Suelen Properties Ltd

Horseshoe Bay and Surrounds, Stewart Island

Oyster Farm Consent Compliance Monitoring 2016

prepared by

Ryder Consulting

December 2016

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Brian Stewart PhD

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Ryder Consulting Ltd.
PO Box 1023
Dunedin
New Zealand
Ph: 03 477 2113

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1. Introduction

Suelen Properties Ltd hold a permit to occupy the coastal marine area with a marine farm at three sites at Nathan's Island, Nugget Point and Horseshoe Bay, Stewart Island, for the purpose of farming Bluff oysters. The areas allowed to be occupied comprise approximately 3.35 h, 0.73 ha and 1.82 ha, totalling 5.9 hectares (Figure 1.1).

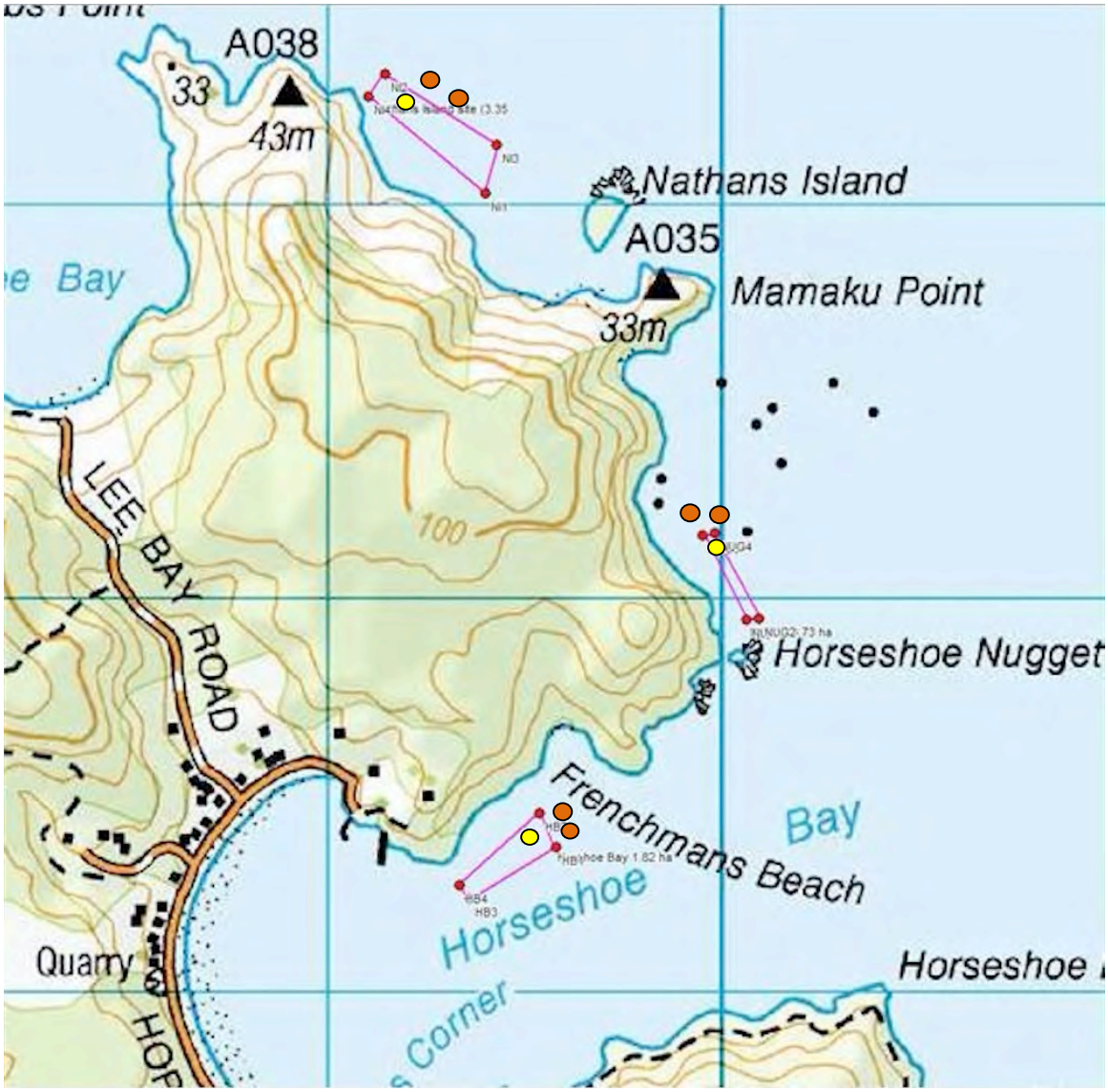

Figure 1.1 *Marine farms (red polygons) surveyed around Horseshoe Bay, Stewart Island, showing approximate locations of survey sites (yellow dots) and control sites (orange dots).*

Condition 1 of the permit states that the consent holder must undertake environmental monitoring. The relevant condition requires that:

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

(a) (i) monitoring of the seabed at representative locations under the marine farm sites shall be undertaken twice in the first year of activity and thereafter annually for the duration of the consent. The monitoring locations shall be approved, in writing, by the Council's Compliance Manager.

(ii) in addition to Clause 1(a)(i), monitoring of the seabed in the wider area associated with the marine farms, at two control sites approved, in writing, by the Council's Compliance manager. The monitoring shall occur twice each year for the first three years, then once every year 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; and*
- *infaunal and epifaunal community composition.*

Monitoring shall include photographic evidence.

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

(a) (i) monitoring the water column shall be undertaken three times during the period 1 November to 30 June each year and once during the period of 1 July to 31 October each year for the first two years after commencement of this consent, by taking a sample at each marine farm site and two control sites outside the marine farm sites, at a depth of 5 metres.

(ii) after the first two years outlined in Clause 2(a)(i), monitoring of the water column shall be undertaken once during the period of 1 November to 30 June each year and once in the period of 1 July to 31 October each year, by taking a sample at each marine farm site and two control sites outside the marine farm sites at a depth of 5 metres.

(iii) the location of the sample sites in Clause 2(a)(i) and 2(a)(ii) above shall be approved in writing, by the Council's Compliance Manager.

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

- *water temperature;*
- *chlorophyll a;*
- *vertical secchi disc depth; and*
- *dissolved oxygen*

Paul Stirling, on behalf of Suelen Properties Ltd, has engaged Ryder Consulting Limited to undertake the 2016 survey.

2. Methods

The seabed beneath each marine farm was photographed by OSH certified divers using SCUBA. A 1.0 m^2 quadrat was photographed under each farm, and at each of the control sites (Figure 1.1). Fauna (species and abundance) within quadrats were assessed by Dr Brian Stewart upon return to Dunedin. Dr Stewart is a marine scientist with 25 years experience in monitoring marine environments in Otago, Southland and around the wider New Zealand coastline.

To assess infauna, depth of redox discontinuity layer (RDL) and presence/absence of H_2S, three cores were taken to a depth of 180 mm using an 87 mm diameter, clear plastic corer. Material obtained was photographed within the corer and the sample was then sieved through a 500 µm mesh sieve. Note was taken of the texture of the sample and whether or not the smell of H_2S was present. Infaunal organisms retained in the sieve were preserved in 70% alcohol and returned to the laboratory for identification and enumeration.

A further two containers (1 x 250 ml and 1 x 500 ml) were filled with surficial sediment (50mm depth) at each site, with the first being retained by Ryder Consulting for particle size analysis and the other being forwarded to Hill Laboratories in Christchurch for analysis of total organic carbon (TOC) content.

Water quality parameters were assessed on site using a YSI field meter equipped with a probe designed to measure temperature and dissolved oxygen. A secchi disc was deployed over the side of the boat at each site to determine secchi depth. Lastly, a 1 litre water sample was collected at each site to be sent to Hill Laboratories for chlorophyll *a* analysis.

3. Results

Sampling was undertaken on the morning of 5th December 2016 at mid-ebb tide. GPS co-ordinates for each site are presented in Table 3.3 and photo quadrats are presented in Appendix 1. The day was fine and sunny with a light north-easterly breeze and negligible chop. Water depth was approximately 10 m in Horseshoe Bay and 11 – 12 m at the Nugget Point and Nathans Island sites, with visibility of around 12 – 15 m.

3.1 Photo quadrats

Photographs of all quadrats are presented in Appendix 1. Photos showed generally clean sand with a diatom film present in all quadrats within Horseshoe Bay and at Nugget Point. Nathan Island quadrats showed clean sand with occasional small tufts of red algae.

Epifauna were sparse, with just a single cushion star (*Patiriella regularis*) visible in the quadrat from Horseshoe Bay C1, three snake stars (*Ophiopsammus maculata*) visible in the quadrat at the Nathan Island C1 quadrat, and a single unidentified solitary ascidian in the quadrat at Nathan Island C2. Also visible in the Nathan Island C2 quadrat was a snail egg mass, possibly from a vitreous moon snail. There was evidence of considerable infaunal activity, with numerous polychaete and amphipod burrows visible in all quadrats.

3.2 Infauna

A moderately diverse and abundant infauna was present at all sites (Table 3.2).

Table 3.2 *Invertebrate fauna from cores taken at three sites around Horseshoe Bay, Stewart Island. Hb = Horseshoe Bay; NP = Nugget Point; NI = Nathan Island; C = Control.*

Phylum		Family	Genus/species	HB	HB-C1	HB-C2	NP	NP-C1	NP-C2	NI	NI-C1	NI-C2
Annelida	Polychaeta	Capitellidae		1	4	3	2	1	2		1	3
		Glyceridae			1							
		Nephtyidae					1		2		2	
		Nereididae						1	2	1	1	1
		Orbiniidae					1					
		Maldanidae							1			1
		Spionidae			2	3						2
Nemertea						1	1					
Hemichordata	Enteropneusta			2								
Crustacea		Callianassidae	*Callianassa filholi*						1		1	
	Amphipoda	Haustoriidae			2	6	2	3	4			3
		Lysianassidae						1				
		Phoxocephalidae		1	2		4	1		1	2	1
	Tanaidacea							1				
Mollusca	Gastropoda	Trochidae	*Zethalia zelandica*					2		3		2
		Turritellidae	*Zeacolpus symmetricus*	1								
	Bivalvia	Veneridae	*Tawera spissa*		2	2						
			Dosina zealandica	2	3	1	1					
		Mactridae	*Mactra discors*	3	5	4						
Brachiopoda			*Notosaria nigricans*					1				
			Calloria inconspicua				2		1			
			Number of animals	10	21	20	14	11	13	5	7	13
			Number per m2	1682	3532	3364	2355	1850	2187	841	1177	2187
			Numer of Taxa	6	8	7	8	8	7	3	5	7
			Diversity index	0.74	0.86	0.77	0.85	0.86	0.79	0.41	0.67	0.8

Most abundant at all sites were polychaetes and amphipods, with molluscs more common at the Horseshoe Bay sites than at the outer sites (Table 3.2). Density of animals ranged from 841 m^{-2} at the Nathan Island farm site to 3532 m^{-2} at the Horseshoe bay C1 site. Diversity ranged from just three taxa at the Nathan Island farm site to 8 taxa at the Horseshoe Bay C1 site and at the Nugget Point farm and C1 sites.

Diversity index is a measure of diversity that takes into account the number of species present, as well as the relative abundance of each species (Table 3.2). When diversity indices (H') for farm sites are compared with control sites using ANOVA we find there is no significant difference ($F_{1,5} = 1.350$, $p = 0.298$).

3.3 Physico-Chemical Parameters

Photographs of all cores are presented in Appendix 2. A redox discontinuity layer is visible in the Horseshoe Bay samples, but cannot be described as well-defined. No RDL was visible in cores from Nugget Point or Nathan Island. Depth of RDL is given for each core in Table 3.3.1. Hydrogen sulphide, detectable as the smell of rotten eggs, was mildly present in the cores from Horseshoe Bay, but was not detectable in the cores from the outer sites (Table 3.3.1).

Visibility was very good, with the divers and Secchi disc clearly visible on the bottom at all sites. Consequently, Secchi depth was in excess of the depth of the water column in all cases.

Total organic carbon (TOC) in sediment samples collected at each site was low and there was no significant difference in TOC concentration when farm sites and control sites were compared using ANOVA ($F1,5 = 2.419$, $p = 0.195$). For Chlorophyll *a* levels were also very low and, once again, there was no significant difference among farm and control sites ($F1,6 = 0.275$, $p = 0.623$) (Table 3.3.1).

Table 3.3.1 *GPS co-ordinates and physico-chemical parameters at each site. HB = Horseshoe Bay; NP = Nugget Point; NI = Nathan Island; C = Control; TOC = total organic carbon.*

Site	Easting	Northing	Temperature (˚C)	Dissolved Oxygen (%)	H_2S	Depth of RDL	Secchi Depth (m)	TOC (g/100g)	Chlorophyll *a* (g/m^3)
HB	1229541	4797377	12.7	109.1	Slight	40 mm - >170 mm, more diffuse with depth	>10	0.15	0.0006
HBC1	1229579	4797396	12.7	107	Slight	Diffuse from surface to >170 mm	>10	0.16	0.0006
HBC2	1229583	4797392	12.7	106.6	Slight	Diffuse from 90 mm to >180 mm	>10	0.15	0.0007
NP	1229974	4798161	12.8	104.5	No	None	>11	<0.13	0.0004
NPC1	123000	4798191	12.6	104.6	No	None	>11	0.12	0.0004
NPC2	1229948	4798213	12.6	104.9	No	None	>11	<0.13	0.0005
NI	1229284	4799240	12.7	101.4	No	None	>11	<0.13	0.0005
NIC1	1229371	4799250	12.7	104.6	No	None	>11	0.12	0.0005
NIC2	1229365	4799270	12.7	104.9	No	None	>11	0.12	0.0004

Sediment texture was free flowing sand at all sites, with a very slightly siltier texture evident in the Horseshoe Bay samples. This is borne out by the grain size analysis for each core, with Horseshoe Bay sample having a slightly higher percentage of grains <125μm in diameter (Table 3.3.2, Figure 3.3).

Table 3.3.2 *Percentage composition for cores collected at farm and control sites around Horseshoe bay, Stewart Island.*

	Percentage Composition					
Site	<63µm	>63µm	>125µm	>250µm	>500µm	>2mm
HB	0.46	2.02	17.24	74.56	5.47	0.25
HBC1	0.28	1.66	12.05	81.67	4.13	0.22
HBC2	0.31	1.85	11.32	81.78	4.55	0.19
NP	0.09	0.90	7.56	85.58	5.66	0.21
NPC1	0.11	0.92	5.65	88.32	4.60	0.39
NPC2	0.13	0.70	9.42	55.97	33.17	0.62
NI	0.10	0.94	10.39	76.19	8.81	3.58
NIC1	0.05	0.39	3.07	94.82	1.60	0.05
NIC2	0.06	0.42	2.86	94.09	2.28	0.29

Overall, when sediment composition was tested using ANOVA there was no significant difference between impact (farm) sites and control sites ($F_{2,48} = 0.003$, $p = 0.996$).

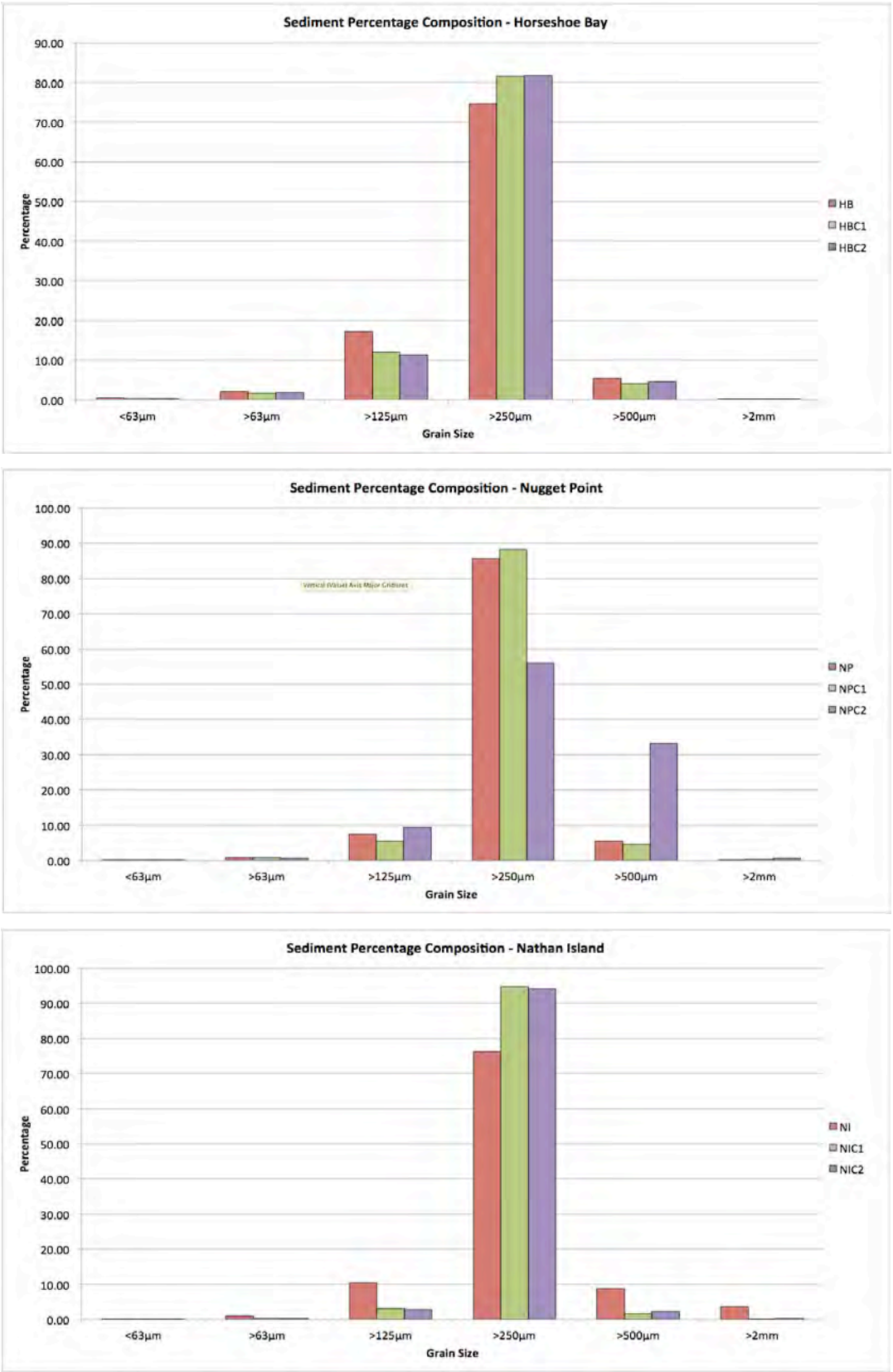

Figure 3.3 *Grain sizes for cores at (top) Horseshoe Bay, (middle) Nugget Point, and (bottom) Nathan Island.*

4. Discussion

Although few epifaunal organisms were observed, those that were present reflect the fauna found in sheltered harbours in Southern New Zealand (Morton and Miller 1973, Cook 2010) and show no obvious adverse effects that may be attributable to the marine farm being examined.

Likewise the infaunal communities are also typical of the communities found in enclosed harbours and estuaries around southern New Zealand (Morton and Miller 1973; Cook 2010; Stewart 2009, 2016) and show no significant difference when diversity indices at farm and control sites were compared.

Very slightly anoxic conditions exist in sediments beneath the marine farm, but similar conditions also exist at the control site. Such conditions are not unusual within sheltered harbours and estuaries in New Zealand (Stewart 2009). Outer sites (i.e. beyond Horseshoe Bay) show no anoxia at either farm or control sites.

ANZECC (2000) does not specify environmental limits for TOC in marine sediments. However, research by Hyland *et al.* (2005) suggested that risks of reduced species richness from organic loading and other associated stressors in marine sediments should be relatively low at TOC concentrations of less than 10 g/100g. Given that the range of TOC concentration encountered under the farms surveyed is <1.3 – 1.5 g/100 g and the range at the control site is <1.3 – 1.6 g/100g it appears that the marine farm is having no adverse effect with respect to enrichment. There are no guidelines for chlorophyll *a* concentrations, but levels in seawater at all farm and control sites are extremely low and show no significant difference.

Sediment texture also appears to be unaffected. Although sediments under the farm are very slightly siltier within Horseshoe Bay than at the outer sites, the difference is not statistically significant when farm sites are compared with control sites.

Overall, it would appear that the marine farms at Horseshoe Bay, Nugget Point and Nathan Island, Stewart Island, are having no discernible adverse effect on the benthic community beneath them, nor on underlying sediments.

5. References

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Hyland, J., Balthis, L., Karakassis, I., Magni, P., Petrov, A., Shone, J., Vestergaard, O. and Warwick, R. (2005). Organic carbon content of sediments as an indicator of stress in marine benthos. Marine Ecology Progress Series 295: 91-103.

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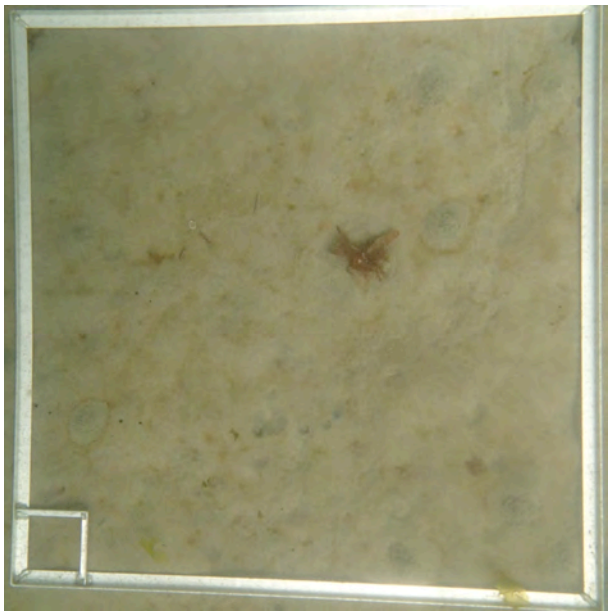
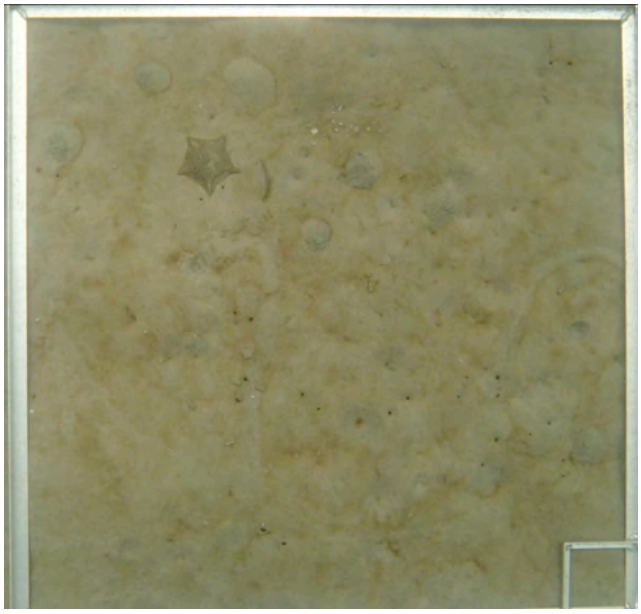
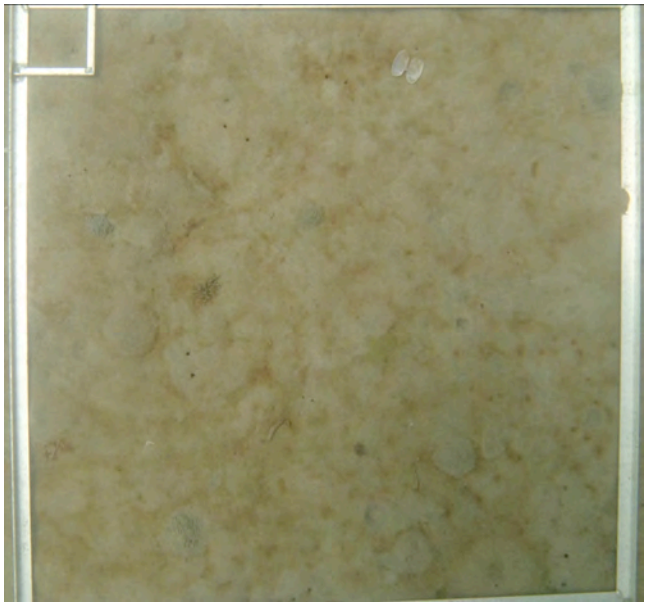
Appendix 1 Photo Quadrats



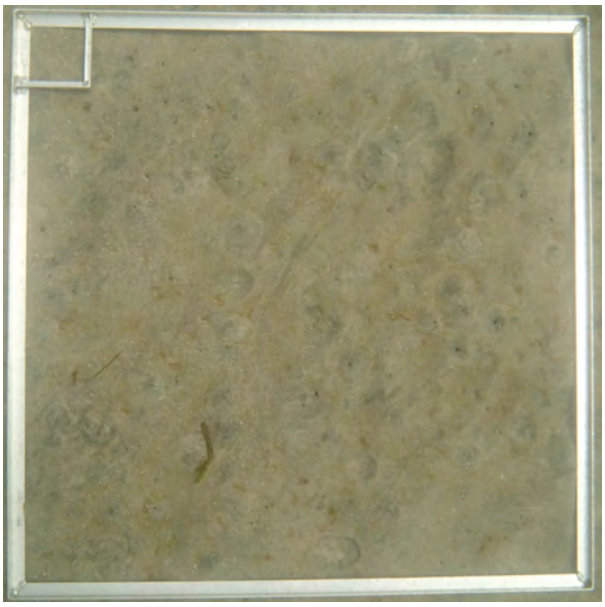
Horseshoe Bay (HB) farm



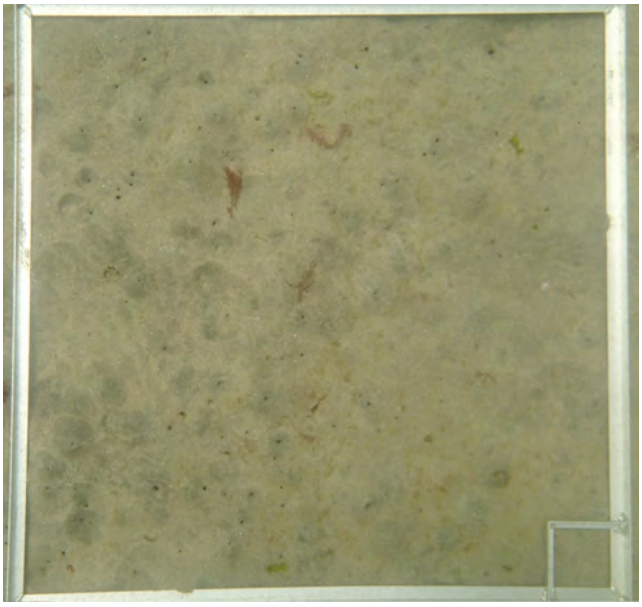
HB Control 1



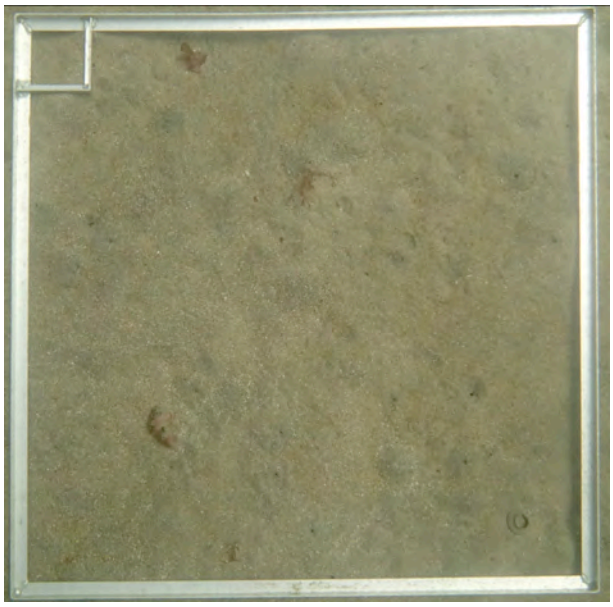
HB Control 2



Nugget Point (NP) farm



NP Control 1



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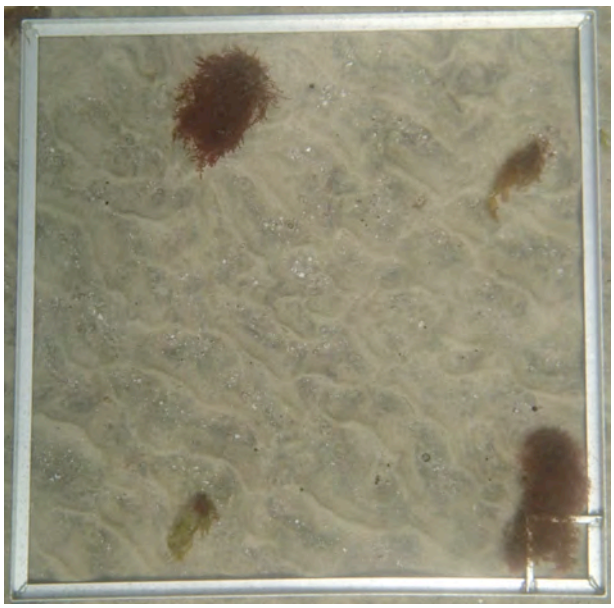
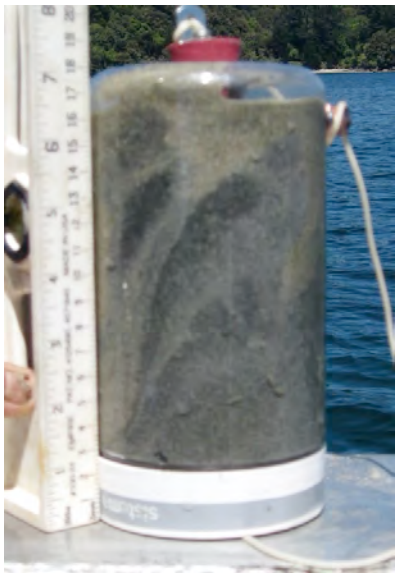


Nathan Island (NI) farm

NI Control 1

NI Control 2

Appendix 2 Cores



Horseshoe Bay (HB) farm

HB Control 1

HB Control 2

Nugget Point (NP) farm

NP Control 1

NP Control 2

Nathan Island (NI) farm

NI Control 1

NI Control 2