controlled by the RCP and would otherwise require consent under a different rule.

5.4 Summary

On the basis of the above analysis, the assessment is that the application is not inconsistent nor contrary to any of the above planning documents.

Big Glory Bay is one of the few areas around Stewart Island that is available and suitable for this type of marine farming. There is space available for the proposed new sites and the cumulative effects of them will be no more than minor, to the extent that a casual observer may not notice the difference before and after the sites are established because they will be same as the existing mussel farming sites.

All of the planning documents recognise the economic benefits from marine farming and make provision for it but also recognise the need to protect outstanding landscapes and areas of high natural character. Adverse effects need to be avoided where appropriate but otherwise mitigated. In this instance, one of the main mitigation measures is selection of Big Glory Bay for the sites.

6. Consultation

No formal consultation has been carried out with potentially affected parties at this time. The applicants have discussed the proposal with Environment Southland staff to see what information is required for the application.

Once an application is completed and lodged, a copy will be forwarded to TRONT (for statutory acknowledgement and customary marine title claim), Te Ao Marama and Department of Conservation. For other affected parties, particularly other marine farmers, the applicants will also provide them with a copy of the application once it is lodged with Environment Southland.

7. Conclusion

It is the conclusion of this assessment of environmental effects that the overall effect of the proposed new sites is no more than minor. If this assessment is confirmed, the application is able to be processed without notification.

The assessment is the potential adverse effects of this proposal will be no more than minor, and that it is not inconsistent with the relevant planning documents. The application may therefore be processed and granted.

John Engel
Manager, Bonisch Environmental

Date: 2 May 2018

Appendix 1

Application forms

bonisch environmental

Application for Resource Consent (PART A)

This application is made under Section 88 of the Resource Management Act 1991

environment SOUTHLAND REGIONAL COUNCIL
Te Taiao Tonga

The purpose of this Part A form and the relevant Part B form(s) is to provide applications with guidance on information that is required under the Resource Management Act 1991. Please note that these forms are to act as a guide only, and Environment Southland reserves the right to request additional information.

To: Environment Southland
Private Bag 90116
Invercargill 9840

Full name, address and contact details of applicant ***(in whose name consent is to be issued)***

Name:	Zane Morgan Smith	Terrence James Maass-Barrett
Address:	56 Golden Bay Road	194 Horseshoe Bay Road or PO Box 129
	Stewart Island 9818	Stewart Island 9818 Stewart Island 9846
Email:	zanemsmith1974@gmail.com	jimandhilli@gmail.com
Phone:	027 221 9217 or 03 2191064	03 219 1040 ~~Fax:~~
	~~Preferred~~	~~Additional~~

Consultant contact details ***(if different from above)***

Contact name/agent: John Engel - Bonisch Environmental

Address: PO Box 1262, Invercargill 9840

Email: john@bonisch.nz

Phone: 027 222 1874 (*Preferred*) 03 218 2546 (*Additional*) Fax: 03 214 4285

Please tick the box for the consent(s) you are applying for and complete the relevant Part B form(s) where available:

Land Use
- [ ] Bore/well
- [ ] New or expanded dairy farming
- [ ] Effluent storage
- [ ] Cultivation
- [ ] Tree planting
- [ ] Gravel extraction
- [ ] Hill country burning
- [ ] Riverbed activity (incl. streams/creeks and stopbanks)
- [ ] Bridges and culverts

Discharge
- [ ] To air
- [ ] To water
- [ ] To land

Water
- [ ] Take and use surface water
- [ ] Take and use groundwater
- [ ] Dam water
- [ ] Divert water

Coastal
- [ ] Whitebait stand
- [ ] Structures/occupation of space
- [ ] Removal of natural materials
- [ ] Disturb foreshore/seabed
- [ ] Discharge/deposit substances
- [ ] Commercial surface water activity
- [ ] Reclaim/drain foreshore/seabed
- [x] Marine farming
- [ ] Other coastal activities

1 Are there any **current** or **expired** consents relating to this proposal? ☐ Yes ☑ No

If yes, please provide consent number(s) and description:

2 Are any other consents required from Environment Southland or **other authorities**? ☑ Yes ☐ No

If yes, please state the relevant authority and the type of consent(s) required:

Undue adverse effects test - Ministry of Primary Industries.

3 For what **purpose** is this consent(s) required: (e.g. discharge of effluent, gravel extraction etc.)

Marine farming of shellfish

4 **Location** of proposed activity

Address: Big Glory Bay, Stewart Island

Legal Description: Coastal marine area

Map Reference (NZTM 2000):

1	1229127	E	4786377	N
2	1228700	E	4784895	N
3	1229092	E	4785037	N

5 The name and address of the **owner /occupier:** (if other than the applicant)

Name: Crown - seabed. Phone:

Address:

6 **Please attach a map or a coloured aerial photograph, showing at a minimum, the location of the proposed activities.**

See Appendix to of AEE.

Checklist: Have you included the following?

✓	Payment of the required deposit *(see attached fee schedule)* Paid online
—	Written approval from all potentially affected parties *(forms available from the Environment Southland website)*
✓	Site plan/location map/sketch of the proposed activity
NA	A copy of the Certificate of Incorporation (*where applicant is a company*)
✓	Part B form(s) specific to your activity and/or a separate assessment of environmental effects (AEE)

Notes:

(a) *If your application does not contain the necessary information and the appropriate fee, Environment Southland must return the application.*

(b) *Council cannot accept electronic lodgement of applications at this time.*

Signature of applicant

I hereby certify that to the best of my knowledge and belief, the information given in this application is true and correct.

I undertake to pay all actual and reasonable application processing costs incurred by Environment Southland.

Name (block capitals) JOHN ENGEL

Signed [signature] Date 2/5/2018

(Signature of applicant or person authorised to sign on behalf of applicant)

Application for a Coastal Permit (PART B)

This application is made under Section 88 of the Resource Management Act 1991

environment SOUTHLAND
Te Taiao Tonga

A complete Part A form needs to be provided with this Part B form. The purpose of this Part B form is to provide applicants with guidance on information that is required under the Resource Management Act 1991. These forms are to act as a guide only and Environment Southland reserves the right to request additional information. **Please also refer to Chapter 18 of the Regional Coastal Plan for Southland, 2013.**

To: Environment Southland
Private Bag 90116
Invercargill 9840

1 What is this application for?

- ☐ The discharge of water to water
- ☐ The discharge of contaminants to water
- ☐ Structures - erecting/placing, reconstructing, altering/extending, removing/demolishing
- ☐ Occupying space within the coastal marine area
- ☐ Removing sand, shingle, shell or other natural material
- ☐ Disturbing the foreshore or seabed - excavating, drilling, tunnelling etc
- ☐ Discharging/depositing any substance in, on, or under the seabed or to coastal waters
- ☐ Commercial surface water activities
- ☐ Reclaiming or draining the foreshore or seabed
- ☑ Marine farming
- ☐ Other activity carried out in, on, under or over the coastal marine area – please specify:

2 What duration of resource consent is sought? Expiry date of 1 January 2040 - 22 years

3 Please describe how the activity will be carried out. For structures, you must include engineering diagrams showing the dimensions and position of the structures.

See AEE attached - structure diagrams are attached in Appendix 3.

Please note that mussel backbone lines are not engineering designed structures. They are only used to suspend the mussel lines from. The anchor sizes are standard and proven for this environment.

4 **Please state the proposed date of commencement of the activity/works and the proposed date of completion.**

Work on installing the mussel lines will commence as soon as practicable once consent is granted. The activity will be ongoing beyond the term proposed for these consents.

5 **Details of the contractor (or any other person) who will undertake the activity works.**

Contracting company name: Not available. However, the anchors and lines will be installed by

Contact person: persons experienced in this type of work.

Phone number: ______

Existing Environment For information relevant to this section, please see the attached application and AEE.

6 **Are any of the following features found within the existing environment of the proposed activity? Describe these features in the space below, along with details of the assessment undertaken to determine the presence of these features.**

	Yes	No
(a) Signs of marine life (e.g. fish, mammals, native birds, shellfish, invertebrates)?		
(b) Areas where food is gathered from (e.g. watercress, eels, wildfowl)??		
(c) Wetlands, wildlife habitats or bird nesting habitats (e.g. swamp areas)?		
(d) Other activities occurring in the area (e.g. commercial activity, fishing, swimming, boating)?		
(e) Areas of particular aesthetic, cultural, heritage or scientific value (e.g. archaeological sites)?		
(f) Waste discharges, water takes and/or monitoring sites?		

6 contd

Please attach photographs and a map or a coloured aerial photograph showing the following:

- the location(s) of your proposed activity;
- any nearby rivers, creeks, estuaries, drains or any other water body;
- the location of any wetland, estuary or wildlife habitats;
- the location of any other coastal activities or structures in proximity to the proposed activity;
- activities/structures occurring on adjacent land, along with the names of the adjacent landowners.

7. In addition to the above description of the existing environment, please describe the following:

- Is the beach aggrading or degrading (if applicable)? Are there any signs of shoreline erosion?
- What is the nature of the seabed (i.e. muddy, sandy, silty, rock etc)?
- In what way has the foreshore/seabed been altered as a result of other activities occurring in the area?

Please provide cross sections and any other supportive evidence as required.

Assessment of Effects For information relevant to this section, please see the attached application and AEE.

8 How will the proposed activity affect the coastal environment in the short term? For example, how do the initial stages of the proposed activity (including, but not limited to, construction and sea bed disturbance) affect the coast, particularly in terms of coastal erosion and effects on ecosystems?

9 How will the proposed activity affect the coastal environment in the long term? For example, through the long-term occupation of the coast.

10 How will your activity effect any other users of the coastal area and/or activities occurring on adjoining land?

11 **Are there any structures near to the proposed activity? If yes, will the proposed activity have any effect on these structures? Please provide specific details including the type of structure, owner of structure, distance from proposed activity, what effects the proposed activity will have on the stability/function of the structure.**

12 **Pursuant to Schedule 4 of the Resource Management Act, 1991, there are a number of matters that must be addressed by an assessment of environmental effects. Please discuss what effects the proposed activity will have on the following:**

(a) any effect on those in the neighbourhood and, where relevant, the wider community, including any social, economic, or cultural effects

(b) any physical effect on the locality, including any landscape and visual effects

(c) any effect on ecosystems, including effects on plants or animals and any physical disturbance of habitats in the vicinity

(d) any effect on natural and physical resources having aesthetic, recreational, scientific, historical, spiritual, or cultural value, or other special value, for present or future generations

(e) any discharge of contaminants into the environment, including any unreasonable emission of noise, and options for the treatment and disposal of contaminants

(f) any risk to the neighbourhood, the wider community, or the environment through natural hazards or the use of hazardous substances or hazardous installations

13 Please include a description of the monitoring or mitigation measures (including safeguards and contingency plans where relevant) to be undertaken to help avoid, remedy or mitigate the actual or potential effects on environmental features and values.

14 For construction works, please describe how you will minimise the release of silt, sediment, concrete and other contaminants into water.

15 Please include a description of any possible alternative locations or methods for undertaking the activity and why these alternatives have not been selected.

16 Please include evidence of any consultation undertaken for this application. This may include (but not be limited to) consultation with adjoining landowners, other consent holders in the immediate area, iwi (e.g. Te Rūnanga O Ngāi Tahu, Te Ao Marama Inc), government departments/ministries (e.g. DOC, Maritime NZ), territorial authorities, advisory bodies (e.g. Fiordland Marine Guardians), non-governmental organisations (e.g. Forest & Bird), industry representatives (e.g. CRA8 Management Committee and recreational associations).

Please note that in accordance with Schedule 4 of the RMA, you may also be required to provide an assessment of whether or not the proposed activity is contrary to any of the relevant provisions of the following documents.

(a) New Zealand Coastal Policy Statement, 2010
(b) Regional Policy Statement for Southland, 1997 (and any proposed/subsequent versions)
(c) Regional Coastal Plan for Southland, 2013 (and any proposed/subsequent versions)
(d) Any other relevant Resource Management Regulations or National Environmental Standards

Staff are able to advise whether this is required, as it is dependant on the location, scale and complexity of your proposal. We invite you to come in for a pre-application meeting with Environment Southland consents staff to discuss this.

END OF FORM

Appendix 2

Site plan
Hydrographic map
Fairway plan

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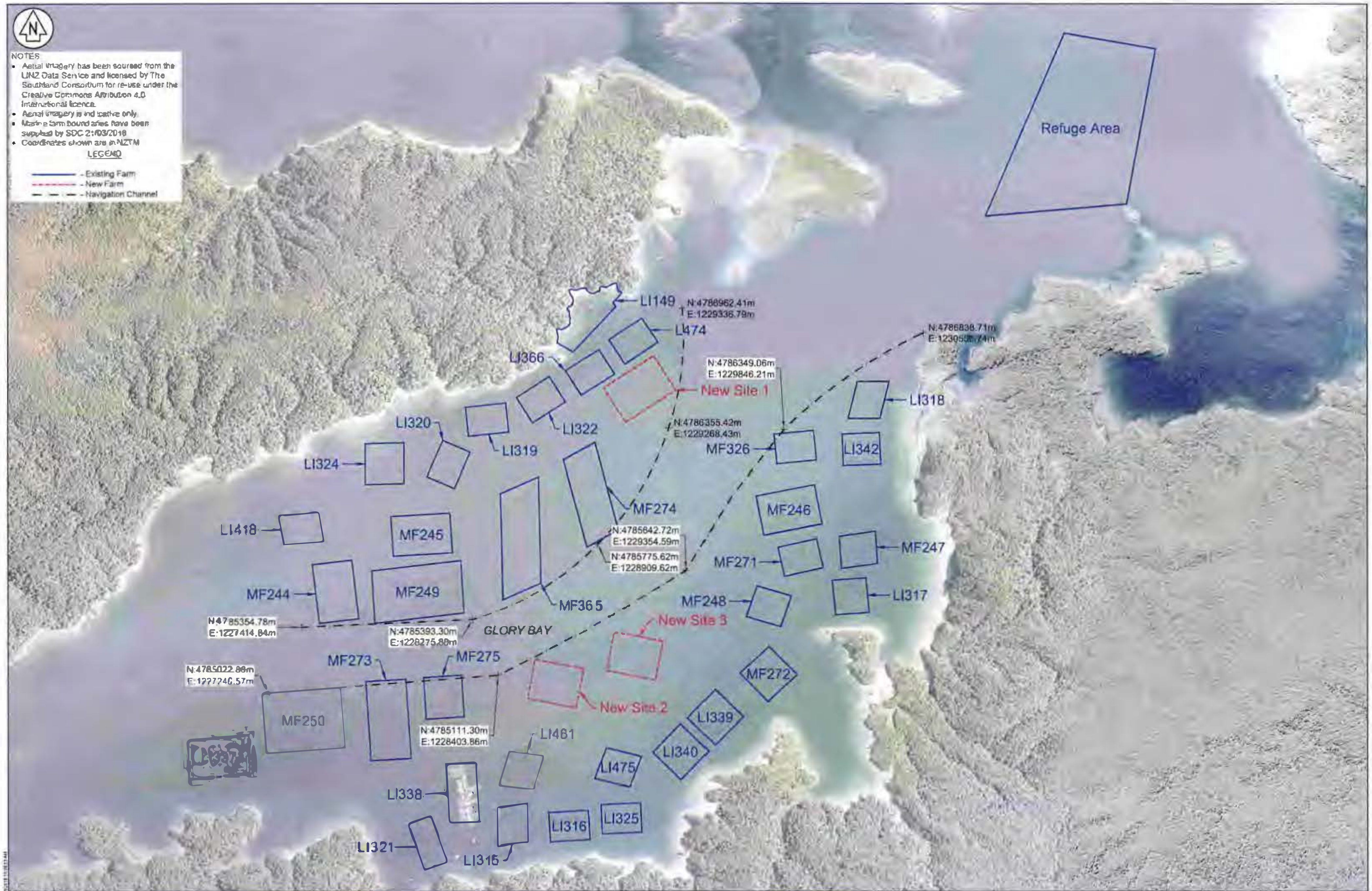

REV	REVISION DETAILS	DRN	CHK	APP	DATE
A	Draft - for client comment	CHM	JFE	JFE	22/03/2018
B	Consent Issue	CHM	JFE	JFE	2/05/2018

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CLIENT: JIM BARRET & ZANE SMITH

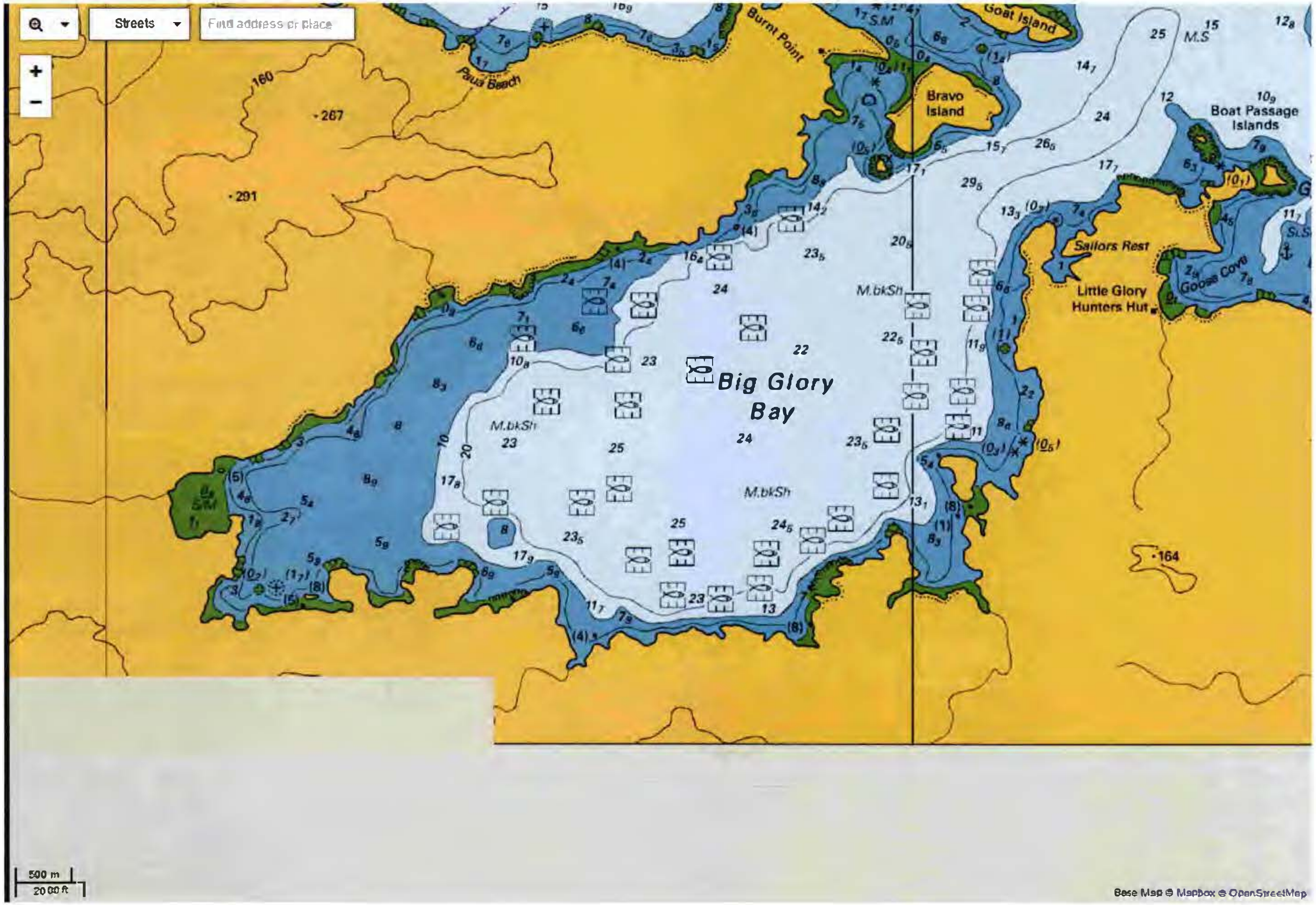
PROJECT: MARINE FARMING RESOURCE CONSENT, GLORY BAY, STEWART ISLAND

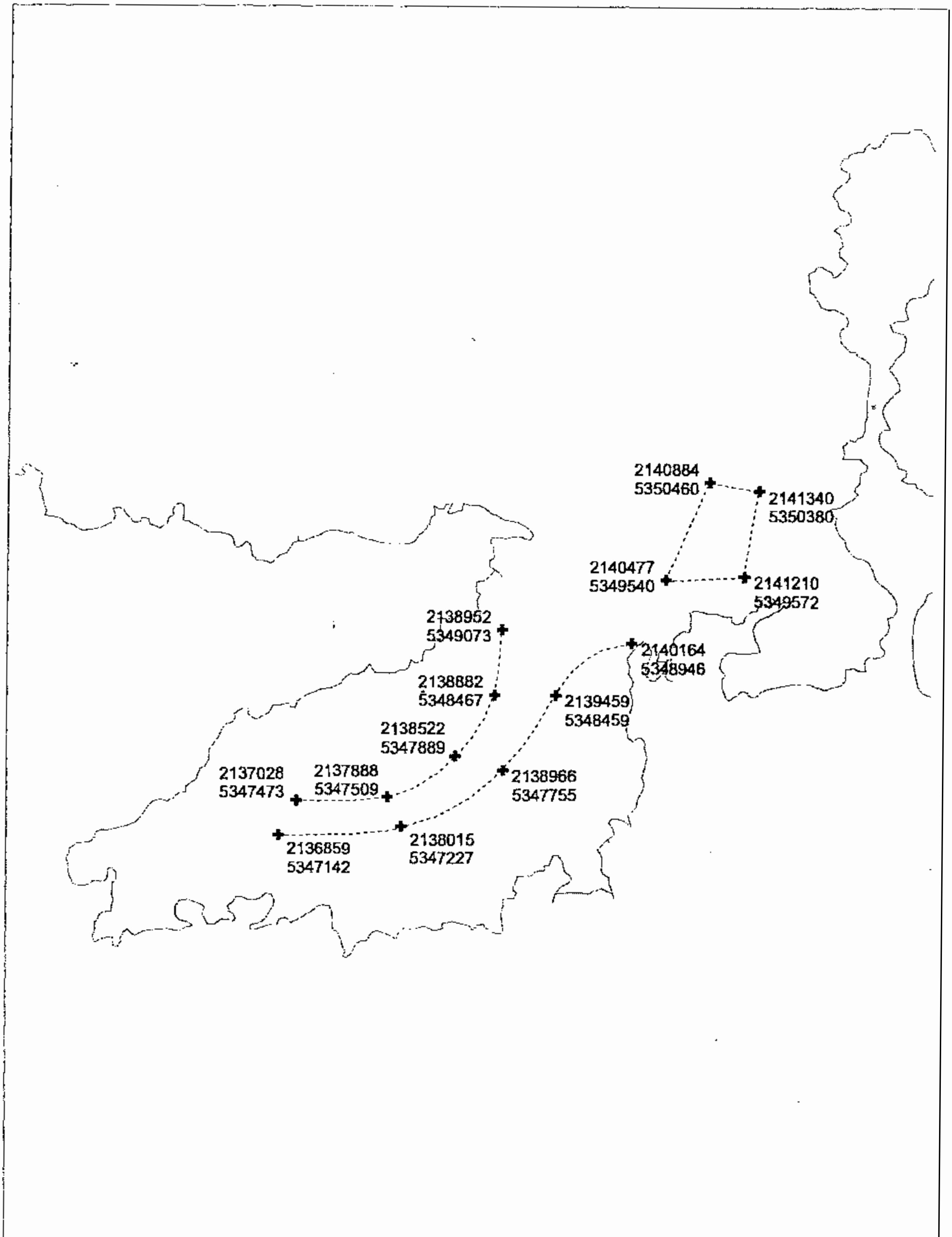
SHEET TITLE: MARINE FARM LOCALITY PLAN

SURVEYED			
DESIGNED			
DRAWN	CHM	22/03/2018	
DRAWING CHECK	JFE	22/03/2018	
DESIGN CHECK			
APPROVED	JFE	22/03/2018	

SCALE (ORIGINAL SIZE A1): 1:8,500
DATE ISSUED: 02/05/2018
JOB NO: 8085 | SHEET: 1 of 1 | REV: B

Hydrographic map of Big Glory Bay.





Key

✚ New Zealand Map Grid Coordinate point defining Fairway and Refuge area

environment SOUTHLAND

N

Big Glory Bay - Fairway and Refuge Area

Environment Southland Coastal Plan 1 : 50,000

Appendix 3

Sketches of proposed farm layout and structures

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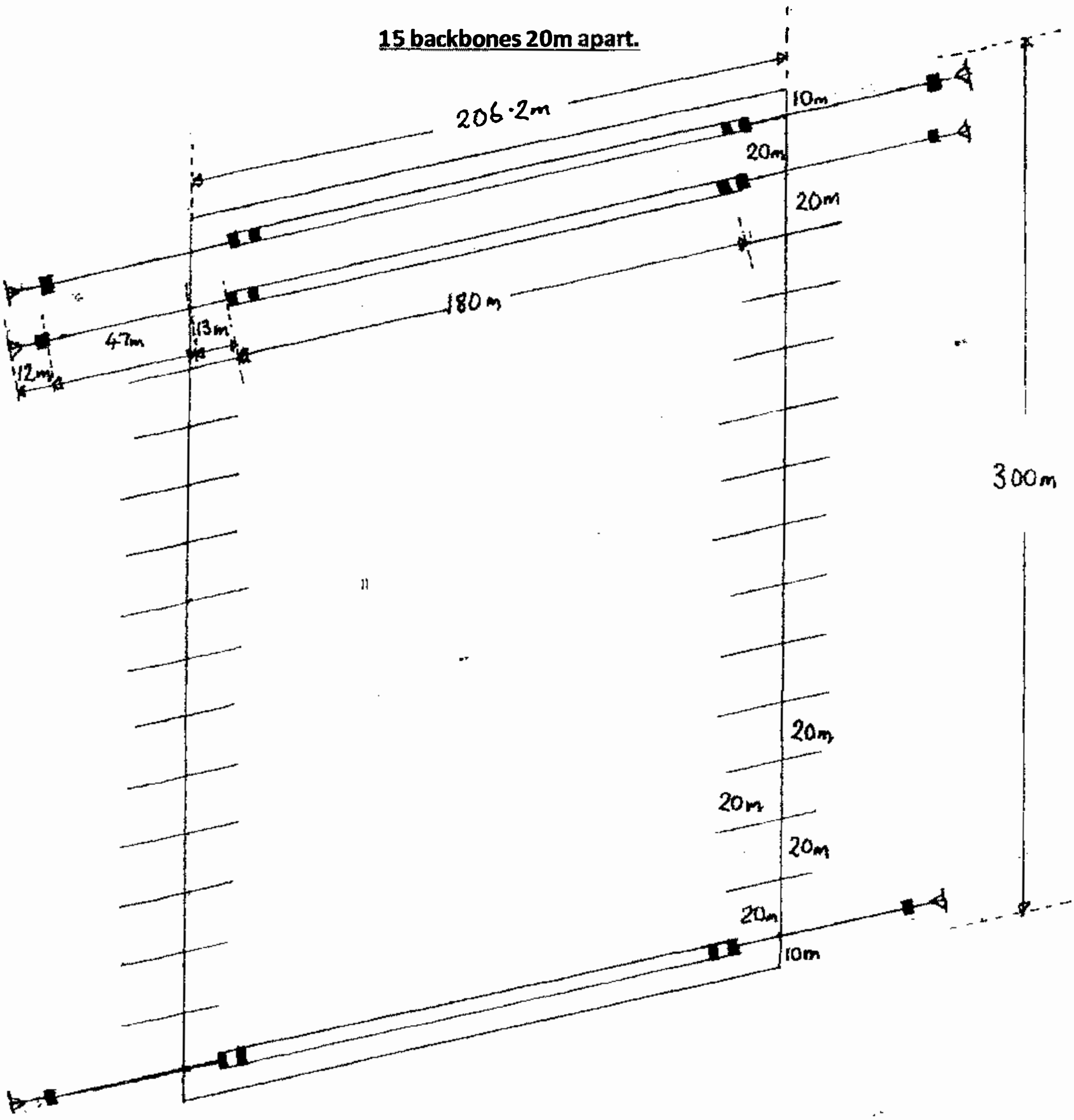
Farm layout spider calculations site 1.

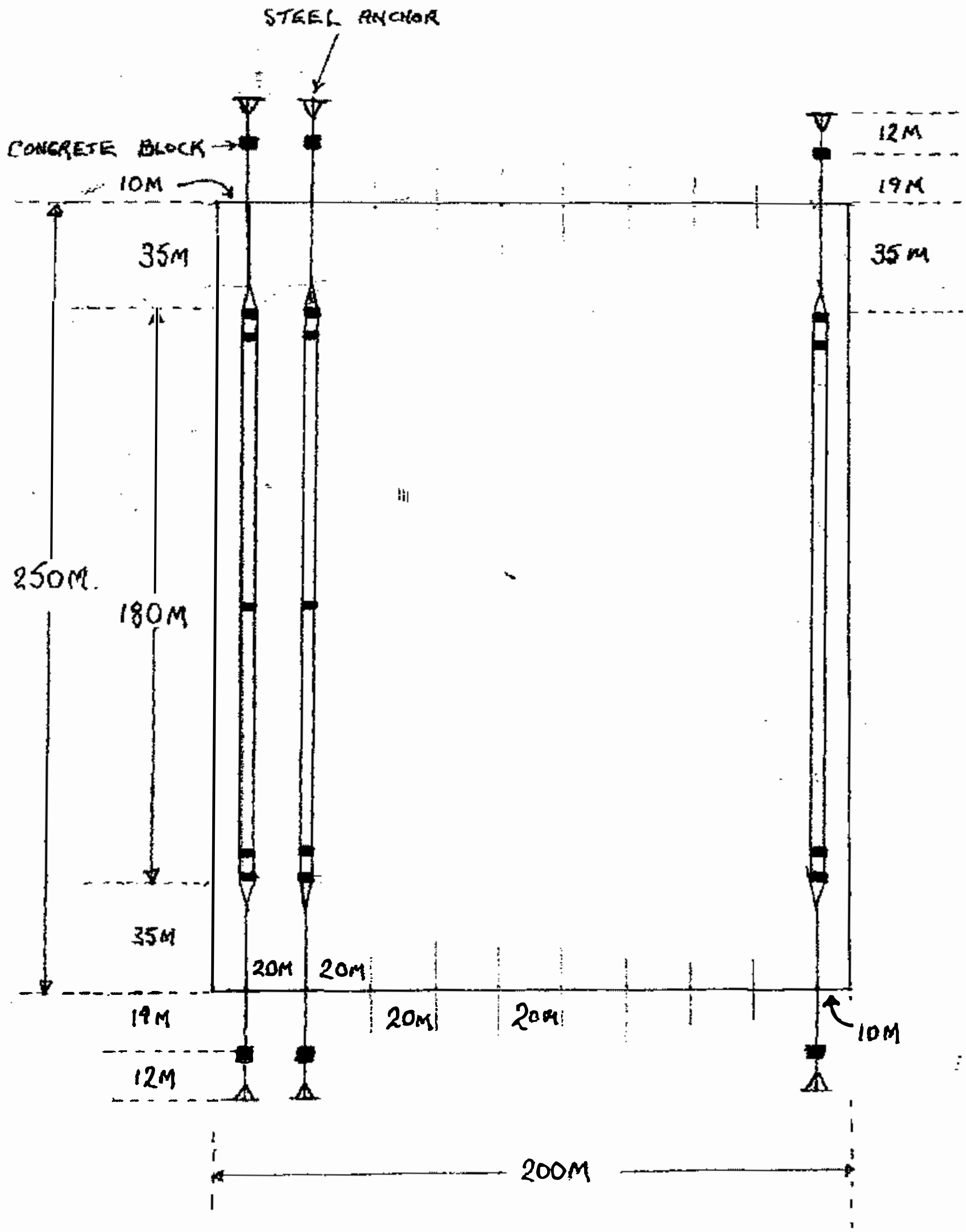
15 backbones 20m apart.



Allowing $1m^2$ per mooring block and $1m^2$ per steel anchor gives $4m^2$ per line = 15 X $4m^2$ = $60m^2$. Plus 0.100m (10cm) wide X length of warp outside marine farm boundary, equals 59m X 2 X 0.100 X 15 = 177 + 60 =$237m^2$. Which means a slice approx 80cm wide off the 300m length.

Farm layout and spider calculation sites 2 & 3.

10 backbones 20m apart.

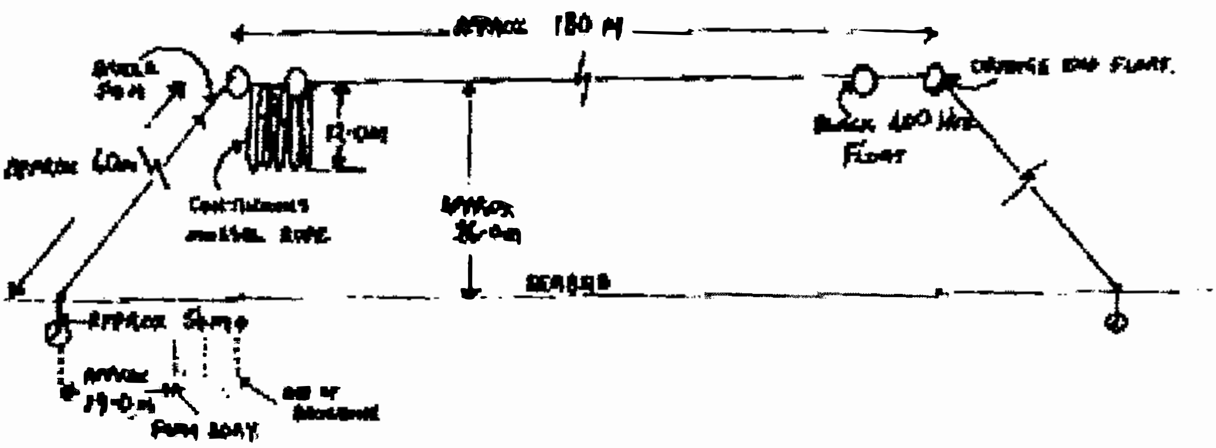


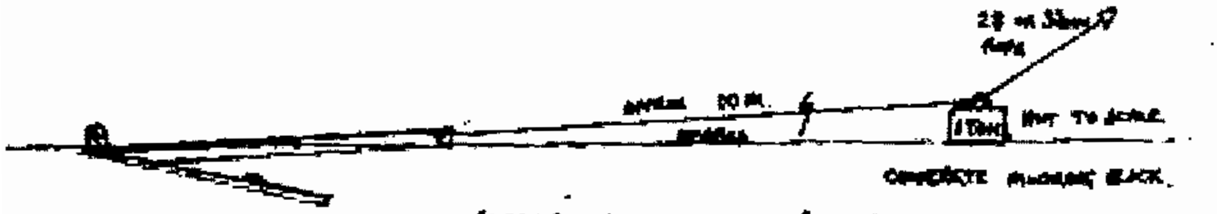
Allowing 1 square metre per mooring block and 1 square metre per steel anchor. Gives $4m^2$ per line equals 10 X $4m^2$. = $40m^2$ per site.

Plus 0.100m (10cm) wide X length of warp outside of MF boundary, equals 31m X 2 X 0.1 per line X 10 lines = $62m^2$

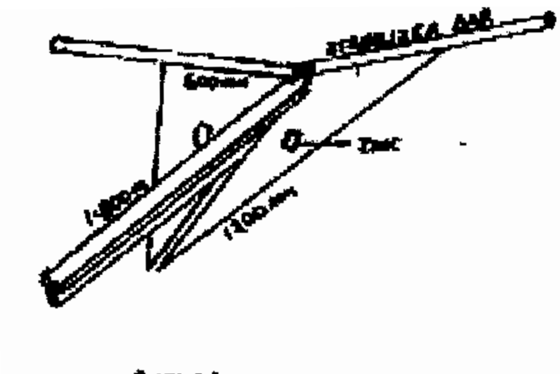
= $102m^2$ per site, that means a slice of just over 50cm wide off one end of the 200m wide site.

STRUCTURE OF BACKBONE AND ANCHORING SYSTEMS NOT TO SCALE.

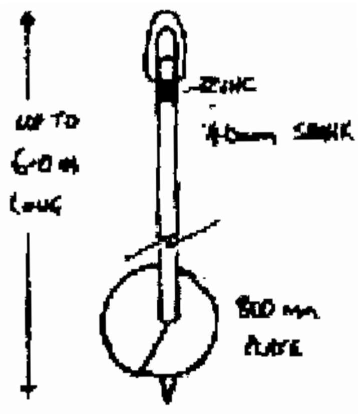




STEEL ANCHOR APPROX 350 kg. ALTERNATIVE TO SCREW ANCHOR



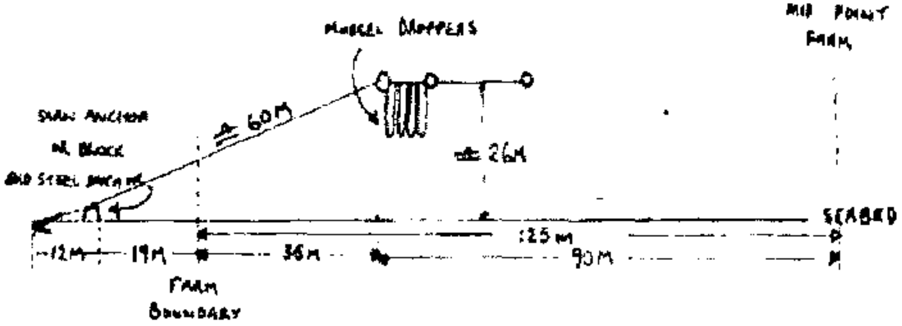
STEEL ANCHOR



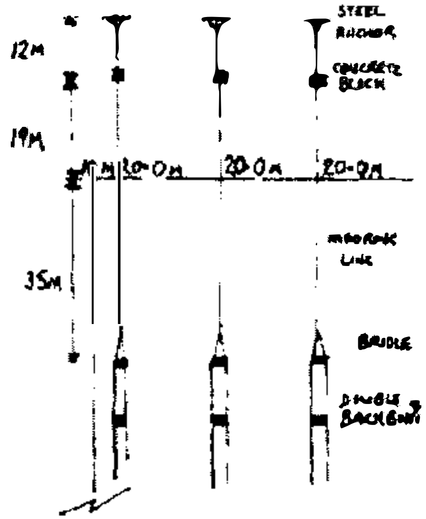
SCREW ANCHOR

EXPLANATION OF "SPIDER SYSTEM" OF MARINE FARM LAYOUT SMITH BARRETT APPIN.

BECAUSE OF DEPTH OF WATER IN BG BAY MARINE FARMS HAVE ADOPTED THIS SYSTEM TO ALLOW MOORING WARPS AND SCREW ANCHORS (OR CONCRETE BLOCKS COUPLED WITH STEEL ANCHORS) TO LIE BEYOND THE NOMINATED M.F BOUNDARIES.



ELEVATION



TOP VIEW

NOT TO SCALE

Appendix 4

Baseline benthic survey of three proposed mussel farm sites in Big Glory Bay, Stewart Island – NIWA – December 2017

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NIWA
Taihoro Nukurangi

Baseline benthic survey of three proposed mussel farm sites in Big Glory Bay, Stewart Island

Prepared for Jim Maass-Barrett and Zane Smith

December 2017

Prepared by:
Jeanie Stenton-Dozey

For any information regarding this report please contact:
Jeanie Stenton-Dozey
Scientist
Marine Ecosystems and Aquaculture
+64-3-348 -8987
jeanie.stenton-dozey@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
PO Box 8602
Riccarton
Christchurch 8011

Phone +64 3 348 8987

NIWA CLIENT REPORT No: 2017384CH
Report date: December 2017
NIWA Project: MMO18501

Quality Assurance Statement		
[signature]	Reviewed by:	Stephen Brown
[signature]	Formatting checked by:	Fenella Falconer
[signature]	Approved for release by:	Helen Rouse

Recommended citation: Stenton-Dozey, J.M.E. (2017) Baseline benthic survey of three proposed mussel farm sites in Big Glory Bay, Stewart Island. Prepared for Jim Maass-Barrett and Zane Smith. *NIWA Client report: 2017384CH. NIWA project: MMO18501.* 29 p. plus appendices

Contents

Figures

Executive summary

This report is a baseline assessment of the benthic environment at three proposed mussel farming areas in Big Glory Bay, Stewart Island. The applicant will submit the report when applying to Environment Southland (ES) for approval to establish these farms. The sampling design was based on the bay-wide compliance environmental monitoring programme for marine farming established in 2012 (ES consent # 207256).

The monitoring indicators for the sediment were: grain size (proportionality of mud/silt to sand); particulate organic carbon (POC) content; depth of the oxygenated layer (DO); depth of apparent Redox Potential Discontinuity (aRPD) layer and the presence of sulphide and bacterial mats. Biological quality was assessed by quantifying invertebrates (and sometimes flora) on the surface (epifauna) and within sediments (infauna). Use of historical data for two designated control sites (one at the bay entrance (CM) and the other mid-bay (CH)) from 2012 and 2013 was approved by ES thus avoiding the necessity to sample these sites during this assessment survey.

At each of the proposed sites, three seabed surface photographs were taken to identify epibenthic features. Two grab samples were extracted at each site and subsurface DO was measured before removing three cores: one for grain size, one for sediment POC and the other for infauna species identification and enumeration. Sediment colour and any sulphide odour were noted and the aRPD layer measured.

Sediment data were analysed for significant differences between the proposed sites and the controls. Epifauna absence/presence matrices and infauna abundance data were analysed using PRIMER v7 software. Three diversity indices were used: the number of species (S) and individuals (N) per sediment core and the Margalef's index of species richness (d). Cluster analysis was used to study the inter-site differences in community structures.

The sediment at the proposed sites comprised significantly less % silt/mud than at the mid-bay control, but was similar in grain size distribution to the control site at the bay entrance. There were no inter-site differences in sediment POC or DO. Percentage POC ranged between 0.9% and 2.86% and subsurface DO concentrations between 2.0 and 5.5 mg O_2/L. No distinct aRDP layers were evident in cores and no sulphide odours were detected.

Epibenthic burrows and tube worm holes were a common feature at all sites. Their presence indicates healthy well oxygenated sediment and they play a key role in bioturbation, thereby oxygenating deeper levels within the sediment. Shell hash (mostly *P. canaliculus*) was present in all triplicate photo-frames from Site 1 and Site 3 even though these sites have never been farmed.

Nine seabed surface-dwelling organisms were identified at the proposed sites: sponges, a holothurian, a fan shell, cushion starfish, solitary ascidians and a pigfish. Brachiopods, a taxonomic group sensitive to disturbance, were present at Site 1 and 3 but not at Site 2. At the control sites, there were 13 living organisms, six of which were common with the taxa at the proposed sites.

There were variations in epibenthic species assemblages within sites (i.e., between sub-samples A, B and C), between the three proposed sites (1, 2 and 3), between the control sites (CM12, CM12, CH12 and CH13) as well as between farm and control sites. Thus, epibenthic features at the proposed farm sites were not distinctive from those at the controls.

Mean infauna abundance (N) at Site 1 was high (166 individuals) and significantly different to all other sites where numbers ranged between nine to 93 individuals. Mean species number (S) was highest at Site 3 (23) but this was not significantly different to the other sites including the controls. Similarly, there were no significant inter-site differences in species richness (range 2.2 to 4.7). All these community indices were higher than that found for infauna communities living under operating mussel farms.

The most common phyla were Annelida, Crustacea and Mollusca. Ninety-five infauna taxa were identified across all sites, dominated by amphipods, ostracods and polychaetes. There was a paucity of molluscan species at the proposed sites (only seven out of 32 listed species). Most molluscs were located at the control sites.

Cluster analysis of inter-site similarities in infauna community structures aligned Site 1 with the bay-entrance control and Sites 2 and 3 with the mid-bay control, an outcome likely determined by their respective locations within the bay. Site 1 is close to the mouth of the bay where the CM site is positioned and Sites 2 and 3 are adjacent to the CH site in the middle of the bay. Common infauna assemblages appear shared between sites depending on their locations inside the bay.

Brachiopods were present at the proposed farm sites and are represented elsewhere in the bay. This group has been identified as being sensitive to disturbance but live specimens have been found under operating mussel farms. Even though benthic deposition is greater in a mussel farm (an element of disturbance), the shell hash may provide an attractive attachment surface for brachiopods.

In the bay-wide monitoring programme for marine farms in Big Glory Bay, the seabed environmental condition is evaluated against two non-farmed areas (control sites) to assess whether there are any undue adverse effects (Section 17, Resource Management Act, 1991). Thus, it is accepted by regulators (Environment Southland) that the reference Sites are representative benthic areas that are healthy biogeochemical environments with integrated and functional faunal communities.

In this study, the three proposed mussel farming sites align with the reference Sites (CM and CH) as assessed by the suite of prescribed environment indicators. The areas are environmentally healthy and have complex community structures that accommodate predator-prey relationships.

1 Introduction

This report is a baseline assessment of the benthic environment at three proposed mussel farming areas in Big Glory Bay, Stewart Island. The applicant will submit the report when applying to Environment Southland (ES) for approval to estabiish these farms. The sampling design for this assessment was agreed upon between NIWA and ES in May 2017 (Stenton-Dozey 2017) and is based on the 2012 bay-wide environmental monitoring programme for marine farming (Appendix A). This approach compares the benthic faunal community composition and sediment characteristics within the boundaries of the three sites with that at two designated control sites distant from all mussel farms. These data provide the baseline against which potential benthic effects of the future mussel farms can be assessed. In this context, cultured mussels can contribute to benthic sedimentation and possible eutrophication. Mussels, feeding mainly on natural phytoplankton, detritus and to a lesser extent small zooplankton (Zeldis et al. 2004), load the water column with organic waste in the form of faeces and pseudofaeces (mucus-laden, uneaten particles).

The scope of this work at the three proposed farm sites is comprised of the following components:

- determine the grain size and particulate organic carbon content of sediments and compare to reference sites,
- identify seabed features and surface dwelling organisms (epifauna) from photographs and compare,
- identify the organisms living in the sediment (infauna) to species level where possible and compare community structures with reference sites and
- Assess the benthic environmental status of the three sites in relation to that of the wider bay as represented by two reference sites.

2 Background

Big Glory Bay (BGB), Stewart Island has been used for long-line culture of green-lipped mussels (*Perna canaliculus*) since 1987 (Table 2-1, Figure 2-1, Figure 2-2). There is a bay-wide benthic compliance monitoring programme for all operating farms that seeks to determine whether marine farms are having an adverse effect on the benthic environment (Environment Southland 2011). Sanford represents all farmers and engaged NIWA from 2012 to 2015 to undertake the benthic compliance monitoring. In the light of NIWA's experience in BGB, we were approached by two local mussel farmers, Jim Maass-Barrett and Zane Smith, to undertake a baseline assessment of the benthic environment at three proposed Sites in the bay. Mussel culture has not occurred at these Sites at any time in the past.

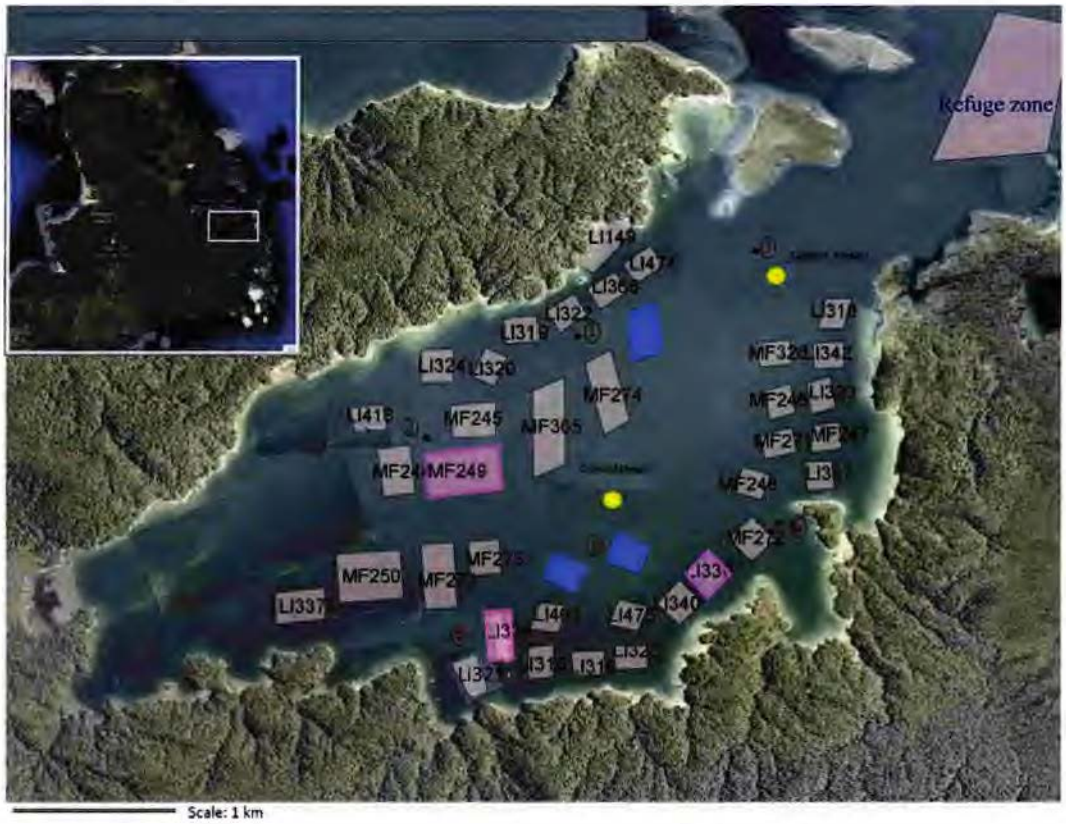

Figure 2-1: Marine farming sites in Big Glory Bay. The grey sites are existing mussel farms, the pink sites, salmon, and the blue are the three proposed mussel farming sites. Yellow dots locate the designated control sites (Control Head (CH) and Control Mouth (CM)).

Figure 2-2: Navigational pathway in Big Glory Bay in relation to the three proposed mussel farm sites. Image provided by Jim Maass-Barrett and Zane Smith.

Table 2-1: The corner coordinates of the three proposed mussel farm sites. Coordinates in WGS84.

Sites	Latitude	Longitude
Site 1		
NE cnr –	46 58.223S	168 07.502E
NWcnr–	46 58.267S	168 07.350E
SEcnr –	46 58.396S	168 07.512E
SW cnr	46 58.429S	168 07.357E
Site 2		
NWcnr	46 59.045S	16806.972E
E cnr	46 59.086S	168.07.142E
SE cnr	46 59.187S	16807.088E
Wcnr	46 59.138S	168 06.913E
Site3		
NWcnr	46 58.975S	16807.283E
E cnr	46 59.026S	168 07.453E
SE cnr	46 59.124S	16807.397E
W cnr	46 59.084S	168 07.218E

3 Methods

3.1 Monitoring indicators

The environmental indicators used to assess the biophysical status of the benthic environment are stipulated by ES in the bay-wide monitoring programme (see Appendix A). To assess benthic sediment quality these were sediment grain size; organic carbon (POC) content; presence of sulphide; depth of the oxygenated layer; depth of the apparent Redox Potential Discontinuity (aRPD) layer and presence of bacterial mats. The biological quality of sediments was assessed by quantifying invertebrates (and sometimes flora) on the surface (epifauna) and within sediments (infauna). These indicators are summarised, with rationales for selection, in Table 3-1.

Table 3-1: The environmental indicators used to assess the biophysical status of the benthos at the three proposed mussel farm sites.

Benthic Quality	Indicator Rationale
Sediment grain size	Proportionality of silt/mud to sand in sediments beneath marine farms may provide an indication of the organic loading from a farm
Particulate Organic Carbon content (POC)	Particulate Organic Carbon (POC) refers to the amount of organic matter preserved within sediment and is therefore a good indicator of organic-rich material originating from marine farming. It reflects the accumulated and more stable fraction of total organic matter buried in marine sediments
Appearance of sulphide depth and general colour of sediment	Depth of the apparent Redox Potential Discontinuity (aRPD) layer: Unenriched sediments are usually greyish in colour whereas organically enriched, anoxic sediments are very dark grey or black. The boundary between the two is called the redox potential discontinuity (RPD) layer. As the level of enrichment increases and the sediment becomes increasingly anoxic, the RPD moves closer towards the sediment surface
Sulphide odour	Presence indicates predominance of sulphate reduction in the decomposition of organic matter under anoxic conditions
Depth of oxygenated layer below the sediment surface	Dissolved Oxygen concentration in the top 20 mm of a sediment core
Mat-forming, filamentous bacteria	These bacteria (e.g., *Beggiatoa* spp.) oxidise sulphide and therefore require oxygen to live. Their presence provides an indication that the sediments are highly anaerobic and sulphide-rich at the sediment surface, but that the overlying water column still contains some oxygen (Sayama 2001)
Epifauna	These are organisms that live on the surface of the sediment. They are not as sensitive as infauna to sediment enrichment but their presence or absence provides an indication of enhanced organic deposition
Infauna	Infauna are animals living within the sediment. For the purpose of this assessment these are animals greater than >0.5 mm (called macrofauna). Their presence/absence, species diversity and abundance collectively provide an indication of biological quality of the seabed

3.2 Field sampling

In the proposed monitoring programme (Stenton-Dozey 2017), ES agreed to the use of historical control Site data thus avoiding the necessity to sample these Sites during the survey for this assessment. Since Jim and Zane were members of the bay-wide monitoring in 2012 and 2013, control Site data from these two years were used in this report. These data were obtained from Stenton-Dozey et al. (2012) and Stenton-Dozey and Cairney (2013).

Within each proposed farm site, the following were undertaken:

- four drop camera photographs were taken to visually assess the seabed and identify epifauna communities;
- two Van Veen grabs (bite area ca. 0.13 m^2, max bite depth 22 cm) were taken;
- dissolved oxygen concentration (DO) was measured at 2 cm below the sediment surface in three places (i.e., three readings per grab);
- one core (depth 12 cm, diameter 15 cm) was extracted from each grab sample for analyses of infauna and;
- two sediment cores (depth 12 cm, 8 cm diameter) were extracted from each grab for sediment analyses as summarised in Table 3-2.

Table 3-2: Methodologies for analysing sediment samples.

Sediment characteristics	Measure	Method
Grain size	% clay, % silt, %sand, % gravel	One core size (15 cm deep and eight cm diameter), frozen and then dry sieving at NIWA lab
Total Organic Carbon content	% particulate organic carbon (POC)	One core size (15 cm deep and eight cm diameter), CHN analyser at NIWA: this provides POC and PON simultaneously Keep these samples frozen
Appearance of sulphide depth and general colour of sediment	Depth of aRPD (apparent Redox Potential Discontinuity) layer	Measurement of aRDP layer (black colour demarcation) from sediment surface in two cores (15 cm deep and eight cm diameter) Photograph of the same core in colour
Sulphide odour	Presence or absence	Odour detection in each core
Depth of oxygenated layer below the sediment surface	Dissolved Oxygen concentration in the top 20 mm of each of two sediment cores	YSI oxygen probe as mg/L
Fauna	**Measure**	**Method**
Infauna	Numbers per core Numbers per taxon Species Richness Similarity Index (Cluster analyses) Multi-dimensional scaling	One core (diameter 15 cm) pushed 15 cm into the grab sample. This sediment removed and sieved though a 0.5 mm mesh. Preserve retained infauna with 70% ethanol. These will be counted and taxa identified at the NIWA labs

3.3 Data analysis

Sediment data (grain size and organic content) from the farm sites were assessed against that from the control sites to identify significant differences using STATISTICA (Statsoft 2011).

Epifauna absence/presence matrices and infauna abundance data were analysed using PRIMER v7 software (Clarke and Gorley 2015). For infauna, a set of diversity measures (or indices) were calculated for each grab sample using the DIVERSE feature in PRIMER. This tabulates the number of species (S) and individuals (N) per sediment core and provides an index of species richness (d), a term which refers to the Margalef's species richness index (d): $d = (S-1)/\ln(N)$. Significant differences in these indices were assessed using one-way ANOVA after testing for the homogeneity between variances around means using Brown-Forsythe Test for uneven samples numbers (Statsoft 2011). Two sediment grab samples were extracted from the proposed farm sites compared to three grabs at the control sites.

The Margalef's index *(d)* is a common index used to classify the ecological status of the environment. It considers the absolute number of individuals in combination with the absolute number of species. Margalef's species richness index *(d)* ranges from 1 (very poor diversity) to c. 12 (very high diversity).

To assess the similarity between infauna assemblages (as abundance) from the different stations, data were square-root transformed to de-emphasise the influence of the dominant species (by abundance) and comparisons made using clustering (Bray-Curtis similarities) (Clarke and Warwick 1994) and nonmetric multidimensional scaling ordination (MDS; Kruskal and Wish 1978). Each mussel farm was compared to the control stations and each salmon farm compared to the 50 m, 100 m and control stations.

4 Results

4.1 Sediments

In this section, statistical comparisons are made between sediment properties (% silt/mud, % sand, % particulate organic carbon (POC), and sub-surface dissolved oxygen (DO) at the three-proposed farm and two control Sites. Non-quantitative characteristics (sulphide odour, presence of bacteria mats (*Beggiatoa* spp.) are given in Appendix B. There was no evidence of a sulphide odour or bacteria mats in any of the sediment samples.

At Site 1 there were nearly equal portions of silt/mud (41%) and sand (46%) in sediments but at the other two Sites there was more silt/mud than sand (Site 2: 55% and 35%, Site 3: 59% and 28%, respectively) (Figure 4-1). Sediments at control sites located at the entrance to Big Glory Bay (CM12 and CM13) were comprised of similar portions of mud/silt and sand as found at farm Sites 2 and 3 (50% to 57% for mud/silt and 31% to 40% for sand). However, sediments at the control sites in the middle if the bay (CH12 and CH13) were predominately made up of mud/silt (69% and 85%) and less sand (12% to 25%).

Sediment %mud/silt at Site 1 was significantly different to both controls in the middle of the bay (CH12 and CH13) while Sites 2 and 3 were only different from CH13 (one-way ANOVA, Appendix C). The proportion of sand in sediment at Site 1 and Site 2 differed to that at CH13.

The other sediment properties measured at the three sites, % particulate organic carbon (POC) and the subsurface sediment dissolved oxygen (DO) concentration, were not significantly different to the control site sediments (Appendix C). Percentage POC in sediments was low at the farm and control Sites: between 0.9% and 1.6% at Sites 1 – 3, and 1.29% to 2.86% at the control sites, the highest measure in this range being at Site CM12 (Figure 4-1, Appendix C). DO concentrations in sediments at Sites 1 to 3 ranged between 2.0 and 3.2 mg O_2/L and at the controls, between 2.0 and 5.5 mg O_2/L.

Sediment colour is shown in grab and core profile photographs in Appendix D. The three sites had a varying degree of dark colouration indicative of organic enrichment. However, this appeared as isolated streaks from 2 to 8 cm from the sediment core surface and there were no distinct aRPD boundaries (see explanatory notes in Table 3-1). Similar dark streaks were evident in the control sediment profiles from 2012 and 2013 (Appendix D).

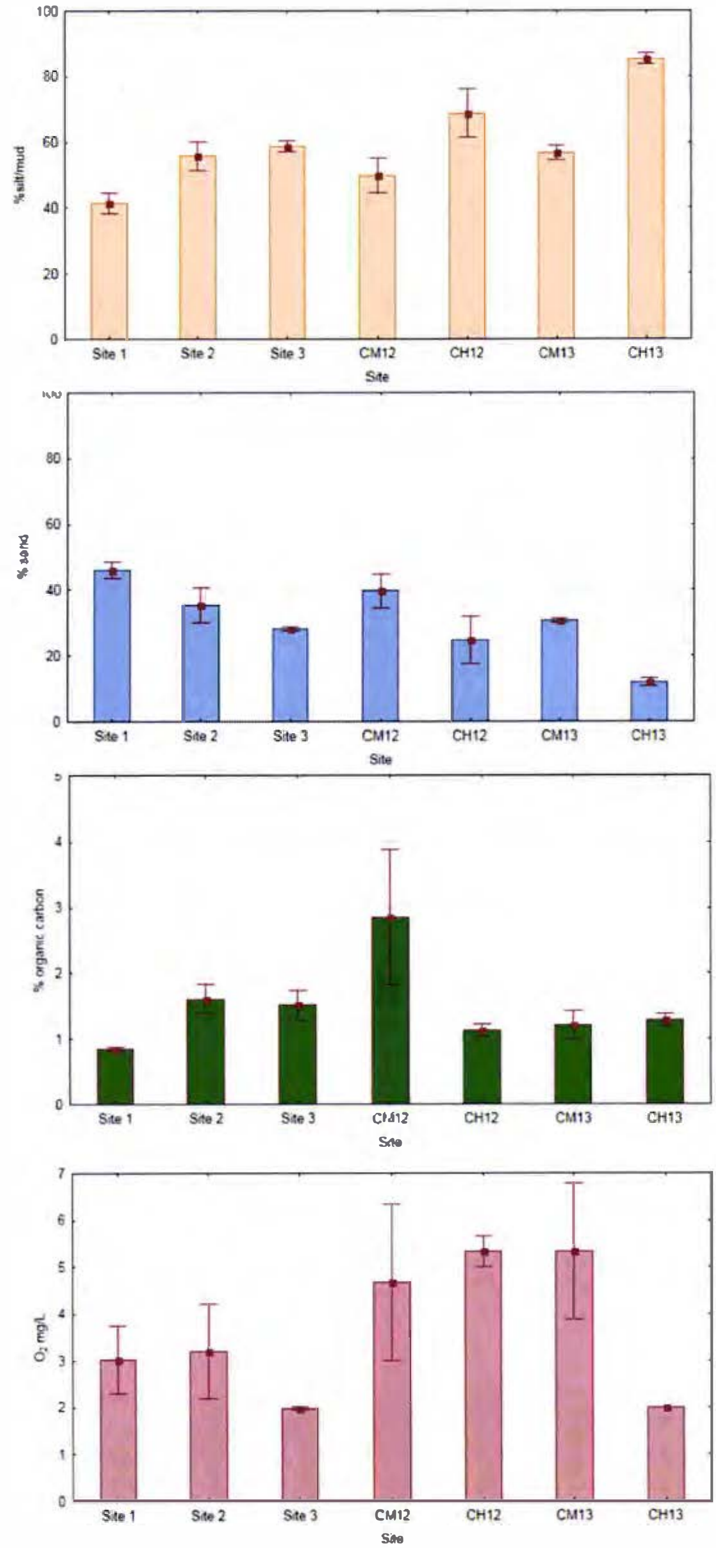

Figure 4-1: Benthic sediment properties. (% silt/mud, % sand, % particulate organic carbon, subsurface O_2 mg/L). From the proposed mussel farm sites (1, 2 and 3) and two control sites. (CM12 = control mouth 2012, CH12 = control head 2012, CM13 = control mouth 2013 and CH13 = control head 2013. The vertical lines indicate 1 SE either side of the mean. The height of coloured bars indicates the mean value.

4.2 Benthic seabed features and epifauna

Within the boundaries of the three proposed sites a total of 12 conspicuous seabed features were recorded (from the three photo quadrants per Site) of which nine were seabed-dwelling organisms (sponges, a holothurian (*Amphicyclus thomsoni*), the fan shell (*Chlamys zelandiae*), the cushion starfish (*Patiriella regularis*), solitary ascidians, brachiopods and a pigfish (*Congiopodus leucopaecilus*) (Figure 4-2). Brachiopods, a species group sensitive to disturbance, were present at Site 1 and 3 but not at Site 2.

At the control sites, there were 16 benthic features of which 13 were living organisms (Figure 4-2). Among the epifauna, six taxa were common within the proposed Sites while seven were only found at the control Sites (a colonial tunicate (Didemnid), a spotty (*Notolabrus celidotus*), brittle starfish (*Ophiopsammus maculata*), scallop (*Pecten novaezelandiae*), sea cucumber (*Australostichopus mollis*), and red and coralline algae. There were no brachiopods at the control sites.

Burrows were a common feature at all sites as well as worm holes. These burrows are made by crustaceans (amphipods, isopods, ostracods and crabs) and some polychaetes. Shell hash (mostly *P. canaliculus*) was present in all replicate photo-frames from Site 1 and Site 3.

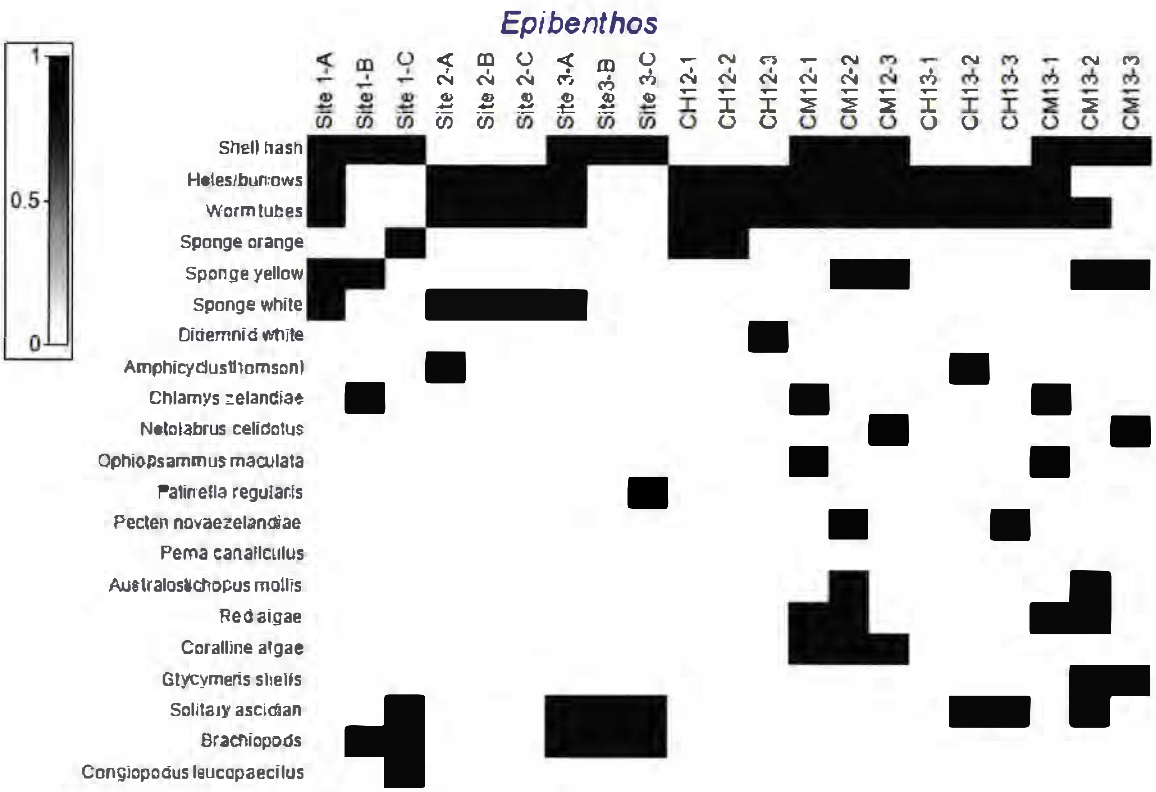

Figure 4-2: Conspicuous epibenthic features and epibiota seen in photo-quadrats. Presented as a presence (black)/absence (white) matrix. The box indicates the separation between absence (0) and presence (1).

Cluster analysis, based on the absence/presence matrix of epibenthic features indicated a clear separation of the triplicate samples per site into two groups at the level of 20% similarity (Figure 4-3). In one group (right side of the dendrogram: Group 1), Site 1 (B&C) and Site 3(B&C) clustered with

CM13 (B&C) while all other Sites (A-C) assembled together in a second group (Group 2). In Group 2, there was a cluster at 70% similarity in benthic features between Site 1A, Site 2A-C and Site 3A and at 60% the same for all the control sites other than those in Group 1. There are therefore some distinctive variations in epibenthic assemblages within sites (i.e., between sub-samples A, B and C), between the three proposed sites (1, 2 and 3), between the control sites (CM12, CM12, CH12 and CH13) as well as between farm and control sites.

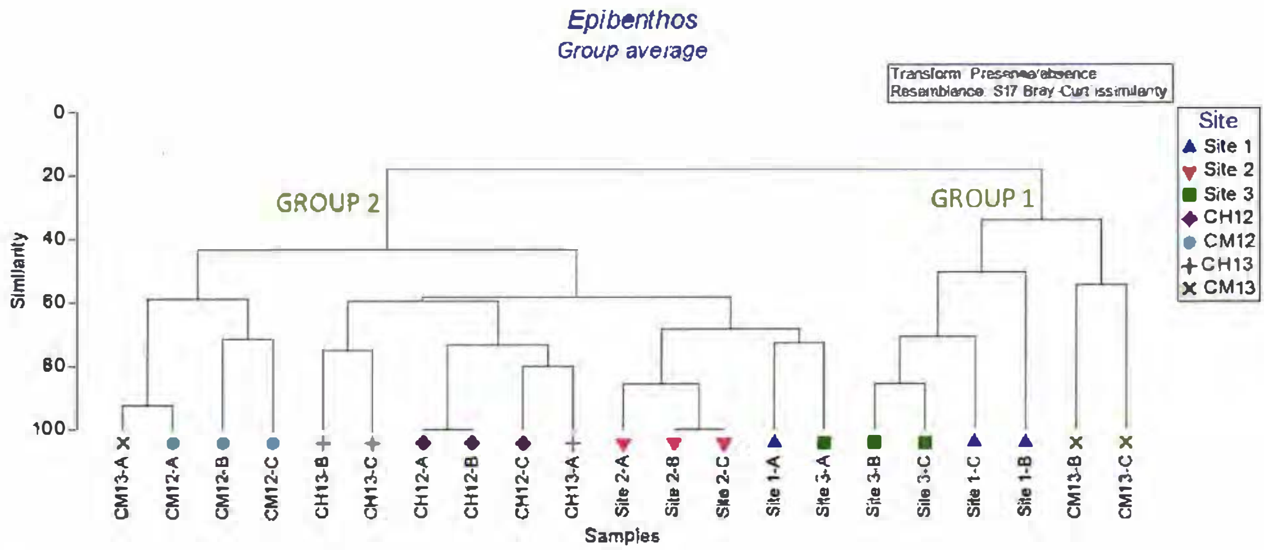

Figure 4-3: Cluster analysis of the epibenthic features evident in photo quadrats from all sites. Each site is comprised of three samples (A-C).

An alternative representation of similarities (MDS, Multiple Dimensional Scaling; Figure 4-4) provides a two-dimensional surface plot of the similarity clusters at 20%, 40% 60% and 80% similarity. The separation of groups 1 and 2 at 20% similarity is shown by the two green circles in Figure 4-4. Within Group 1, control CM13 (B&C) was 40% similar to Site 1 (B&C) and Site 3 (B&C). In Group 2 the remaining proposed sites and control sites (i.e., except CM13 (B&C)) were 40% similar. The highest level of similarity between any control and the proposed sites was 60% between CH13 (B&C) and Sites 1-A, 3-A and 2 A, B and C.

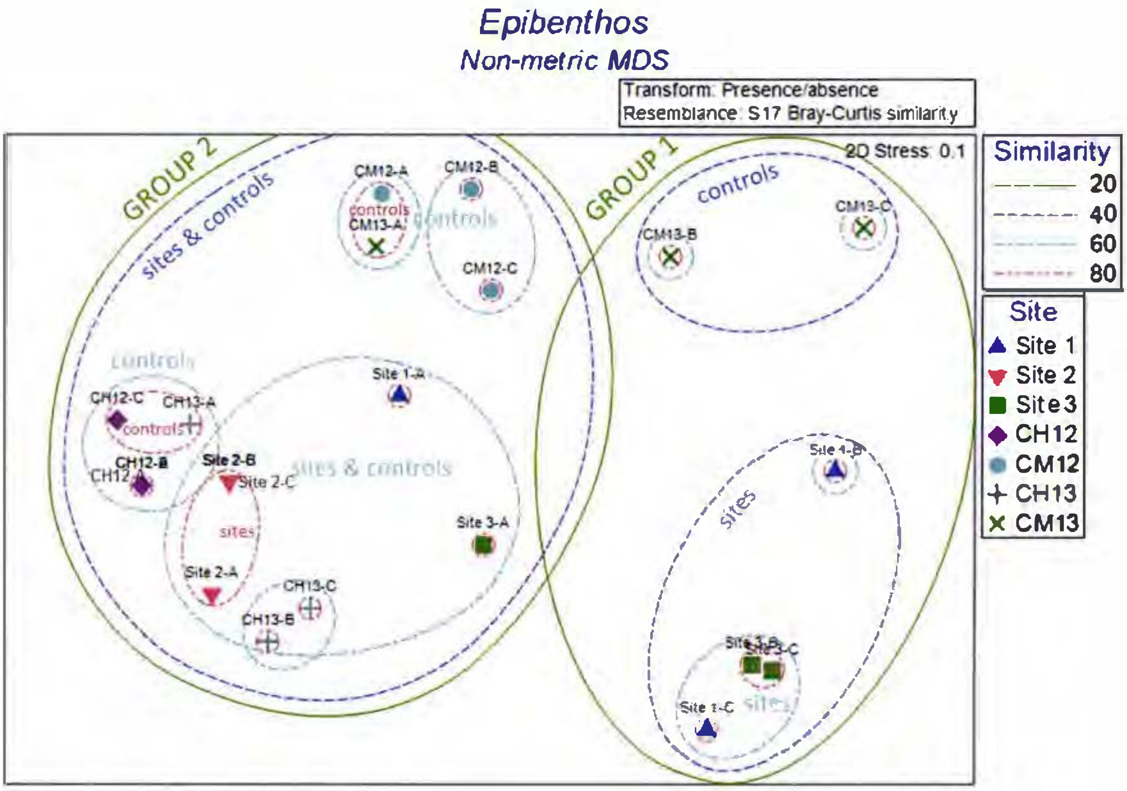

Figure 4-4: MDS plot of the epibenthic features associated with the three-proposed farm and two control sites. Each site is comprised of three samples (A -C). Circles of similarity between sites are imposed on the MDS for 20%, 40%, 60% and 80%.

4.3 Benthic infauna

4.3.1 Infauna abundance and diversity

Abundance

The mean infauna abundance (N) at Site 1 was 166 (SD = 47) individuals/core, at Site 2, 52 (SD = 9) and at Site 3, 93 (SD = 6) (Figure 4-5). By comparison there was a lower range in abundance at the control Sites (39 to 57 individuals/core). The highest number of individuals was at Site 1 (166) and this significantly set it apart from Site 2 (but not Site 3) and all the control sites (one-way ANOVA; $F_{(6,11)}$= 8.2, $p < 0.05$).

Number of species

The number of species (S) in the cores was highest at Site 3 (23, SD = 9) and at the control site at the entrance to the bay, CM13 (18, SD = 7) (Figure 4-5). The lowest S was in sediments from CM12 (9, SD = 2). There was no significant differences in species numbers between any of the sites (one-way ANOVA; $F_{(6,11)}$= 1.9, $p > 0.05$).

Species richness

The mean Margalef's species richness index *(d)* (a measure of biodiversity in the sediments) was highest at Site 3 (4.7, SD = 1.9) followed by CM13 (4.4, SD = 1.5) and lowest at CM12 (2.2, SD = 0.7)

(Figure 4-5). There were no significant differences in *d* between any of the sites (one-way ANOVA; $F_{(6,11)} = 1.8$, $p > 0.05$). The ecological status of these areas can be classified as good according to these *d* indices (scoring range from poor to excellent is 1 to 12, see Table 3-1).

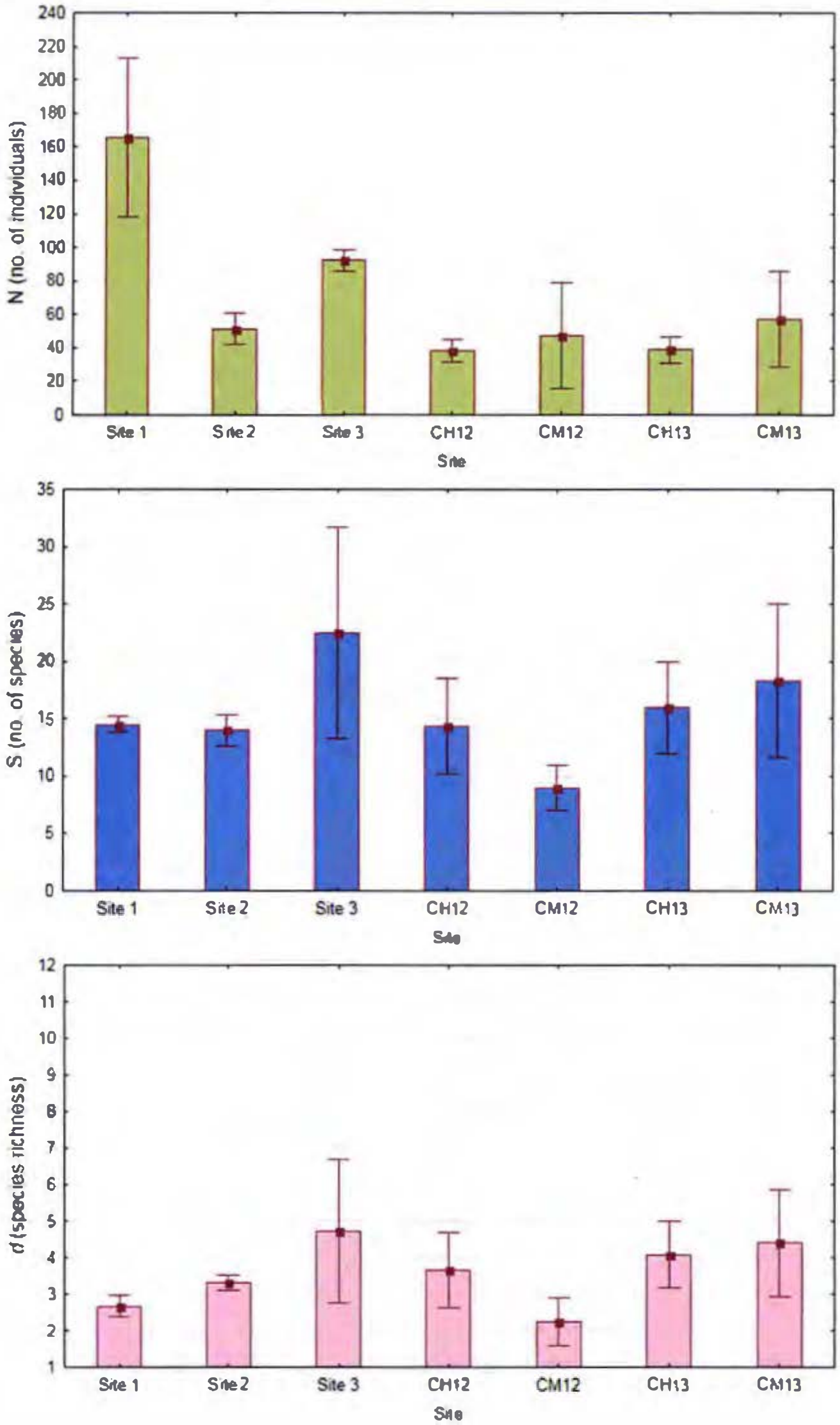

Figure 4-5: Mean number of infauna individuals (N) and species (S) /core and species richness (*d*) per site. The vertical lines indicate 1 SE either side of the mean. The height of coloured bars indicates the mean value.

4.3.2 Infauna community structure

The most common phyla in terms of the number of individuals in any one grab sample were Annelida, Crustacea and Mollusca (Figure 4-6). At Site 1-A there was a total of 156 crustaceans. This phylum was also well represented at Site 1-B (71), Site 3-A (34) and Site 3-B (29). Among the control sites, crustaceans were numerous among the grabs extracted at the entrance of the bay (CM12 and CM13). Annelid abundance was generally higher at the proposed sites (ranged from 23 to 57 individuals per grab) than among the controls, except for CH13 (26 to 34 individuals per grab).

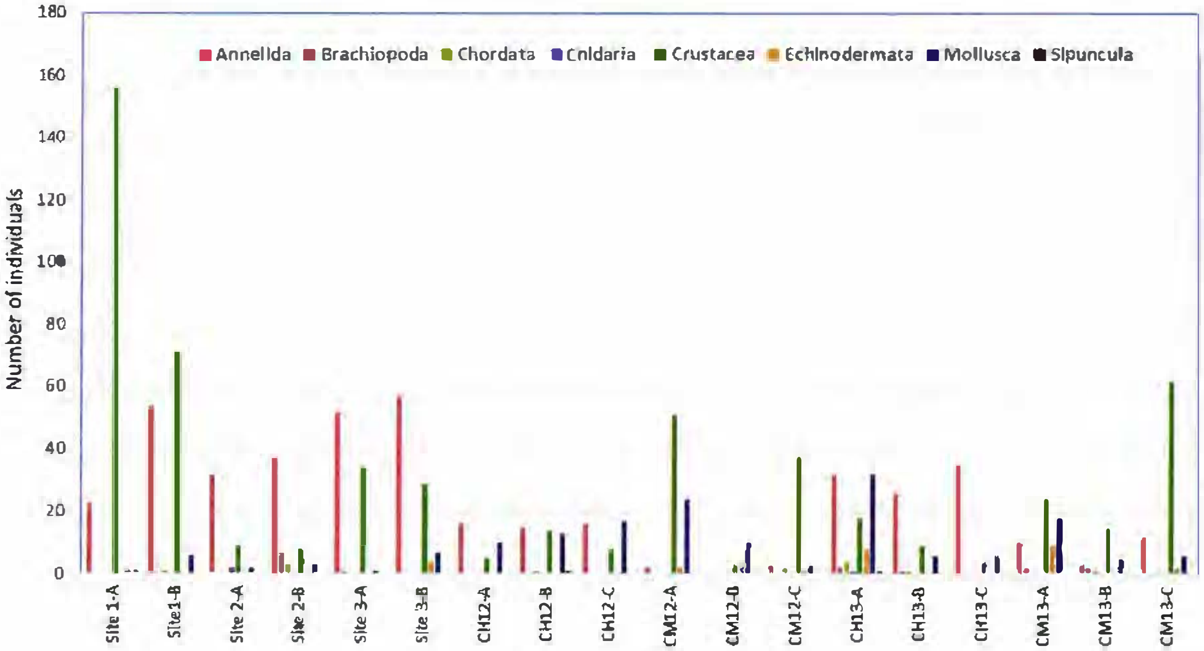

Figure 4-6: Number of infauna individuals per phylum per grab sample.

A further assessment of potential farming impacts on the ecological status of benthic infauna is to consider the baseline species composition at the farm sites relative to the controls. A species composition matrix, comprising 98 species and based on abundance per species was constructed aligning the three proposed sites with the four control sites (Figure 4-7). There are many striking features in this matrix, particularly the high number of amphipods across all sites. It is this abundance that accounts for the high crustacean numbers in Figure 4-6. The amphipods from control samples were not identified to species level in 2012 and 2013 but in the present survey this was undertaken. One species dominated, *Ampelisca chiltoni*, with 106 individuals at Site 1-A and 53 at Site 1-B. Ostracods were also numerous at some sites: Site 1-A (35), Site 3-A&B (15 to 20 individuals) and CM12-C and CM13-A (19). Across all proposed farm sites and the controls there were 18 crustacean species.

In total, there were 32 annelid species which were dominated numerically by three polychaete families, *Maldanid* sp. (15 to 45 at Site 1), *Lumbrinerid* sp. (six to 14 at Sites 2 and CH13) and *Cossurid* sp. (12 to 25 at Site 2, Site 3 and CH13).

Molluscs were represented by 32 species of which only seven were found in the grab samples from Sites 1, 2 and 3: the bivalves *Linucula hartvigiana, Zemysina globus, Tawera spissa, Asthenothaerus* *maxwelli, Prothyasira peregrine and Leptomya retiaria,* and a gastropod, *Opisthabranchia sp*. The numbers per species were low, in the range of one to four and only one species *Tawera spissa,* was also found at the control sites. All other mollusc species, 25 in total, were only present at the CH and CM sites. The is therefore a distinctive difference in molluscan species composition between farm and control sites.

The presence of brachiopods can be indicative of a sensitive habitat. The brachiopod species, *Neathyris lenticularis,* was found in the grab samples from Site 2-B (a clump of seven individuals) and Site 3-A (one specimen). The same species was present at CM13-A (two individuals) and CM13-B (one specimen). One specimen of the species *Terebratella sanguineo* was present at CH13-B and another at CM13-B.

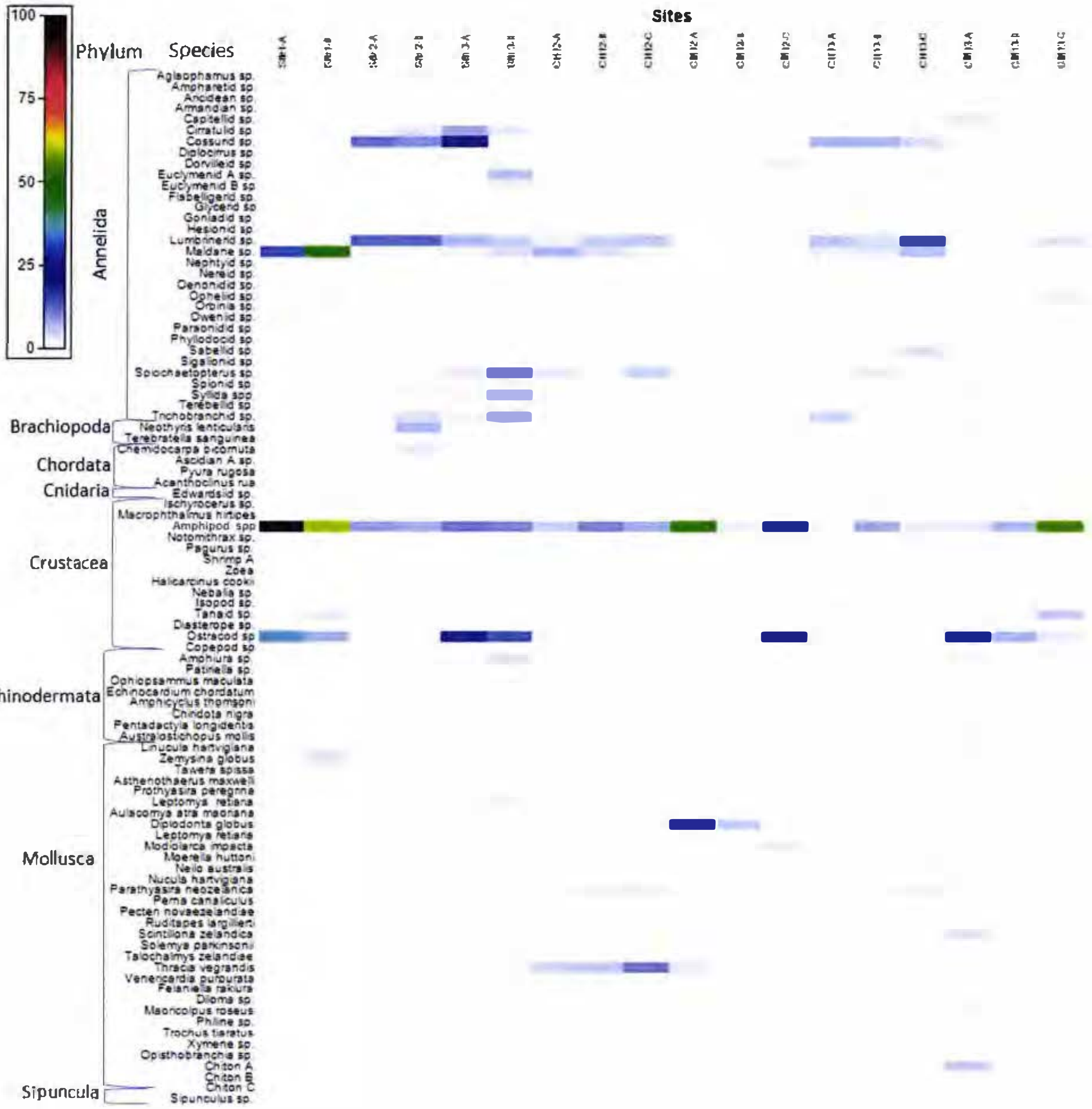

Figure 4-7: Infauna abundance matrix per species at each Site. The replicate samples are designated A, B and C.

4.3.3 Infauna community similarities

The similarity in species composition (based on abundance) within (two or three replicate samples at each site) and between sites (proposed farm and controls) can be assessed using cluster analysis (Figure 4-8). At 20% similarity two control samples, CM12-A and CM12-B separate out from all the other samples which, in turn, are assembled together at 25%. In this second cluster two distinct groups are evident, one in which Site 1 has a species composition that has 30% similarity to CM13 and CM12-C and another in which Sites 2 and 3 have 33% similarity to CH12 and CH13.

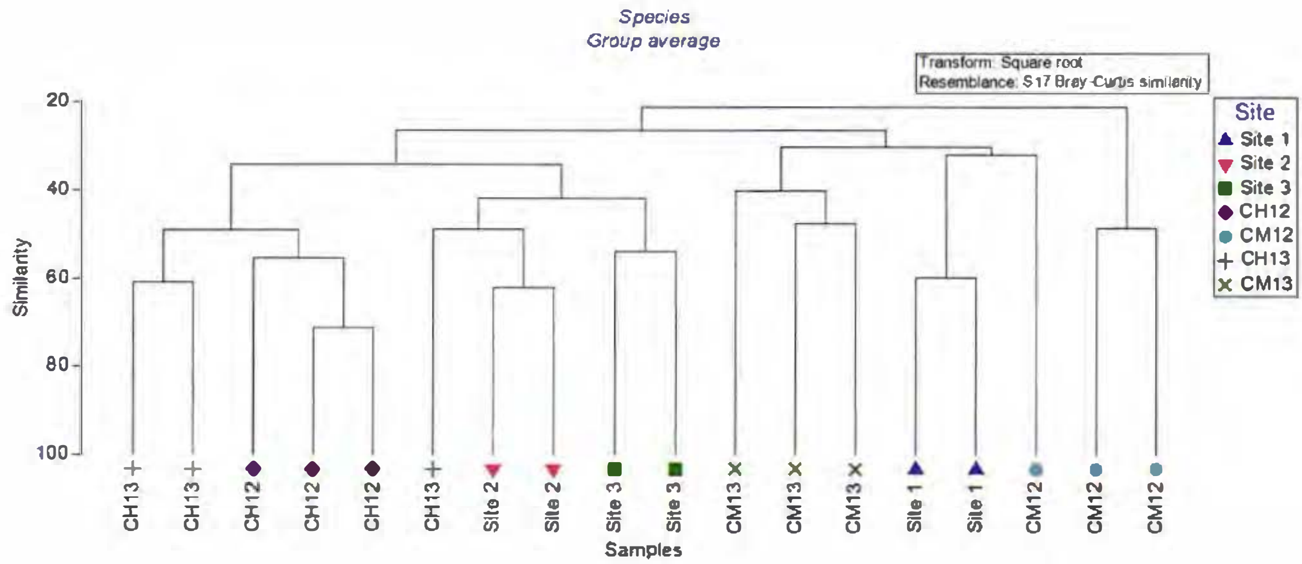

Figure 4-8: A Bray-Curtis cluster dendrogram based on similarities between infauna species and their abundance. The three proposed Sites 1, 2 and 3. The control sites CM (entrance to Big Glory Bay) and CH (middle of the bay). 12 = 2012, 13 = 2013.

The average percentage similarity between the grab samples at any one Site is highest at Site 1 and 2 and CH12 (60%) and lowest at CM12 (33%) (Figure 4-9).

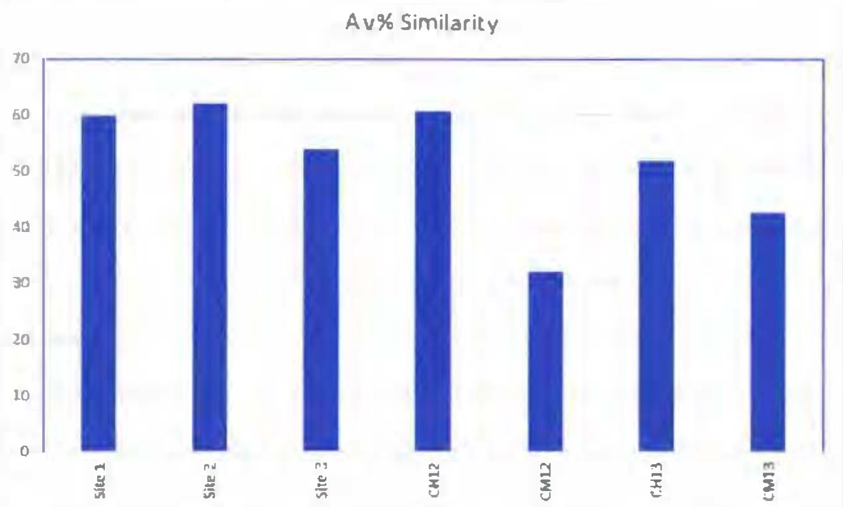

Figure 4-9: The average percentage similarity between the grab samples at any one site. n= 2 for the proposed sites and n = 3 for the controls.

Amphipods contributed between 7% to 23% towards the percentage similarity between grab samples within each of the seven Sites and ostracods between 8% and 10% at Site 1, Site 3 and CM3 (Figure 4-10). The polychaetes *Maldanid* sp., *Lumbrinerid* sp, *Cossurid* sp. *Cirratulid* sp. account for 4% to 15% species similarity between samples at some but not all sites. The species similarities between grab samples from Sites CH13 and CM13 were very different to those at the other sites. At CH13, four species contributed 4% to 12% (three bivalve and one sea cucumber species) and at CM13 four species account for 4% similarity (two bivalve and two polychaete species).

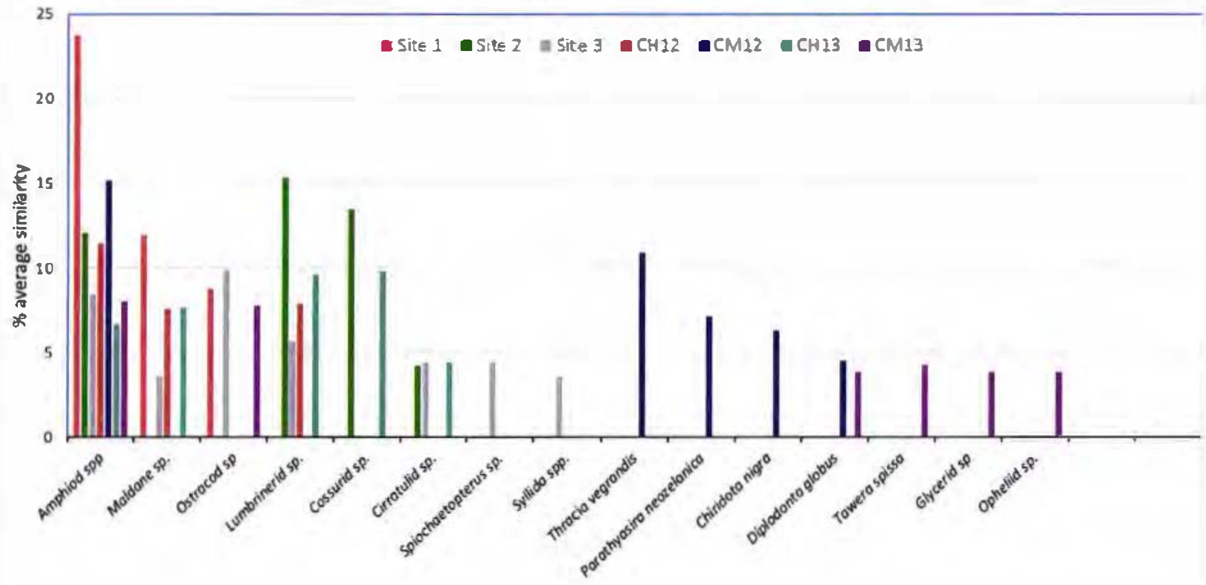

Figure 4-10: Average percentage similarity among infauna species between grabs samples at each Site. n= 2 for the proposed sites and n = 3 for the controls.

An MDS plot brings more clarity to the degree of separation between sites based on similarities between infauna species and their abundance (Figure 4-11). The extensive spatial dissociation between CM12-A&B from CM12-C is emphasised and contrasts to the grouping of CM13 samples. In two-dimensional space CM12-A is closer to CM3 samples (30% similarity). Sites 2 and 3 cluster with CH13-A at 40% and with CH13-B&C and CH12 at 30%.

The distinctive percentage similarity grouping of Site 1 with the CM controls and Sites 2 and 3 with CH controls is likely determined by their respective locations within the bay. Site 1 is close to the mouth of the bay where the CM sites are positioned and Sites 2 and 3 are adjacent to the CH sites in the middle of the bay. Common community structures appear shared between sites depending on their locations inside the bay.

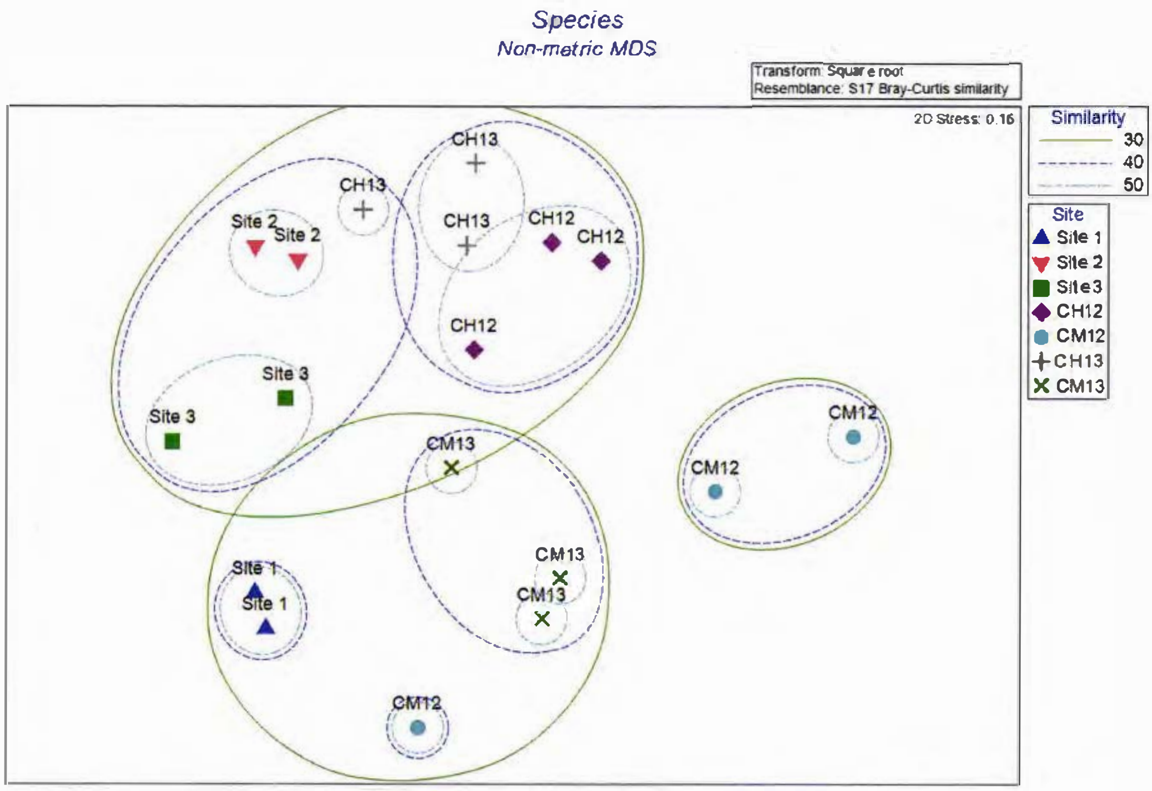

Figure 4-11: A MDS plot based on similarities between sites in terms of infaunal assemblages. The three proposed Sites 1, 2 and 3. The control sites CM (entrance to Big Glory Bay) and CH (mid-bay). 12 = 2012, 13 = 2013.

5 Discussion

5.1 Sediments

The proportionality of mud/silt to sand was similar between Sites studied in this report except at the mid-bay control Site (CH) where sediment was comprised of more mud/silt (60% to 80%) than at the three proposed Sites. The percentage particulate organic carbon (POC), a measure of the amount of organic matter preserved within sediment, was low at all proposed Sites (< 1.6%). This low organic content together with an oxygenated (DO) subsurface (2 to 3.2 mg O_2/L), and no marked aRPD layer or sulphide odours indicates less than minor enrichment. By contrast impacted mussel farm Sites have sediments with more mud/silt (60 % to 80%), higher POC (2% to 4%) and lower DO (1 to 2 mg O_2/L) (Stenton-Dozey et al. 2012, Stenton-Dozey & Cairney 2013).

Dissolved oxygen is a key factor in regulating both benthic community complexity and many benthic biogeochemical cycles, such as sulphur and nitrogen (Aller 1979, Yingst and Rhoads 1980, Jenkins andKemp 1984). During periods of hypoxia (<2 mg/L) changes in community structure and behaviour altergeochemical profiles in the sediments as bioturbation declines from lack of oxygen to support macrofaunal activity.

Sediment characteristics are likely shaped to some extent by the shearing forces of bottom current and resuspension. The bottom current flow through the mouth of the bay, close to the location of Site 1 and control site CM, appears to be predominantly into BGB while the surface flow is strongly tidal (DHI 2011).

5.2 Seabed features and epifauna

Burrows and worm holes were a common feature at the three proposed sites. These burrows are made by crustaceans (amphipods, isopods, ostracods and crabs) and some polychaetes. Their presence indicates healthy well oxygenated sediment and they play a key role in bioturbation, moving sediment to the surface and thereby oxygenating deeper levels (Aller 1979).

Shell hash (*P. canaliculus*) was present at Sites 1 and 3 even though mussel farming has not taken place in these areas. The shell hash may originate from incidental dislodgement of mussels during general operation of the approximately 28 working farms in the bay. The presence of the hash is a baseline feature that must be noted in any future assessments of farm impacts.

There were some distinctive variations in epibenthic assemblages within sites (i.e., between triplicate samples), between the three proposed sites (1, 2 and 3), between the control sites (CM12, CM12, CH12 and CH13) as well as between farm and control sites. This indicates strong spatial variability in epibenthic features across the bay from the mouth (CM) to the north-east area (Site 1), to the middle of the bay (CH) and approximately 1 km from the south-bay edge (Sites 2 and 3). This high degree of variability will need to be considered in future assessments.

5.3 Infauna

In the analysis of infauna data, three indices of abundance and diversity were used to characterise the proposed sites and designated controls: the number of species (S) and individuals (N) per sediment core and the mean Margalef's species richness index *(d)*. This latter index ranges from 1 (very low diversity) to c. 12 (very high diversity).

The mean abundance of infauna individuals was higher at the proposed sites than the controls with the significantly highest number at Site 1 (166/core) mainly due to the presence of many amphipods. The highest mean number of species was found at Site 3 (23) and the lowest at CM12 (9). However due to the variation within sites, there was no significant difference detected between sites.

The sites with the highest species number also presented with the highest species richness index based on the formula $d = (S - 1)/\ln N$. The highest index was at Site 3 (4.7) and the lowest at CM12 (2.2). This range is constrained considering the overall scoring range for *d* is 1 to 12. There was no significant difference between sites.

Species richness was lower under operational farms surveyed previously (Stenton-Dozey et al. 2012, Stenton-Dozey and Cairney 2013), thus the proposed new Sites can be considered representative of the wider unimpacted bay seabed in terms of infauna species richness.

Besides the indices above, inter-Site comparisons of species community structure were also undertaken. The most common phyla at the proposed and control Sites were Annelida, Crustacea and Mollusca (Figure 4 6). The abundance of annelid and crustacean species was generally higher at the proposed sites, while the highest number of molluscan species was at the control sites.

The two identified brachiopod species at the proposed Sites, *Neothyris lenticuloris* and *Terebratella sanguinea* are endemic to New Zealand (Bowen 1968) and common around Stewart Island especially in Paterson Inlet where they are protected (together with another two species) within the Te Whaka a Te Wera Mataitai Reserve. Their status has resulted in the Ministry for the Environment identifying brachiopod beds as indicators of sensitive environments[1] (MacDiarmid et al. 2013) and therefore this group is included in the Schedule 6 list of the Exclusive Economic Zone (EEZ) and Continental Shelf (Environmental Effects) Act 2012.

However, brachiopods are sometimes found under operating mussel farms (Stenton-Dozey and Cairney 2013). Indeed, Inglis et al. (2000) have noted that in the Firth of Thames brachiopods are sometimes more abundant under mussel farms than in **nearby areas disturbed by trawling or dredging**. Brachiopods prefer hard substrate for attachment (MacDiarmid et al. 2013) and mussel shell hash under farms may provide such a habitat.

Overall 98 species were identified in this study dominated by the three phyla above. Amphipods were abundant ranging in numbers from eight to 137/core. *Ampelisca chiltoni* dominated with up to 106 individuals at Site 1. Ostracods and polychaetes were also numerous at some sites.

Cluster analysis of percentage species similarity within and between sites presented two distinct groups, one in which Site 1 had a species composition 30% similar to CM13 and CM12-C and another in which Sites 2 and 3 had 33% similarity to middle-bay control sites (CH). The two control sites (CM and CH) were only 20 to 25% similar in species composition.

Site 1 infauna community structure is therefore most similar to the closest control site at the bay entrance while Site 2 and Site 3 communities align with the mid-bay control. The two control sites are approximately 2 km apart and their infauna communities are more dissimilar than similar. This

[1] In this context "sensitivity" is defined by the United Kingdom's Marine Life Information Network (MarLIN) as:

- the tolerance of a species or habitat to damage from an external factor, and
- the time taken for its subsequent recovery from damage sustained as a result of an external factor

http://www.marlin.ac.uk/sensitivityrationale.php implies that infauna community structures in unfarmed areas differ spatially across the bay from the entrance to mid-bay.

6 Conclusion

Brachiopods were present at the proposed farm sites and are represented elsewhere in the bay. This group has been identified as being sensitive to disturbance but live specimens have been found under operating mussel farms. Even though benthic deposition is greater in a mussel farm (an element of disturbance), the shell hash may provide an attractive attachment surface for brachiopods.

In the bay-wide monitoring programme for marine farms in Big Glory Bay, the seabed environmental condition is evaluated against two non-farmed areas (control sites) to assess whether there are any undue adverse effects (Section 17, Resource Management Act, 1991). Thus, it is accepted by regulators (Environment Southland) that the reference sites are representative benthic areas that are healthy biogeochemical environments with integrated and functional faunal communities.

In this study, the three proposed mussel farming sites align with the reference sites (CM and CH) as assessed by the suite of prescribed environment indicators. The areas are environmentally healthy and have complex community structures that accommodate predator-prey relationships.

7 Acknowledgements

Thank you to Zane Smith for providing a vessel for the benthic survey in Big Glory Bay. Thank you to NIWA staff members, Louis Olsen, for undertaking the field work and for data assemblage, Andy Williams, for identifying infauna, Stephen Brown, for photo identification of epibenthic features and the Hamilton laboratory staff for analysing the sediments. Graham Fenwick helped with some of the amphipod identifications. A last thank you to Stephen Brown for reviewing this report and to Helen Rouse for the final check and release. Fenella Falconer kindly formatted the report.

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Appendix A Big Glory Bay Monitoring Programme

File No: S005-004
Consent No: 207256

APPENDIX ONE
Big Glory Bay Monitoring Programme

1. The consent holder shall monitor the effects of the marine farming activities on the seabed, as follows:

(a) (i) except for LI339, LI340, MF249, MF250, MF271, MF272 and MF365, monitoring of the seabed at representative locations under the marine farm site shall be undertaken at least once prior to 1 January 2025.

Note: It is the Council's intention that the Programme shall monitor at least two marine farm sites per year within the bay from the following marine farm sites LI149, LI315, LI316, LI317, LI318, LI319, LI320, LI321, LI322, LI323, LI324, LI325, LI337, LI338, LI342, LI366, LI418, LI461, LI474, LI475, MF244, MF245, MF246, MF247, MF248, MF273, MF274, MF275 and MF326 so each site is monitored at least once prior to 1 January 2025.

(ii) an exception to Clause 1(a)(i) is if the marine farm site is actively farming salmon at the site, then monitoring of the seabed under the salmon cage as close as possible, and at 50 metres and 100 metres from that salmon cage shall be undertaken annually.

If the marine farm site is fallowed, the monitoring of the seabed shall be undertaken at five years, 10 years and 15 years from the date of the last annual monitoring occurring at the site. If the marine farm site is reactivated to farm salmon then the annual monitoring regime recommences and replaces this fallowing monitoring regime.

(iii) in addition to Clause 1(a)(ii), no longer than one year prior to the marine farm site erecting structures to farm salmon, monitoring of the seabed under where the salmon cages are to be located as close as possible, and at 50 metres and 100 metres from where salmon cage are be located shall be undertaken. The monitoring report shall be furnished to the Council's Director of Environmental Management at least three months prior to the marine farm site erecting structures to farm salmon.

Note: this condition also applies to the site if it had been vacated of structures and stock for the purpose of fallowing the seabed. This condition does not apply to fallowing certain sections of the marine farm site by moving structures around within the same site.

(iv) in addition to Clause 1(a)(i), monitoring of the seabed at two control sites identified in the Programme and approved, in writing, by the Council's Director of Environmental Management. The monitoring shall occur every year for the first three years, then once every three years thereafter.

(b) the samples will be analysed for the following to assess the sediment quality:

- sediment colour, including providing a colour photograph of the sediment sample;
- depth of the oxygenated layer below the sediment surface;
- occurrence of hydrogen sulphide.

- sediment texture and grain size;
- total organic carbon content;
- infaunal and epifauna community composition; and
- zinc and copper trace metal levels pursuant to Clause 1(a)(ii) and (iii) listed above when relates to salmon farming.

2. The consent holder shall monitor the effects of the marine farming activities on the water quality, as follows:

(a) (i) monitoring of the water column shall be undertaken monthly for the first two years, commencing from 1 July 2011, by taking samples at four sites within Big Glory Bay and two control sites inside the bay, at a depth of 5 metres, as identified in the Programme and approved, in writing, by the Council's Director of Environmental Management

(ii) after the first two years outlined in clause 2(a)(i), monitoring of the water column shall be undertaken three times during the period of 1 November to 30 June each year and once during the period of 1 July to 31 October each year at four sites within Big Glory Bay and two control sites inside the bay, at a depth of 5 metres, as identified in the Programme and approved, in writing, by the Council's Director of Environmental Management.

(b) the water quality samples will be analysed for the following:

- water temperature;
- chlorophyll *a*;
- vertical seechi depth; and
- dissolved oxygen.

Appendix B Physical characteristics of benthic sediments

Latitude	Longitude	Site	Grab	Sample	Site depth (m)	%silt/mud	% sand	% particulate organic carbon	aRDP (cm)	Core depth (cm)	O_2 mg/L	Bacteria	Sulphide odour	Nephloid layer
46.97315	168.12403	Site 1	A	Site1-A	25.10	44.42	48.72	0.81	none	10	2.31	No	No	No
46.97213	168.12424	Site 1	B	Site1-B	25.00	38.16	43.66	0.88	3	10	3.75	No	No	No
46.98483	168.11694	Site 2	A	Site2-A	26.90	60.17	30.12	1.83	3	9	4.22	No	No	No
46.98585	168.11669	Site 2	B	Site2-B	26.30	51.45	40.70	1.38	8	13	2.2	No	No	No
46.98444	168.12158	Site 3	A	Site3-A	25.60	56.93	27.50	1.74	5	12	1.95	No	No	No
46.98444	168.1228	Site 3	B	Site3-B	25.40	60.61	28.94	1.29	7	13	2.02	No	No	No
46.58136	168.08017	CM12	A	CM12-A	22.10	55.88	33.39	4.92	none	8	3	No	No	No
46.58136	168.08017	CM12	B	CM12-B	22.10	54.37	35.79	1.98	none	10	3	No	No	No
46.58136	168.08017	CM12	C	CM12-C	22.10	39.35	50.00	1.67	none	12	8	No	No	No
46.58988	168.07063	CH12	A	CH12-A	26.20	54.13	39.45	0.94	none	11	5	No	No	No
46.58988	168.07063	CH12	B	CH12-B	26.20	76.79	17.11	1.14	none	18	6	No	No	No
46.58988	168.07063	CH12	C	CH12-C	26.20	75.46	17.77	1.29	none	16	5	No	No	No
46.58136	168.08017	CM13	A	CM13-A	22.00	53.08	31.31	1.16	none	8	3	No	No	No
46.58136	168.08017	CM13	B	CM13-B	22.00	57.03	31.28	0.86	none	13	8	No	No	No
46.58136	168.08017	CM13	C	CM13-C	22.00	60.21	29.69	1.61	none	10	5	No	No	No
46.58988	168.07063	CH13	A	CH13-A	26.00	83.22	13.58	1.35	indistinct	11	2	No	No	No
46.58988	168.07063	CH13	B	CH13-B	26.00	88.85	9.52	1.11	indistinct	11	2	No	No	No
46.58988	168.07063	CH13	C	CH13-C	26.00	84.17	12.46	1.41	indistinct	10	2	No	No	No

Appendix C Statistical analyses of benthic sediment data

Table C-1: Summary statistics: mean and standard deviations for sediment properties.

Site	%silt/ mud			%sand			%Organic Carbon			O_2 mg/L		
	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
Site 1	41.29	2	4.43	46.19	2	3.58	0.85	2	0.05	3.03	2	1.02
Site 2	55.81	2	6.16	35.41	2	7.48	1.61	2	0.32	3.21	2	1.43
Site 3	58.77	2	2.60	28.22	2	1.01	1.52	2	0.32	1.99	2	0.05
CM12	49.87	3	9.14	39.73	3	8.98	2.86	3	1.79	4.67	3	2.89
CH12	68.79	3	12.72	24.78	3	12.71	1.12	3	0.18	5.33	3	0.58
CM13	56.77	3	3.57	30.76	3	0.93	1.21	3	0.38	5.33	3	2.52
CH13	85.41	3	3.01	11.85	3	2.10	1.29	3	0.16	2.00	3	0.00

Table C-2: One-way ANOVA analysis $p<0.05$: Shows significant differences (red) between sites for all sediment indicators. Homogeneity of variances with unequal N confirmed with Brown-Forsythe Test: $p>0.05$ for all parameters.

	SS Effect	df Effect	MS Effect	SS Error	df Error	MS	F	p
%silt/ mud	3235.906	6	539.3177	598.5162	11	54.411	9.912	0.001
%sand	1944.151	6	324.0252	564.7153	11	51.338	6.312	0.004
%Organic Carbon	7.205	6	1.2008	7.0361	11	0.640	1.877	0.173
O_2 mg/L	34.550	6	5.7584	33.0795	11	3.007	1.915	0.166

Table C-3: Ad hoc paired tests Tukey HDS for sediment %silt/mud and %sand. Marked differences (red) are significant at $p<0.05$.

Tukey ad hoc test	%silt/mud			% sand		
	{1}	{2}	{3}	{1}	{2}	{3}
Site 1 {1}		0.48	0.29		0.74	0.24
Site 2 {2}	0.48		1.00	0.74		0.94
Site 3 {3}	0.29	1.00		0.24	0.94	
CM12 {4}	0.85	0.97	0.83	0.95	0.99	0.60
CH12 {5}	0.02	0.50	0.75	0.08	0.67	1.00
CM13 {6}	0.32	1.00	1.00	0.30	0.99	1.00
CH13 {7}	0.00	0.01	0.03	0.00	0.05	0.25

Appendix D Sediment core profiles

Site 1-1 grab and cores

Site 1-2 grab and cores

Figure D-1: Site 1-1 & 1-2, grab and cores.

Site 2-1 grab and cores

Site 2-2 grab and cores

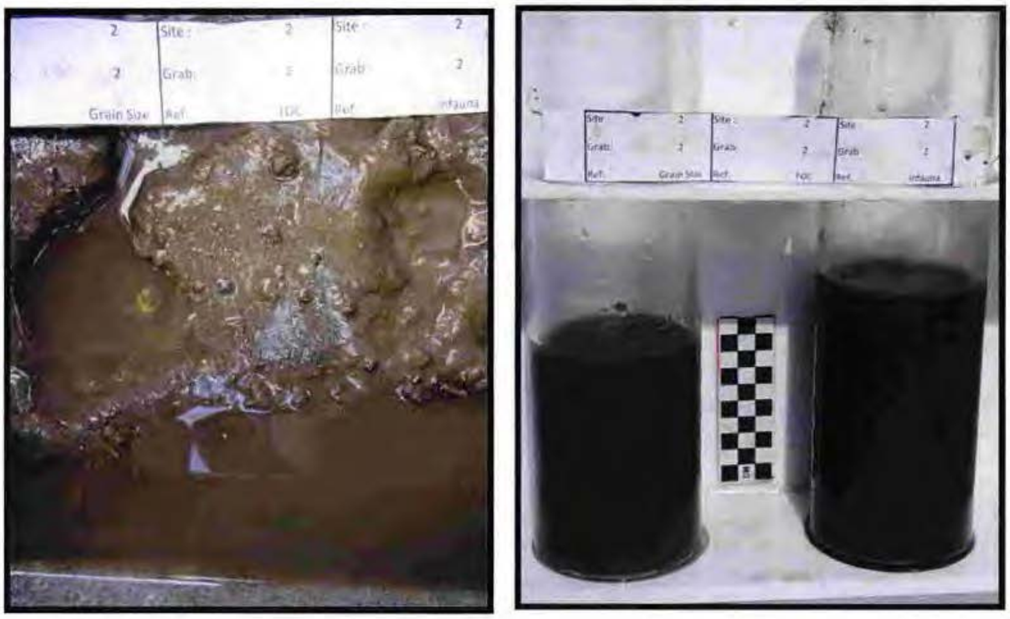

Figure D-2: Site 2-1 & 2-2, grab and cores.

Site 3-1 grab and cores

Site 3-2 grab and cores

Figure D-3: Site 3-1 & 3-2, grab and cores.

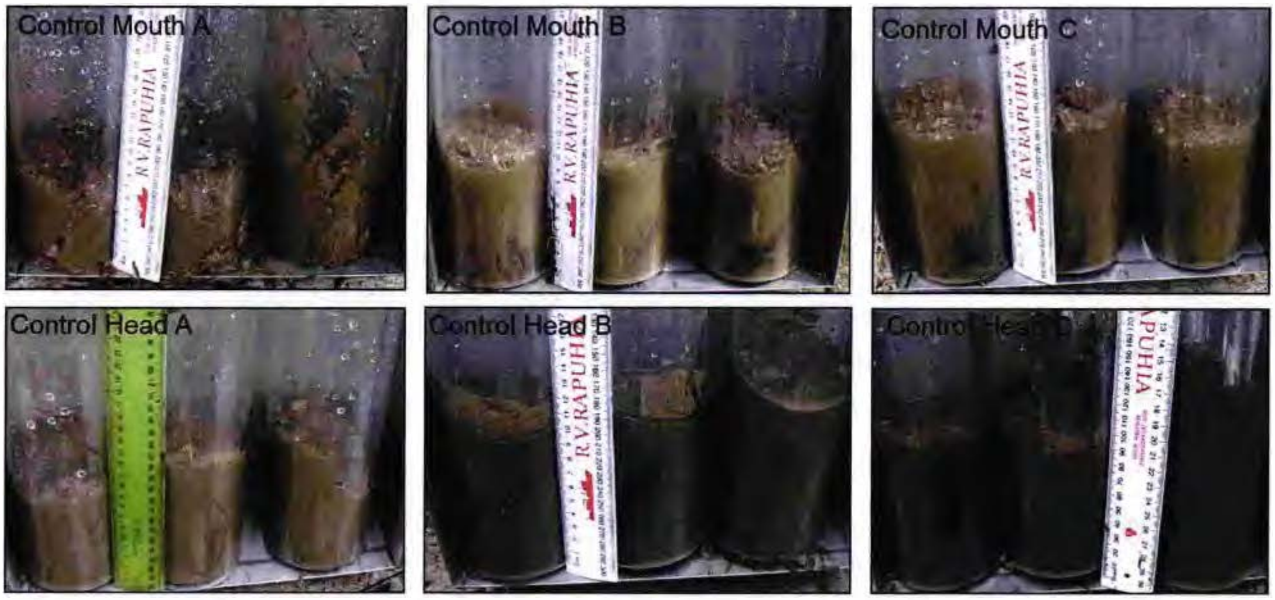

Figure D-4: Sediment core profiles for control sites CM12 and CH12. (Stenton-Dozey et al. 2012).

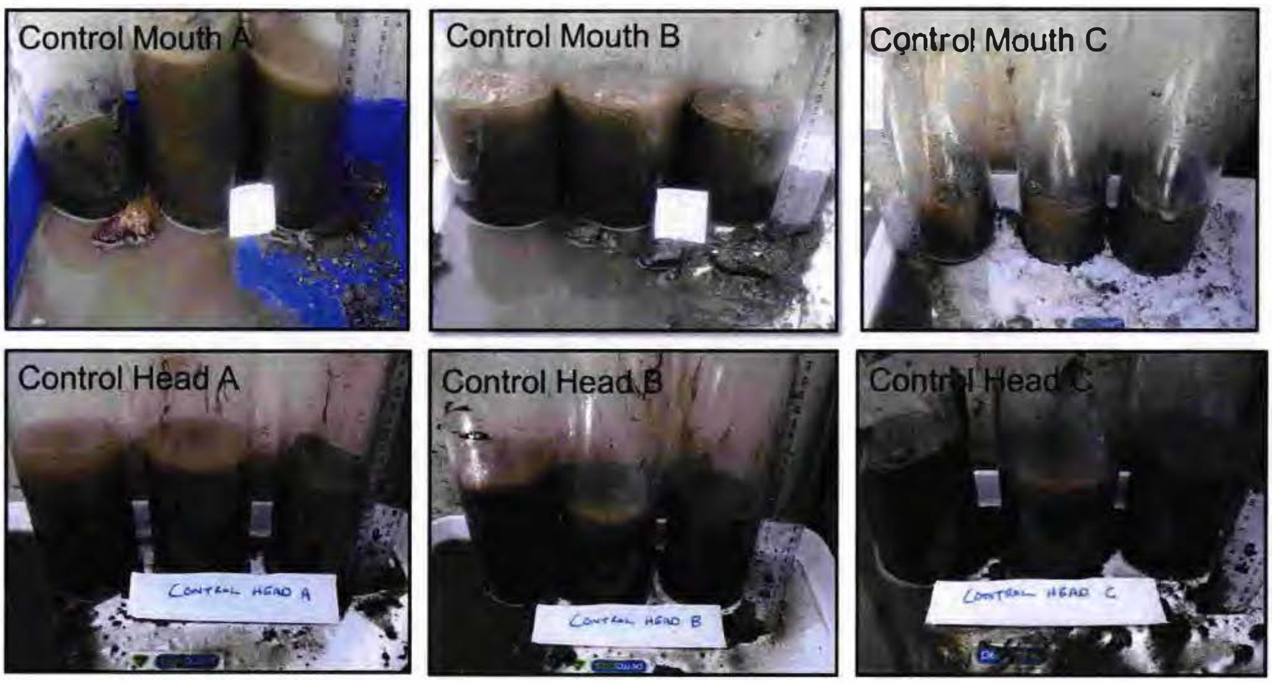

Figure D-5: Sediment core profiles for control sites CM13 and CH13. (Stenton-Dozey and Cairney 2013).

Appendix E Drop-camera photos of sediment surface

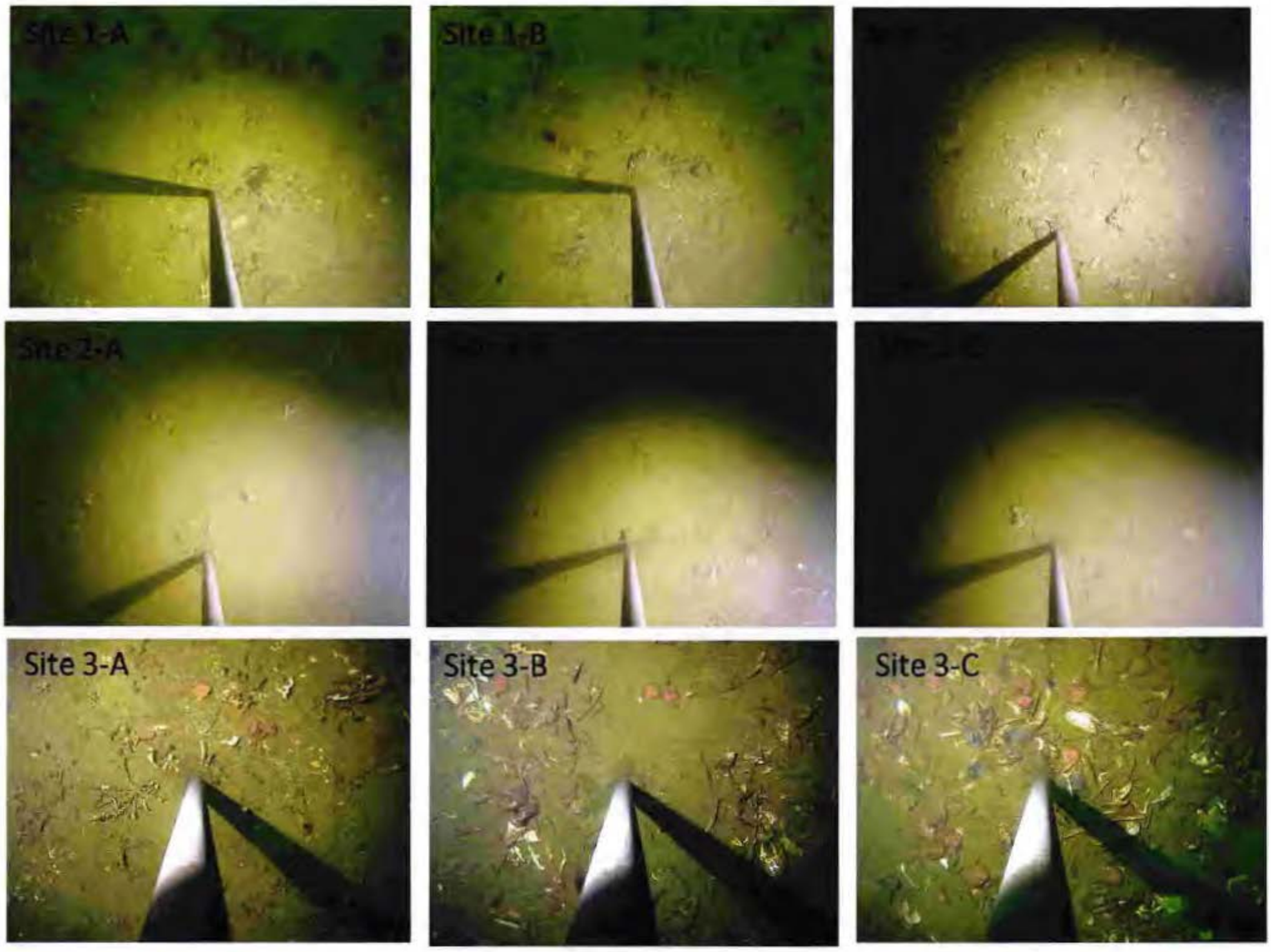

Figure E-1: Drop-camera photos in triplicate (A-C) of the sediment surface at the three proposed sites.

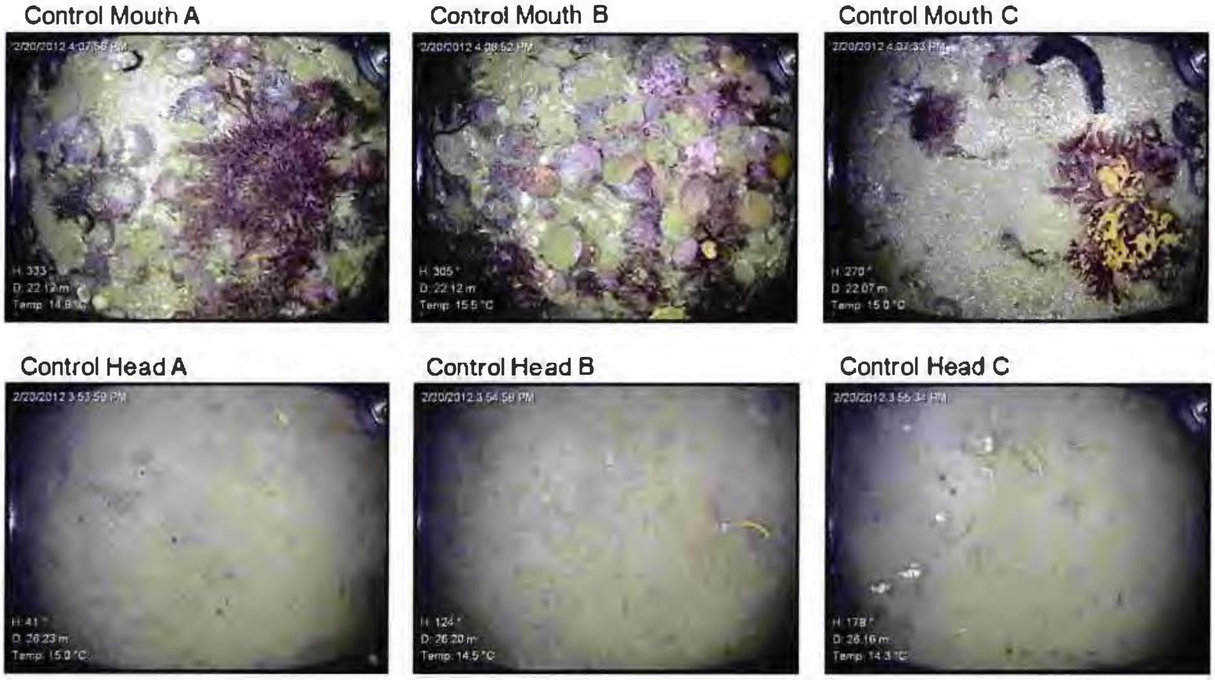

Figure E-2: Drop-camera photos in triplicate (A-C) of the sediment surface at control sites CM12 and CH12. (Stenton-Dozey et al. 2012).

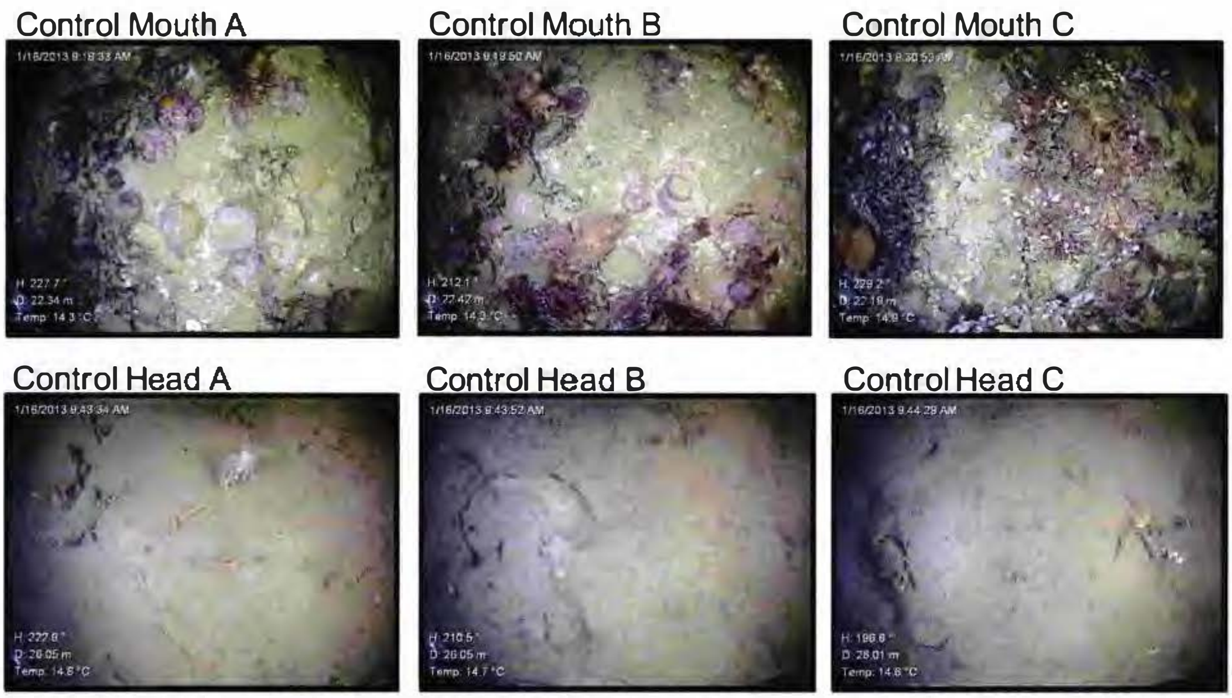

Figure E-3: Drop-camera photos in triplicate (A-C) of the sediment surface at control sites CM13 and CH13. (Stenton-Dozey and Cairney 2013).