NIWA
Taihoro Nukurangi

Ecological assessment of marine farms Pe30 and Pe31 for resource consent renewal, Wainui, Golden Bay.

NIWA Client Report: NEL2007-18
September 2007

NIWA Project: WAI07401

NIWA
Taihoro Nukurangi

Ecological assessment of marine farms Pe30 and Pe31 for resource consent renewal, Wainui, Golden Bay.

Authors
Ken Grange
Mark Hadfield

Prepared for

Waitapu Fishing Co

NIWA Client Report: NEL2007-18
September 2007

NIWA Project: WAI07401

National Institute of Water & Atmospheric Research Ltd
217 Akersten St, Port Nelson
P O Box 893, Nelson, New Zealand
Phone +64-3-548 1715, Fax +64-3-548 1716
www.niwa.co.nz

© All rights reserved. This publication may not be reproduced or copied in any form without the permission of the client. Such permission is to be given only in accordance with the terms of the client's contract with NIWA. This copyright extends to all forms of copying and any storage of material in any kind of information retrieval system.

Contents

Reviewed by:

Approved for release by:

Formatting checked

Executive Summary

1. The two seaward mussel spat farms (Pe30 and Pe31) of the block of 6 at Wainui Bay, Golden Bay have been operational for over 10 years, and are due for resource consent renewal.

2. Analysis of tidal currents measured over a neap/spring cycle has provided good validation of a hydrodynamic model used to predict the amount of water filtered by mussels in the farms, and to calculate potential phytoplankton depletion and benthic deposition.

3. Only 10-12% of the water flowing through the farms is filtered by the mussels, with consequent minimal phytoplankton depletion. Any depletion more than 200 m from the farms is unlikely to be measurable.

4. Benthic deposition of faecal material is low and almost entirely restricted to within the consent boundaries. Shell debris occurs only directly beneath the dropper lines.

5. Benthic sampling has shown a small increase in organic material beneath the farms, and some alteration to infaunal species composition, but there continues to be a healthy and diverse fauna beneath the farms.

6. It is not expected that continuation of the operation of the farms will lead to any further effects.

1. Introduction

Marine farms Pe30 and Pe31, each of 3 ha, are located at the seaward end of the block of 6 spat catching sites in Wainui Bay, Golden Bay (Figure 1). Each farm is over 600 m from shore, and they were developed for spat catching over 10 years ago. NIWA has been commissioned to provide an assessment of the existing activity on marine ecological matters as part of an application for resource consent renewal.

Figure 1. Approximate outlines of the 6 spat catching sites at Wainui, Golden Bay. Pe30 and Pe31 are the 2 seaward (north-eastern) farms.

The Tasman District Council (TDC) Discretionary Rule 25.1.5FF outlines the general considerations for resource consent at Wainui Bay, and Discretionary Rule 26.2.2 provides the information that must be submitted for coastal permits. After consultation with TDC, the following parameters are addressed in this report:

(a) A description of the hydrodynamic and hydrographic properties of the site and in its vicinity.

(b) An assessment of the amount of water filtered by the mussels on the lines within the two farms and hence the potential for phytoplankton depletion.

(c) A description of benthic habitat characteristics, including sediment grain size, epifauna and infauna.

(e) A description of effects of the activity on phytoplankton depletion, deposition of material to the seabed, and effects on habitats and species.

Little or no information has been found on the site characteristics that existed before development over 10 years ago, so the effects of the development have been assessed by comparisons with sites distant from the farms, i.e. beyond the potential ecological effects footprint.

At present the farms are used for spat catching, and the assessment of existing effects is based, necessarily, on spat catching. The assessment of phytoplankton depletion and benthic deposition in this report are, however, based on a mussel farm in full production. This allows a "worse case scenario" assessment should the sites be used in the future for spat holding or mussel farming.

A considerable knowledge base has been developed on the actual and potential effects of mussel farm development over the past few years, principally based on Fisheries Resource Impact Assessments (FRIA) and resource consent surveys throughout New Zealand, e.g. Golden/Tasman Bays (Morrisey et al. 2006), Marlborough Sounds (Stenton-Dozey et al. 2006), Canterbury (Fenwick et al. 2003), and Wilsons Bay, Firth of Thames (Gall et al. 2003).

2. Methods

2.1 Hydrodynamics

Hydrodynamics (water physics) play a key role in the interaction between a mussel farm and the local and wider aquatic environment. Since mussels feed on suspended particulates, the rate of delivery plays a significant role in mussel growth as does the rate of export in the dispersion of faeces, pseudofaeces, and shell drop.

NIWA has developed hydrodynamic models that use net current velocity and direction, flushing time through the farm and mussel filtration to plot depletion footprints. By combining current velocity and direction with water depth and the settling rates of faeces/pseudofaeces it has been possible to predict the footprint of farms in terms of water filtration and benthic deposition. Summaries of these models are found in Morrisey et al. (2006) and in a large number of FRIA reports, e.g. Stenton-Dozey et al. (2007).

An acoustic Doppler current profiler (ADP) was moored at the site over a neap/spring tide from 25 July – 2 August 2007. The data obtained from that instrument was used to validate the output from a ROMS (Regional Oceanographic Model System) model of tidal currents in the area surrounding Wainui Bay. The boundaries of the model were set at 172.834° E and 173.141° E longitude, and 40.860° S and 40.670° S latitude, with 150 m grid spacing. Tidal heights and currents for the main (M2) tidal component were specified using output from the NIWA EEZ tidal model, as used in FRIA investigations in Admiralty Bay, Pelorus Sound, Port Underwood, Port Levy, and Golden Bay. Bathymetry data were based on LINZ Chart NZ61, with close attention to chart datum heights relative to mean water level. The modelled tidal currents in the form of tidal ellipses are compared with measured outputs from the ADP are presented in Fig 2.

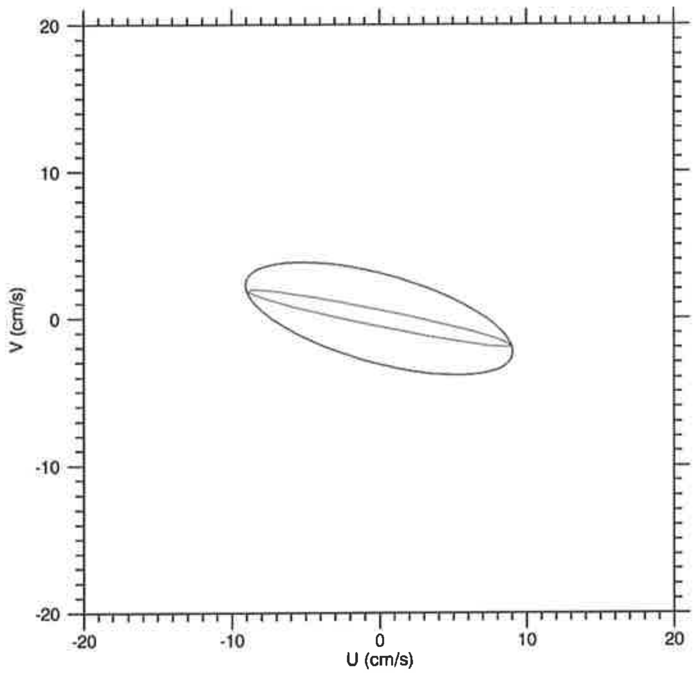

Figure 2. **Validation of tidal model by comparing measured tidal ellipse (blue) with modelled (red).**

The major axis of the tidal ellipse is aligned along 100°-280° in both cases. The model matches the measurements in the magnitude of the currents along this axis, but underestimates the magnitude of currents perpendicular to this axis, i.e. its ellipse is not "round" enough. This degree of agreement is reasonable given that the ADP was placed quite close to a headland, which will affect the shape of the tidal ellipses (see section 3.1 below).

2.2 Depletion and deposition

Phytoplankton and faecal/pseudofaecal deposition were both estimated using Lagrangian particles, or virtual parcels or floats, released from the position of the farm. These floats will move with the modelled currents, but each is also given a random displacement at each step, equivalent to a diffusion process to allow for mixing. These float trajectories are essentially the same for both the depletion and deposition calculations, except in the model fewer particles are released for the depletion calculation and they are tracked (the model is run) for longer, because the depletion process involves time scales of several days, whereas deposition involves time scales of a few minutes at most.

Phytoplankton depletion is estimated by how much of the water passing through the farms is filtered by the growing spat or mussels, or in the model, how many of the floats have been processed, i.e. had their phytoplankton depleted by the mussels. For these calculations we have assumed a dropper density of 0.06 dropper per metre (600 droppers per hectare), the dropper length is 10 m, the filtration rate per unit length of mussel rope per unit time is 14.35 m^2 day^{-1} (or 0.598 m^2 hr^{-1}), and time scale for processed water to be replenished is 3 days.

Benthic deposition is calculated from how far and in what direction the particles will extend from the farm before reaching the sea floor. For these calculations we have used the same dropper densities and lengths as above, with the deposition rate of the mussels (mass of detritus produced per unit length of mussel rope per unit time) being 0.967 kg day^{-1}, and the sinking speed of the detritus as 0.05 m s^{-1}.

2.3 Benthic habitats

An assessment of the benthic effects from the existing spat catching farms was made using three methods. The first used high-resolution side-scan sonar to delimit the spatial extent of mussel shells and debris beneath and around the farms. The second used grab sampling to quantify the benthic species and sediments present within and beyond the farm boundaries, and the third used remote video to provide a qualitative assessment of the species living on the surface of the sediment.

2.3.1 Side-scan sonar

Side-scan sonar swaths, each 60 m wide (30 m either side of the vessel) were made using a high-frequency (675 kHz) Tritech towfish. A total of 5 swaths was completed, covering the entire area of both farms. The position of the side-scan sonar was automatically recorded every 2 seconds along each swath from a GPS and saved in real time to a laptop on board the vessel using SeaNet Pro software and post-processed with Triton Isis software to produce geo-referenced images that could be opened in ArcMap v9 GIS or Google Earth, where locations of features of interest could be determined.

2.3.2 Benthic infauna and sediments

Benthic samples were taken using a van Veen grab (bite area ca 0.13 m^2, maximum bite depth 22 cm) at 14 locations – 4 within the boundaries of each of the 2 farms, and 6 outside (Fig 3). From each grab sample 2 cores were removed using a clear perspex tube and the depth to the redox discontinuity (black) layer measured before one sample was placed in a sealed container for subsequent grain-size analysis and the other for organic content analysis. The remainder of the grab sample was washed through a 0.5 mm sieve and all material retained was preserved in 70% isopropyl alcohol and sorted to the lowest practical taxonomic level in the laboratory.

Grain-size distribution was determined by oven drying the sediment sample at 100°C overnight, weighing and washing through staked 200 µm and 63 µm sieves, and the fraction retained on each sieve dried and weighed, with the weight of material passing through the 63 µm sieve obtained by subtraction from the original weight. Dry weights for each fraction were expressed as percentages of the total dry weight, and expressed as % gravel, sand and mud.

The amount of organic material in the sediments was determined by freeze-drying each sample, grinding, combusting in a furnace at 500°C for 4 hours, and reweighing. The weight of organic matter was determined by subtracting the combusted weight from the original (freeze-dried) weight and expressing the results as a percentage.

Multivariate statistical analysis (non-parametric multidimensional scaling, or nMDS) (Clarke 1993) of benthic infaunal data was used to identify any differences between faunal assemblages living within the existing farms and nearby areas outside the farms.

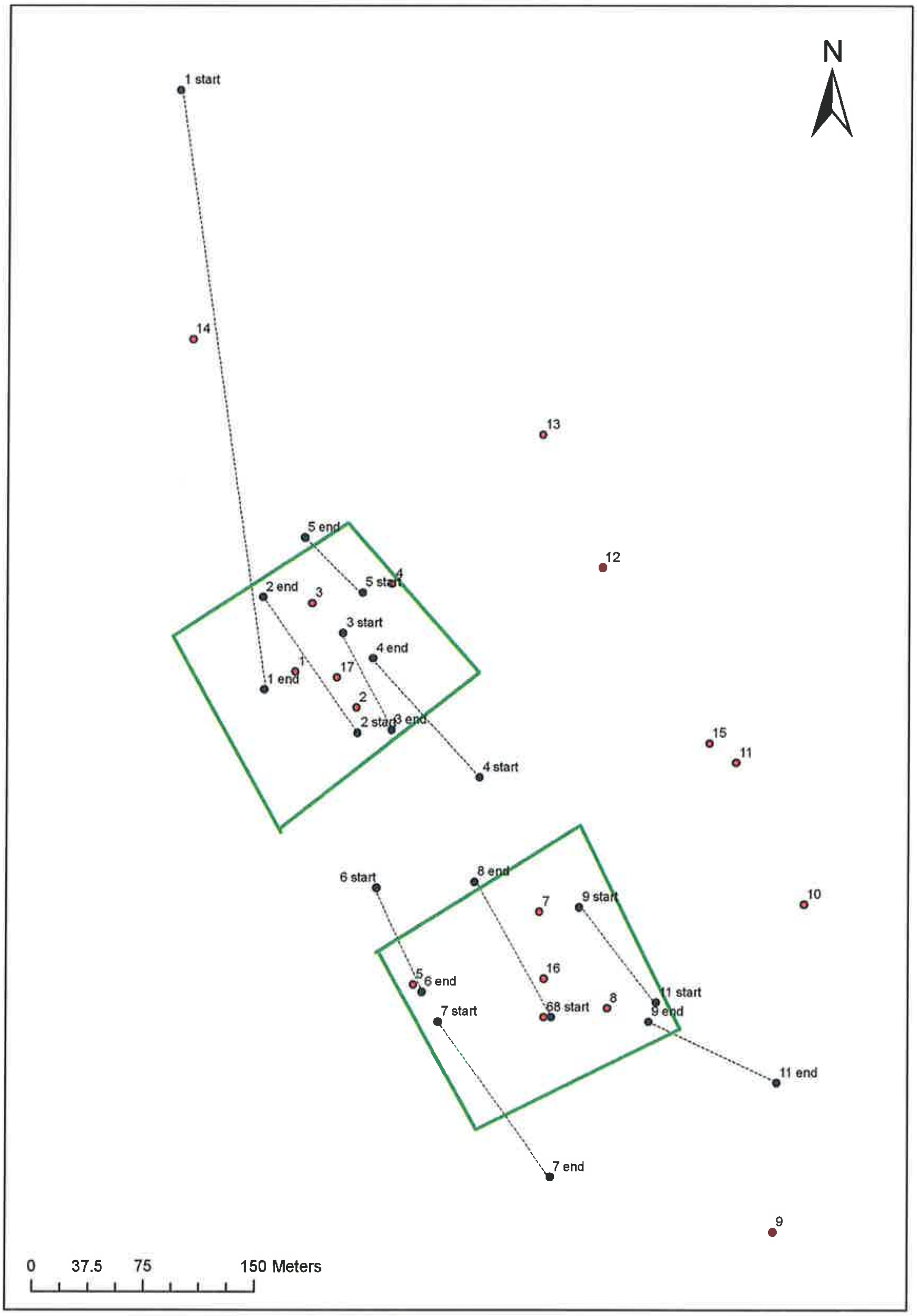

Figure 3. **Position of all benthic grab samples and video tows. Grabs are in red and the dashed lines represent the start and end points of the video tows.**

2.3.3 Video

Benthic video tows were used to record epifauna both within and beyond the farm boundaries. Each tow was recorded to DVD directly from a small remote-operated vehicle (ROV) mounted to a sled that was dragged at constant speed along the seabed. In total, 10 video tows, each approximately 50 m in length (except tow 1 which was ~375 m) were completed; 5 within the boundaries of each farm, with 3 of each extending beyond the area of the longlines. The positions of the start and finish of each ROV transect was recorded on GPS, and shown in Figure 3.

3. Results

3.1 Hydrodynamics

Analysis of the tidal currents at 5 m depth showed the strength of the currents along the dominant direction increasing from 5.7 $cm.s^{-1}$ at neap tide to 12.8 $cm.s^{-1}$ at spring tide, with the average over the period of 9.5 $cm.s^{-1}$. The residual current was directed westward at 3.1 $cm.s^{-1}$. These currents are moderate to high compared with many existing mussel farming areas in the Marlborough Sounds, and elsewhere in Golden Bay.

The modelled tidal currents in the form of tidal ellipses are shown in Fig 4. Current direction tends to be generally aligned parallel to the coast, and speeds increase near headlands, as expected. At the locality of the two farms in this report, the tidal currents are influenced by the adjacent headland, and tend to be stronger than further in Wainui Bay, where other spat farms are located.

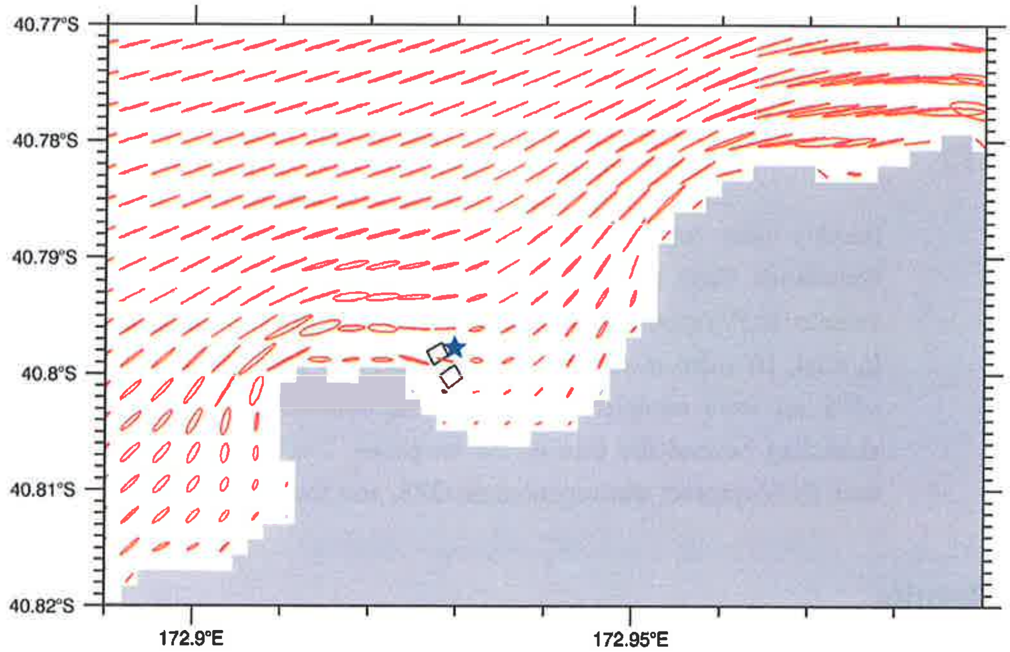

Figure 4. **Modelled tidal ellipses in southern Golden Bay. The position of the spat farms Pe30 and Pe31 are outlined, and the position of the ADP current metre is shown in blue.**

3.2 Depletion

Maximum percentage of water processed by the stocked farm is largely within the boundaries and slightly to the south, reflecting the current speed and direction, with a maximum of 10-12% of the water flowing through the farm being processed (Fig 5).

While this could assume that 10-12% of the phytoplankton passing through the farm is depleted by the mussels, this would be an over-estimate of the potential depletion because mussels do not filter with 100% efficiency, and some of the water flowing through the farm will be filtered more than once by mussels. This value also does not take into account any re-growth of phytoplankton. The modelled results also assume each farm is stocked with mussels at standardised densities and sizes, as would occur in a full mussel farm, not a spat farm.

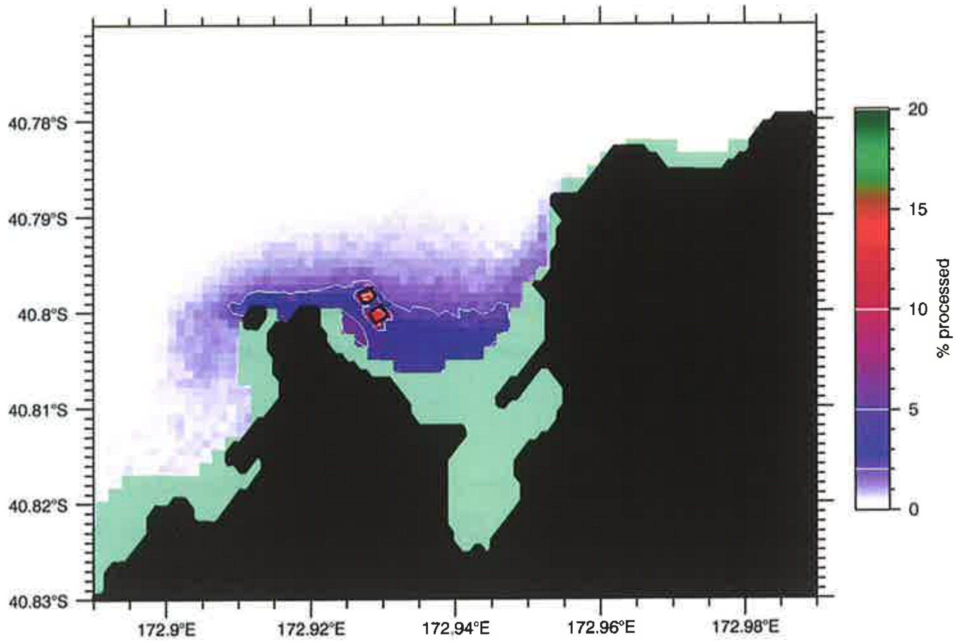

Figure 5. **Percentage water processed within and around the existing spat farms Pe30 and Pe31 in Wainui Bay, Golden Bay**

3.3 Deposition

Modelled deposition of pseudofaeces and faeces from the mussels indicates both that the amount of deposition (<0.5 $g.m^{-2}.d^{-1}$) and the spread of it is small (Fig 6). Deposition does not occur beyond the farm boundaries.

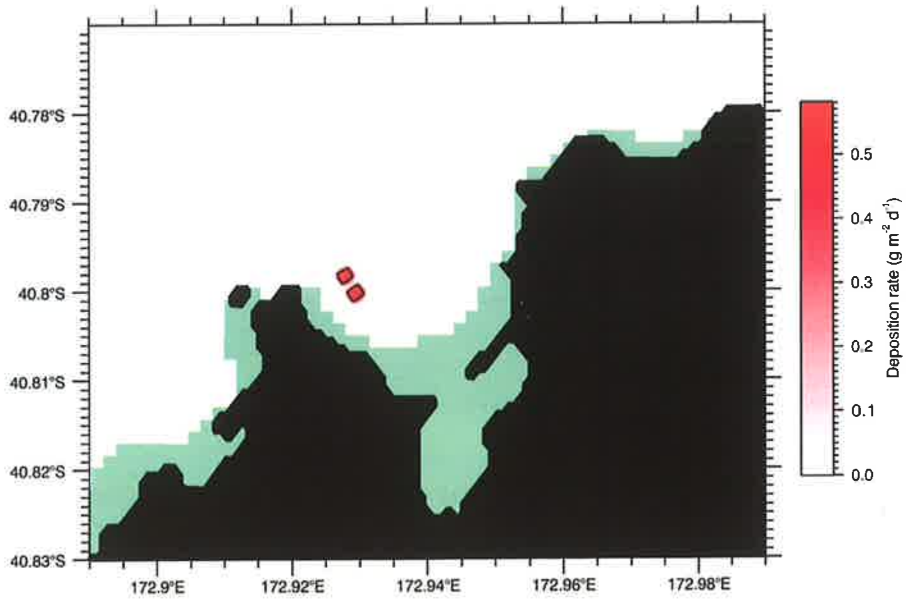

Figure 6. **Predicted deposition rates from the existing farms Pe30 and Pe31 in Wainui Bay.**

3.4 Side-scan sonar

Typically, beneath mussel farms there is an accumulation of dead shells and living mussels that have either fallen from the droppers or settled on to shells and grown. From previous experience there appears to be little difference between spat farms and mussel farms for these characteristics. Because the presence of shell material increases the sonar reflectivity of the sea floor, side-scan sonar is an effective method to map the extent of shell drop.

Figure 7 shows a mosaic of the 5 side-scan sonar transects in relation to the surface structures of Pe30 and Pe31. There are clear differences in the reflectivity (lighter areas) in the sonographs directly beneath the farms, but not beyond.

Figure 7. **Geo-referenced side-scan sonar transects overlaid on a Google Earth image of the spat farms at Wainui Bay. The surface structures of spat farms inshore of Pe30 and Pe31 are clearly visible, as is highly reflective material directly beneath P30 and Pe31.**

A more detailed image of a portion of one of the side-scan sonographs is shown in Figure 8. This image clearly shows anchor blocks and warps at the end of 2 backbones, along with the base of the droppers. More reflective material beneath the droppers is caused by shell drop, whereas the darker sea floor beyond the anchor blocks is mud.

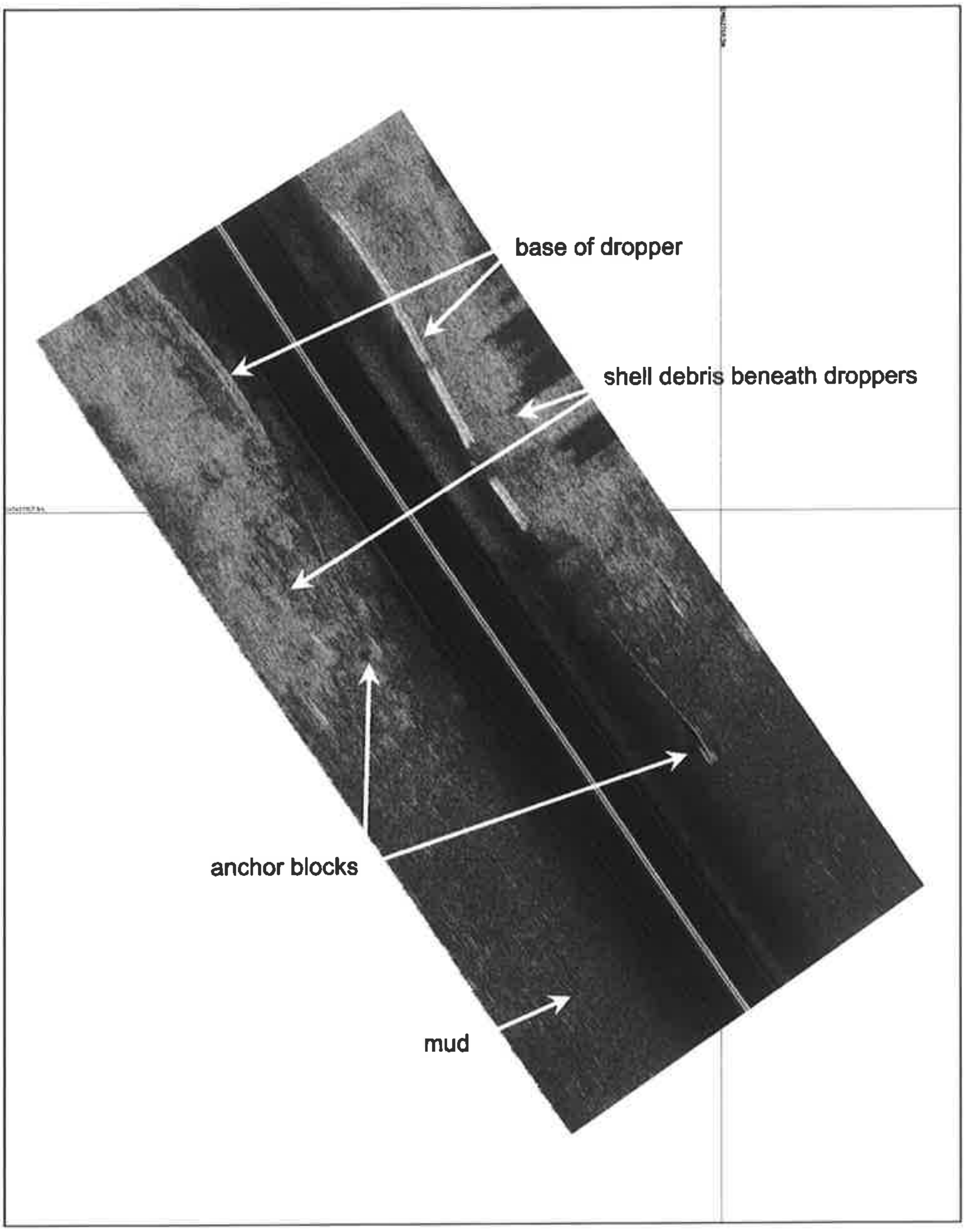

Figure 8. **Portion of side-scan image (approx 120 m x 60 m), showing various features, Wainui Bay spat farm.**

3.5 Benthic habitats

3.5.1 Sediments

The general area of the spat farms in Wainui Bay supports benthic habitats dominated by soft muddy sediments. Percentage composition of mud within the existing spat farms ranged from 54-73% (Pe30) and 73-85% (Pe31) to 82-94% outside farms. The slightly lower percentages within the farms are due to coarser (shell) material amongst the mud. The raw data for the sediment grain size samples are listed in Appendix 1, while the percentages of gravel, sand and mud from each site are shown in Figure 9.

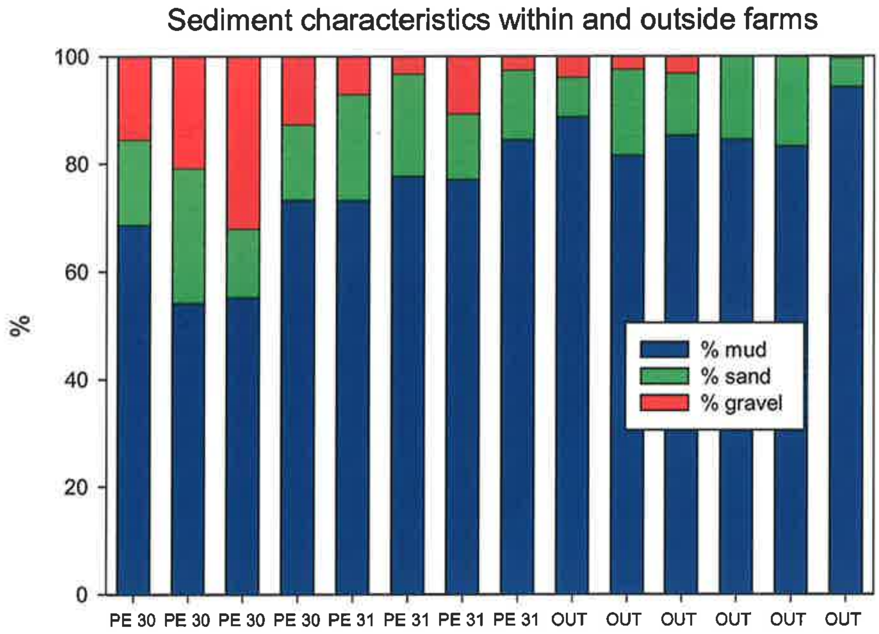

Figure 9. Percentage of each size fraction of sediments, Wainui Bay.

The amount of organic material in each sample ranged from 3.8-5.6%, with no distinct redox discontinuity layer observed in any sample, showing the sediments either beneath or outside the existing spat farms are not organically enriched enough to show any sign of anoxia. Figure 10 shows a plot of sediment organic content at each site.

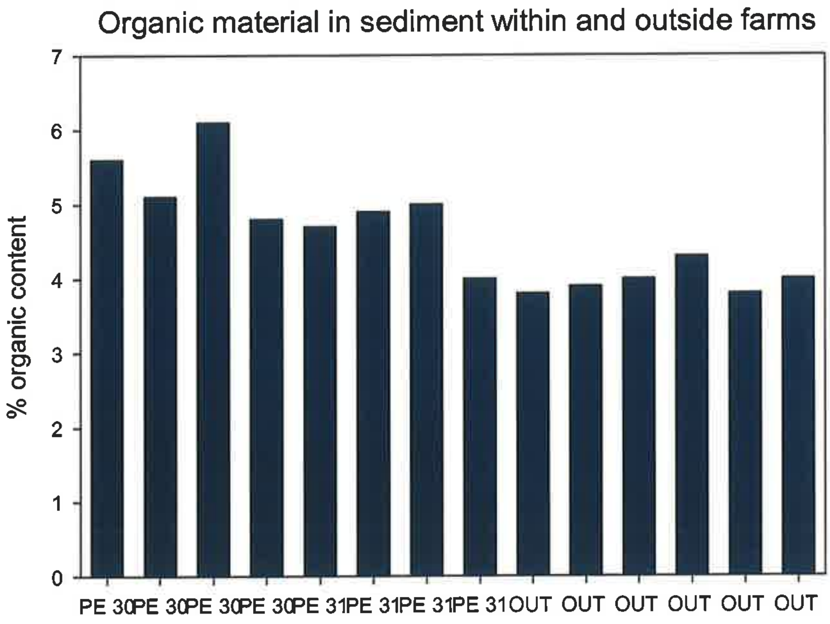

Figure 10. **Sediment organic content at each site, Wainui Bay.**

The mean percentage of organic content in the sediments within the existing spat farms was 4.0% and outside the farms was 5.1%. These differences are statistically significant (Fig 11), indicating slightly elevated organic content beneath the existing farms. The absolute values are, however, low compared to other mussel farming areas in Golden Bay and Marlborough Sounds.

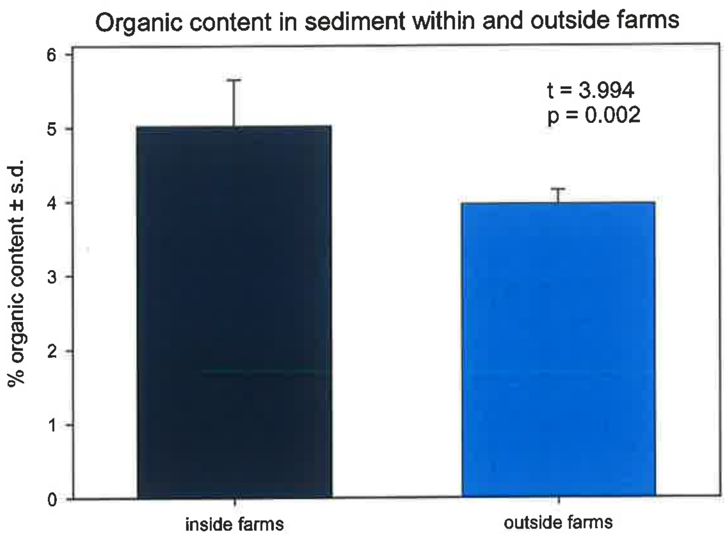

Figure 11. **Comparison of mean organic content of sediments within and outside spat farms, Wainui Bay.**

3.5.2 Biota

The benthic fauna were comprised of species that are generally common and widespread in mud habitats around New Zealand, including the Marlborough Sounds and Tasman/Golden Bay (pers. obs.). In total, 48 taxa were identified from all grab samples. Most species occurred both within and outside farms, but overall there were more taxa recorded within (34) than outside (24) the farms (Appendix 2). The infauna were dominated by 15 species of bivalves, 12 polychaete worm taxa, and 3 species of gastropods. Over all samples, numerically the most abundant species were the crab *Macrophthalmus hirtipes*, onuphid and lumbrinereid polychaete worms, the whelk *Cominella adspersa*, and the bivalves *Ruditapes largillierti* and *Nucula hartvigiana*. Total numbers of individuals in the grab samples ranged from 13 to 79 (mean 25), and the number of taxa from 5-16 (mean 10).

There were no significant differences in mean numbers of taxa, or mean numbers of individuals in grab samples within and outside the farm boundaries (Fig 12).

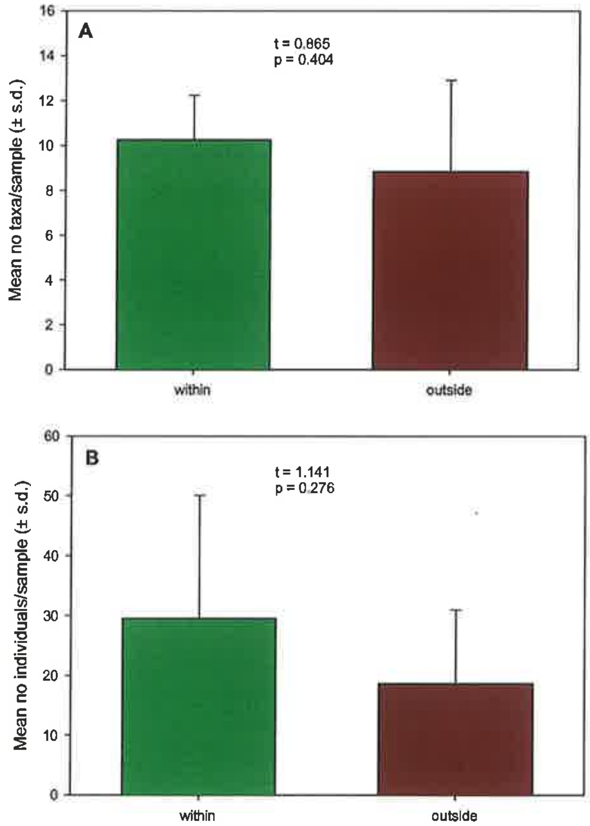

Figure 12. Comparisons of taxa abundance in samples collected within and outside spat catching farms, Wainui Bay.

The nMDS analysis, which clusters those samples with similar numbers of individuals and types of species together, clearly separated samples collected within the spat farm boundaries from those outside (Fig 13) indicating different taxa were collected from the two sets of samples. The samples taken from within each of the spat farms were, however, very similar.

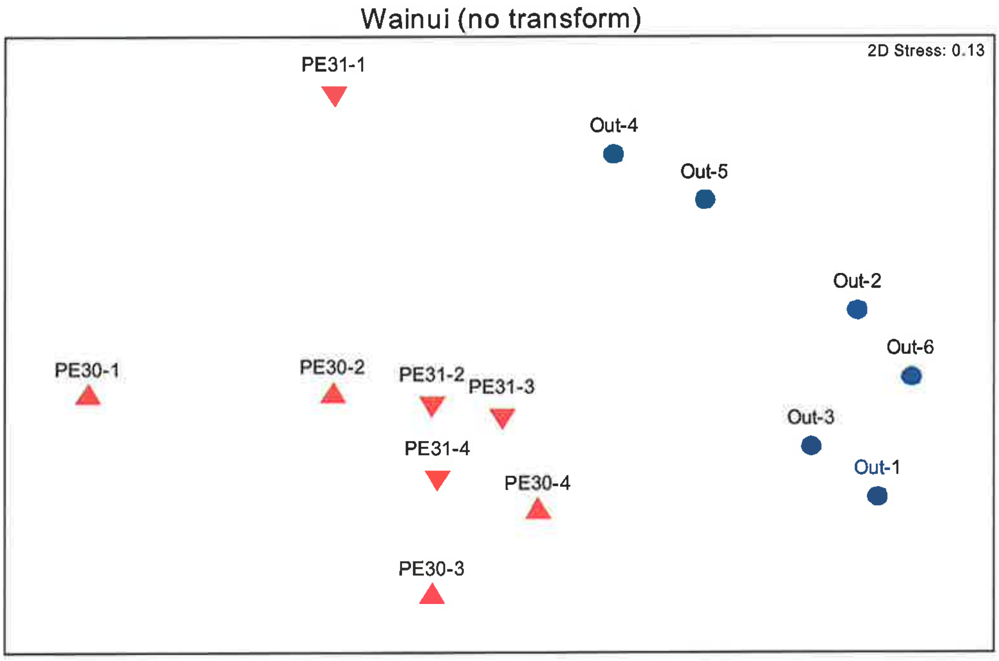

Figure 13. nMDS plot showing the relative faunal similarities among samples from Wainui Bay. Samples with relatively similar taxa lie closer together.

The taxa that contributed to the differences in fauna between farm and outside samples were identified using a routine in the programme SIMPER. While most taxa occurred at both farm and outside sites, the infauna that characterised samples within the existing spat farms comprised polychaete worms from the families Onuphidae, Glyceridae and Lumbrineridae, the carnivorous whelk *Cominella adspersa*, and the bivalve *Ruditapes largillierti*. The infauna characteristic of samples outside the farmed areas were polychaete worms from the families Lumbrineridae and Maldanidae, the bivalve *Dosinia lambata*, and the heart urchin *Echinocardium cordatum*. These results are in close agreement with samples taken over many mussel farms throughout the Marlborough Sounds.

Analysis of the ROV video footage allowed a qualitative description of the surface-dwelling species (epifauna) both within and outside the spat farms. Few differences were obvious beneath farms and outside the boundaries, except for the accumulation of shell drop and living mussels inside the farms (Fig 14).

Figure 14. Video frame grabs from within (tow 2) and outside (tow 7) spat farms, Wainui Bay.

The shell drop beneath the farms consisted of individuals and clumps of both green-lipped mussels (*Perna canaliculus*) and blue mussels (*Mytlius galloprovincialis*). In addition, horse mussels (*Atrina zelandica*) and scallops (*Pecten novaezelandiae*) were common beneath and outside farms. Three species, camouflage crabs *Notomithrax*, and the starfish *Coscinasterias muricata* and *Patiriella regularis* were recorded only within the farm boundaries. The kelp *Undaria* was reasonably common on all video tows.

4. Discussion

The two seaward spat farms within the block at Wainui Bay, Golden Bay, have been operational for more than 10 years. Samples taken from within and outside the farms show that the organic content of the sediment is significantly higher within the farms, but the absolute values are low, and there was no evidence of black anoxic conditions in the sediment at any site. It is possible that the slight elevation in organic material is a consequence of reduced current flow through the farm, and the armouring effect of fallen mussel shells reducing oxygen permeating into the sediment. The organic content beneath the farms is not cause for concern and this is reinforced by the infauna present.

Biological samples taken from within and outside the farms show a diverse fauna of common and widespread species. No rare species were recorded, and there were no apparent differences in the numbers of species present within and outside the farms. However, there are differences in the types of species present, with increased abundances of carnivorous seastars, crabs, and polychaete worms present within the farms. Outside the farms, there are a few species, including heart urchins and bivalves, which did not occur in samples within the farms. These results are comparable to those obtained from a large number of other surveys throughout the Marlborough Sounds and Golden Bay. The increased numbers of predators beneath the farms are likely to be a result of increased availability of food from fallen spat, growing mussels, and other species that have become attached to the shells on the sea floor.

In terms of epifauna, the obvious difference between samples from within and outside the farms is the presence of clumps of living and dead mussels beneath the farms. These are a direct consequence of mussel spat being dislodged from the ropes and surviving on the sea floor. Species generally regarded as more intolerant of conditions beneath mussel farms, such as scallops and horse mussels, were found to be common beneath these spat farms.

The tidal currents at the locality of the farms are moderate. The currents are important for bringing planktonic food to the growing spat, and for removing detritus and faecal material produced by the spat. The currents are not strong enough to disperse dislodged spat or shells, and this is shown by the presence of reflective material in side-scan images confined to the area directly beneath the dropper lines. Modelled distribution of the deposition of fine detrital material estimates very low concentrations within the farm boundaries, and very little deposition beyond, restricted to 20-30 m from the droppers. These results are confirmed by the presence of diverse and "natural" benthic communities beneath the farms.

The proportion of water flowing through the farms that would be filtered if they were fully stocked mussel farms has been modelled and shown to be small, at 10-12%. Assuming 100% efficiency, then this would be maximum amount of phytoplankton depletion that could be expected. The depletion "footprint" from the farms is small, and filtration levels of <5% occur within 200 m of the farms. This amount of depletion would likely be undetectable in terms of trying to measure chlorophyll a differences between the farm and outside.

In conclusion, the ecological effects of the two spat farms Pe30 and Pe31 at Wainui Bay after more than 10 years of operation have been small. There is no reason to expect this would change through continued farming of the sites.

5. Acknowledgements

We are grateful to Winstone Rountree for providing a suitable vessel for the fieldwork, and for the deployment and retrieval of the ADP. We would also like to thank the NIWA team in Nelson for completing the fieldwork, analysing the samples, and running some of the statistical calculations.

6. References

Clark, K.R. 1993. Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology 18*: 117-143.

Fenwick, G., Ross, A., James, G., Sagar, P. 2003. Marine farming in Canterbury: biophysical issues associated with suggested aquaculture management areas. *NIWA Client Report CHC2003-045, prepared for Environment Canterbury.* 104 pp.

Gall, M., Zeldis, J., Image, K. 2003. An assessment of phytoplankton depletion associated with Area A in the Wilson Bay marine farming zone. *NIWA Client Report WBC03501, prepared for Group A Consortium.*

Morrisey, D., Stenton-Dozey, J., Hadfield, M., Plew, D., Govier, D., Gibbs, M., Senior, A. 2006. Fisheries resource assessment (Golden Bay, Tasman Bay interim AMAs). *NIWA Client Report NEL2006-014, prepared for Ministry of Fisheries.* 164 pp.

Stenton-Dozey, J., Morrisey, D., Stevens, C., Grange, K. 2006. Fisheries resource impact assessment for marine farming applications in Crail, Clova, and Beatrix Bays, Marlborough Sounds. *NIWA Client Reports CHC2005-114.1 to CHC2005-114.15.*

Stenton-Dozey, J., Morrisey, D., Hadfield, M., Hurren, H. 2007. Fisheries resource impact assessment for marine farming permit applications in Admiralty Bay. Site: U991671. *NIWA Client Report CHC2007-081.*63 pp.

7. Appendix 1. Raw data for sediment grain size analysis

Farm No.	No.	Initial weight (g)	Shell (>2mm)	Sand/ fine shell (63um-200mm)	Mud (<63um)	% Mud	% Sand	% Shell	Total	Weight minus shell (g)	% fines, excl. shell	% medium excl. shell	Total	% Mussel Shell
PE 30	1	95.19	14.67	15.14	65.38	68.68369	15.90503	15.41128	100	80.52	81.19722	18.80278	100	50
PE 30	2	97.5	20.25	24.43	52.82	54.17436	25.05641	20.76923	100	77.25	68.3754	31.6246	100	50
PE 30	3	88.9	28.42	11.37	49.11	55.24184	12.78965	31.9685	100	60.48	81.2004	18.7996	100	70
PE 30	4	127.34	16.11	17.89	93.34	73.29983	14.049	12.65117	100	111.23	83.91621	16.08379	100	60
PE 31	5	143.5	10.11	28.24	105.15	73.27526	19.67944	7.045296	100	133.39	78.829	21.171	100	70
PE 31	6	137.95	4.42	26.31	107.22	77.72381	19.07213	3.204059	100	133.53	80.29656	19.70344	100	10
PE 31	7	133.56	14.21	16.33	103.02	77.13387	12.22671	10.63941	100	119.35	86.31755	13.68245	100	60
PE 31	8	122.65	3.09	15.87	103.69	84.54138	12.93926	2.519364	100	119.56	86.72633	13.27367	100	50
OUT	9	123.45	4.77	9.11	109.57	88.75658	7.379506	3.863913	100	118.68	92.3239	7.676104	100	40
OUT	10	131.05	3.13	20.98	106.94	81.60244	16.00916	2.388401	100	127.92	83.59912	16.40088	100	5
OUT	11	145.01	4.48	16.73	123.8	85.37342	11.53714	3.089442	100	140.53	88.09507	11.90493	100	5
OUT	12	146.63	0	22.59	124.04	84.59388	15.40612	0	100	146.63	84.59388	15.40612	100	0
OUT	13	147.39	0.26	24.31	122.82	83.32994	16.49366	0.176403	100	147.13	83.4772	16.5228	100	1
OUT	14	139.02	0.32	7.56	131.14	94.33175	5.438066	0.230183	100	138.7	94.54939	5.450613	100	5

8. Appendix 2. List of taxa collected from each grab sample, Wainui Bay.

		Site/Farm	PE30	PE30	PE30	PE30	PE31	PE31	PE31	PE31	OUT	OUT	OUT	OUT	OUT	OUT
		Rep	1	2	3	4	1	2	3	4	1	2	3	4	5	6
		Grab no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Depth	11.2	11.3	11.2	11.4	10.2	10.2	10.3	10.2	9.9	10.2	10.2	10.3	10.6	11
Group1	Group	Species														
Nemertea	Nemertea	Nemertea		1												
Polychaeta	Polychaeta	*Aglaophamus* sp.												1	1	1
Polychaeta	Polychaeta	Capitellidae		3						2						
Polychaeta	Polychaeta	Dorvilleidae		1				1							1	
Polychaeta	Polychaeta	Glyceridae	1	2	2			2	2	3						
Polychaeta	Polychaeta	Lumbrineridae			1	2		5	3	3	3	2	2	1	2	3
Polychaeta	Polychaeta	Maldanidae									4	2	3		2	1
Polychaeta	Polychaeta	Onuphidae	1	6	2	3	5	4	5	4			1	3	2	
Polychaeta	Polychaeta	Orbiniidae							4	1						
Polychaeta	Polychaeta	Polynoidae	2													
Polychaeta	Polychaeta	Terebellidae	3						2							
Polychaeta	Polychaeta	Sylliidae							1							
Mollusca	Gastropoda	*Amalda mucronata*											1			1
Mollusca	Gastropoda	*Austrofusus glans*			2	1										
Mollusca	Gastropoda	*Cominella adspersa*	4	4				3		4						
Mollusca	Gastropoda	*Pleurobranchia maculata*													1	
Mollusca	Gastropoda	*Trochus tiaratus*			1											

		Site/Farm	PE30	PE30	PE30	PE30	PE31	PE31	PE31	PE31	OUT	OUT	OUT	OUT	OUT	OUT
		Rep	1	2	3	4	1	2	3	4	1	2	3	4	5	6
		Grab no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Depth	11.2	11.3	11.2	11.4	10.2	10.2	10.3	10.2	9.9	10.2	10.2	10.3	10.6	11
Mollusca	Bivalvia	*Angulus gaimardi*			2		2				1					
Mollusca	Bivalvia	*Arthritica bifurca*	5					3							1	
Mollusca	Bivalvia	*Dosinia lambata*										3	3		1	3
Mollusca	Bivalvia	*Gari lineolata*											1		2	
Mollusca	Bivalvia	*Mytilus galloprovincialis*	1													
Mollusca	Bivalvia	*Neilo australis*												2	1	
Mollusca	Bivalvia	*Nucula hartvigiana*	9		1		3									
Mollusca	Bivalvia	*Nucula nitidula*		1										5	1	
Mollusca	Bivalvia	*Ruditapes largillierti*		1	4	3	5			2						
Mollusca	Bivalvia	*Solemya parkinsoni*						1								
Mollusca	Bivalvia	*Tawera spissa*				1		1		1						
Mollusca	Bivalvia	*Tellina edgari*														1
Mollusca	Bivalvia	*Theora lubrica*												3	7	
Mollusca	Bivalvia	*Venericardia purpurata*												1		
Mollusca	Bivalvia	*Zenatia acinaces*														1
Mollusca	Polyplacophora	*Amaurochiton* sp.									1					
Crustacea	Isopoda	Unidentified isopod					1	1								
Crustacea	Amphipoda	Unidentified amphipod				1		1							4	
Crustacea	Decapoda	*Halicarcinus varius*					1			2						
Crustacea	Decapoda	*Macrophthalmus hirtipes*		1			58		1			5		1	8	
Crustacea	Decapoda	*Pagurus* sp.		1	5	1			1	1			1			
Crustacea	Decapoda	Unidentified decapod (shrimp)					1						1			1

		Site/Farm	PE30	PE30	PE30	PE30	PE31	PE31	PE31	PE31	OUT	OUT	OUT	OUT	OUT	OUT
		Rep	1	2	3	4	1	2	3	4	1	2	3	4	5	6
		Grab no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Depth	11.2	11.3	11.2	11.4	10.2	10.2	10.3	10.2	9.9	10.2	10.2	10.3	10.6	11
Echinodermata	Asteroidea	*Coscinasterias muricata*		1			1			1						
Echinodermata	Asteroidea	*Patiriella regularis*		1	2		2									
Echinodermata	Ophiuroidea	*Amphiura rosea*								1						
Echinodermata	Ophiuroidea	*Ophionereis fasciata*			2											
Echinodermata	Echinoidea	*Echinocardium cordatum*										1		1	4	2
Echinodermata	Holothuroidea	*Stichopus mollis*	1													
Brachiopoda	Brachiopoda	*Magasella sanguinea*									1					
Ascidiacea	Ascidiacea	*Corella eumyota*		1		1										
		Total no. taxa	9	13	11	8	10	10	8	13	5	5	8	10	16	9
		Total no. individuals	27	24	24	13	79	22	19	28	10	13	13	19	43	14