record id: 2247

(U041951)

NIWA

Taihoro Nukurangi

Site-specific fisheries resource impact assessment
Okoha Holdings Ltd. – U950008
Anakoha Bay, Marlborough Sounds

Prepared for

Okoha Holdings Ltd. – U950008

By NIWA

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Contents

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1. Introduction

As part of the Fisheries Resource Impact Assessment protocol, applicants are required to provide a report for their specific sites. This report describes the generic methodology used to meet this protocol and then provides a tabulated information summary of this particular site, supported by data appendices. Detailed benthic drop camera and side-scan sonar images are provided "by-exception", that is if a key issue is identifiable, such as rocky reefs, scallop beds, or unique benthic fauna, images will be in the summary table.

2. Site-specific surveys

2.1 Hydrodynamics

The FRIA requires that some consideration be given to the effect of the farm on the local currents. Recent work by NIWA (Plew et al. 2003, Figure 1) has shown that there is the potential that the farm will reduce the currents in and around the farm. Jackson and Winant (1983) found that the flow in large kelp beds (km scale) slowed down by around 67%. Observations extending from the work of Plew et al. (2003) show similar behaviour in large mussel farms. In terms of flow distortion by smaller farms such as the present site, the latest developments in our understanding (Plew et al. 2003) suggest that there will be a reduction in flow across farms. A percentage reduction in current at the downstream end of the farm is estimated from Figure 1, by viewing U/U_0 as the reduced velocity relative to the velocity if the farm were not there; $U/U_0 = 1$ means there is no flow reduction, $U/U_0 = 0.75$ means there is a 25% reduction in flow.

Records of 2 days of current data were gathered for each applicant site. The local current speed (cm s^{-1}) was calculated from the velocity magnitude averaged through the top 14 m of the water column over a period of 48 hours. This was compared with contemporary recordings from a longer term mooring at the centre of the bay to estimate a local current magnitude parameter - the ratio of the mean current speed at the site to the mean at the central site. Using simultaneous measurements over longer than a single tidal period is vital as the flow in Port Gore and Anakoha Bay is not particularly regular or completely controlled by the tides. The tidal magnitude data were resolved from ADP measurements recorded near the farm.

Lagrangian drifter tracks were used to illustrate the movement of discrete parcels of water. In many studies moored current meters are used to determine trajectories of water masses passing through farms. This is viable away from the coast but must be treated with care near shorelines. It points to the need to consider (i) dispersion and (ii) Lagrangian information when identifying provenance and downstream trajectories.

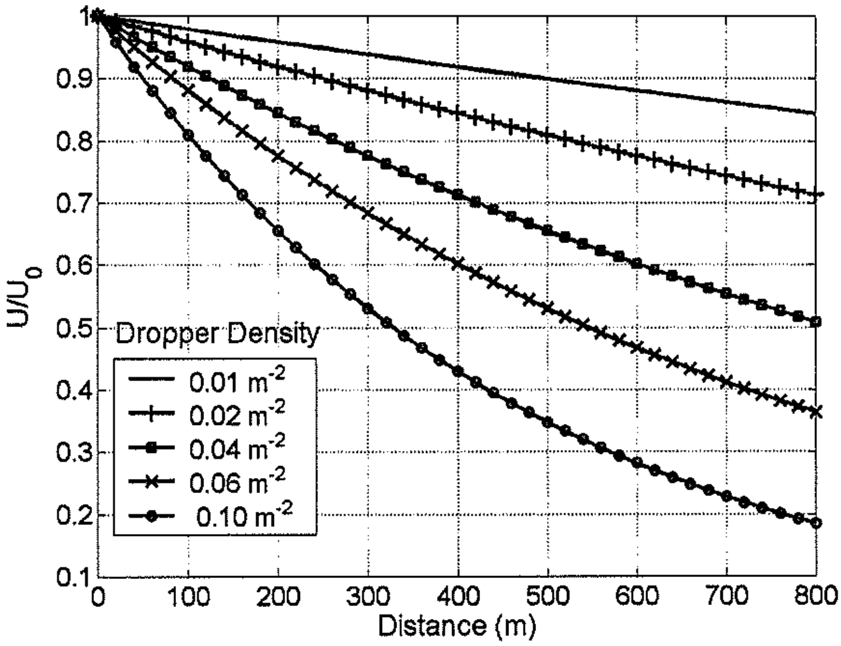


Figure 1 : **Scaling analysis from Plew et al. (2003) for proportional velocity decay through energy loss from a unidirectional flow. Each curve represents a different mussel line density (dropper per unit area) with the diagonally crossed line (0.06) being comparable to typical densities here. A modified drag coefficient of $C_d = 1.0 \times \sin(25°) = 0.42$ is used.**

2.2 Water utilisation and biodeposition

The mean proportion of water processed at a specific site was calculated over an area with a maximum distance of 2 km from the farm boundary. This mean is then compared to the bay-wide average water usage based on the combined effect of all farms. Biodeposition rate (or Benthic Deposition Parameter in kg faeces/day/100m^2) is given as a range for the area from the edge of a farm to as far as particles disperse from the farm boundary based on Hartstein's model, (Hartstein, 2003). The eight mussel stocking scenarios are applied for each site and compared to bay-wide averages of percentage water processed:

Scenario 1: Current stocking on existing farms as of October 2003

Scenario 2: Current stocking on existing farms **and** in those extensions, new farms and renewals for which we are contracted for the FRIA assessment

Scenario 3: "Standardised" stocking densities on existing farms is based on 20% of farm being seeded with spat (20-35 mm) with density of 1000 individuals/m dropper length, the remaining 80% being evenly divided between 3 sizes: 35-60mm (180 individuals/m dropper length), 60-85mm (150 individuals/m) & 85-110mm (120 individuals/m).

Scenario 4: "Standardised" stocking as for Scenario 3 on existing farms plus contracted extensions, new farms and extensions.

Scenario 5: "Dilution" stocking assuming current stocking densities – this assumes that no additional mussels are added to the extension but mussels in the existing farm (at current stocking densities) are evenly re-distributed into the existing and contracted extension area: this does not include new farms and renewals.

Scenario 6: "Dilution" stocking assuming standardised stocking as described in Scenario 3 - this assumes that no additional mussels are added to the extension but mussels in the existing farms (at standardised stocking densities) are evenly re-distributed into the existing and contracted extensions: this does not include new farms and renewals.

Scenario 7: Harvestable stocking on existing farms is based on 100% of farms being stocked with large mussels ready for harvesting, 85-110mm (120 individuals/m).

Scenario 8: Harvestable stocking as for Scenario 5 on existing farms plus contracted extensions.

The benthic deposition parameter (BDP) is linearly linked to mussel stocking density and reflects the biodeposition of mussel faeces and pseudofaeces under 3 stocking scenarios in a 2 km radius around each farm and/or proposed extension:

(1) biodeposition with current stocking (October 2003)

(2) biodeposition in existing farms with standardised stocking

(3) biodeposition as for (2) plus the extensions, new farms and renewals

2.3 Sediments and side-scan sonar sampling

Positions of sampling stations (grab and drop camera) and side-scan sonar transects were determined using hand-held or shipboard GPS. Possibly due to unusually severe solar flare activity at the time of sampling, some errors in positioning occurred and some re-sampling (in May 2004) was necessary to ensure adequate spatial coverage.

Three replicate grab samples were taken at each of the regional stations using a Van Veen grab (bite area ca 0.13 m^2, max bite depth 22 cm). The sampling strategy for individual sites was different. In general, five replicate samples were taken in each application site. For existing farms applying for an extension, two samples were taken within the existing farm and three within the extension. For new farm applications, 5 random samples were taken in or around the application area. Where an existing farm was applying for a renewal of its permit, 3 samples were taken outside the farm and 2 samples within the farm. Actual numbers and spatial distributions of samples at each site are detailed in the site-specific reports.

Two core samples were taken through the lid of each grab sample, and the depth of the redox discontinuity (black) layer was measured to the nearest millimetre using a ruler. One core sample was retained to determine organic content and the other for grain-size analyses (in some cases, fauna and sediments were analysed in separate grab samples, as indicated in each site-specific report).

Grain-size distribution was determined by oven drying a sample of sediment at 100 °C overnight and washing a weighed subsample through stacked 2000-µm and 63-µm sieves. The fraction retained on each sieve was dried and weighed and the weight of material passing 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.

The amount of organic matter in the sediments was determined by freeze-drying each sample, grinding, and 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 expressed as a percentage.

Side-scan sonar transects were run using a high-frequency (675 kHz) Tritech towfish at boat speeds of 1-2 knots. The side-scan was interfaced with GPS, recording positions every 2 seconds. The side-scan images and GPS positions were recorded using SeaNet software on to a laptop in real-time.

All side-scan transects were analysed by running the profiles back and recording the positions of features of interest or boundaries of sediment types. In addition, each side-scan transect was saved as a series of bitmap files and stitched together to provide a visual record that could then be placed into GIS along with the adjacent farm boundaries or application site. Side-scan data as images are presented by exception only in each site-specific report.

Drop camera images (0.175 m^2) were taken at stations within extension areas and, where an existing farm was present, additional images were taken inside it. Numbers of images varied among applications, but at least 3 were taken inside each application area and 2 in each existing farm. These were compared to the 'regional' samples taken in the central part of each bay (21 in Anakoha Bay, 24 in Port Gore). The drop camera employed a digital still camera and strobe light source. The nature of the sediment in each image was categorised by visual estimates of percentage mud, sand and shell/gravel, and hard substrata such as cobbles.

2.4 Fauna

Sampling strategies for benthic infauna and habitats at farm and/or extension sites were indicated in Technical Appendix II of the FRIA Guide (Ministry of Fisheries 2002), and consolidated in the NIWA proposal agreed upon between MFish and NIWA. (Ross et al. 2003). The remainder of the grab samples described above was washed through 2 stacked sieves of 1-cm and 1-mm mesh and all material retained, including animals, was bagged, labelled and preserved in 70% isopropyl alcohol. Animals were identified to the lowest possible taxonomic level, and enumerated, on return to the laboratory.

Drop camera stations (see above for details) were positioned to cover benthic habitats not sampled by the Van Veen grab with a view to integrating information for a more comprehensive assessment of the benthos (and sediments – see above). The images were analysed to semi-quantify the epibenthos using abundance classes.

The objective of the statistical analyses of benthic fauna samples was to identify any differences among assemblages living below mussel farms (where present), those in the application areas, and those at 'regional' sampling stations, so that any actual impacts could be identified and used to predict future changes. We used canonical analysis of principal coordinates (CAP, constrained by sample group: Anderson & Willis 2003) to identify differences in the assemblages of animals in the different groups of samples. Abundances of organisms inside and outside each farm and application area are provided in an appendix to each site-specific report.

3. Summary information for U950008

Flow in Anakoha Bay region is dominated by tide and wind-driven currents penetrating from its northern entrance. This particular farm is in the south-western part of the bay, where currents are somewhat weaker than they are in the north.

Since this is a renewal of an existing farm, mussel density scenarios are limited to 1 (average current stocking Oct 2003), 3 and 7.

Okoha Holdings Ltd. – U950008

CURRENTS

Summary Information

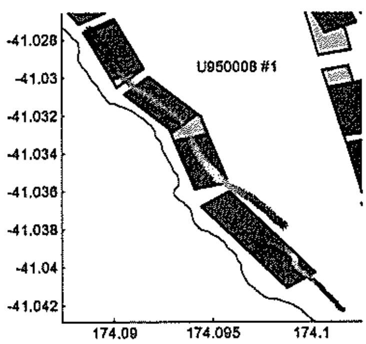
Speed: average = 3.5 cm s^{-1}

Magnitude parameter = 0.44

Flushing time-scale = 3.9 days

Deposition parameter = 14.5 m

Estimated downstream reduction in current – 28%



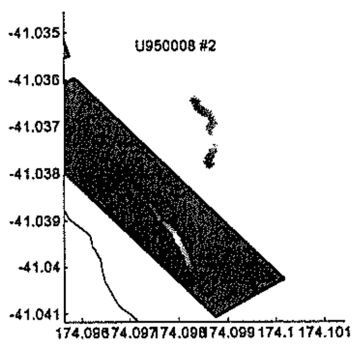


Figure 2. Drogue trajectories (asterisks) compared with pseudo-trajectories (solid) calculated from an ADP moored at the farm site. There were two drogue releases, on different phases of the tide. The colours represent time, with red being the start of the release. The grey boxes are farm areas and extensions.

Comments

The average speed of 3.5 cm s^{-1} indicates that currents at this site are weak to moderate. The magnitude parameter of 0.44, relative to the Anakoha Bay central mooring, is typical of sites in southern Ankoha Bay.

The ADP data (Appendix 1) show that the flow tends to be aligned NW–SE and varies episodically, but does not stay in phase with the tidal variation in sea level.

Flushing at this site should occur at a similar rate to other sites in southern Anakoha Bay, ie. somewhat slower than in the northern part of the bay.

The drogue trajectories do not agree well with the ADP pseudo-trajectories at this site, because of the variable currents.

The estimated downstream reduction in current is significant because of the large farm area.

<table>
<tr><th></th><th colspan="4">Summary Information</th><th>Comments</th></tr>
<tr><td rowspan="4">WATER UTILISATION</td><td>number</td><td>Mussel density stocking scenarios</td><td>Average % water processed</td><td>Average % water processed for all farms bay-wide</td><td rowspan="4">This table shows the average percentage water processed in the localised area of the proposed renewal U950008 considering three different mussel density scenarios. This site processed water at 3 to 4 times the bay-wide average for each stocking scenario. This can be expected considering the local hydrodynamics (Figure 2) where weak and variable current flow would lead to slower water turnover .</td></tr>
<tr><td>1</td><td>Averaged Current</td><td>3.68</td><td>1.11</td></tr>
<tr><td>3</td><td>Standardised</td><td>4.68</td><td>1.34</td></tr>
<tr><td>7</td><td>Harvestable</td><td>7.26</td><td>2.08</td></tr>
<tr><td rowspan="3">BENTHIC DEPOSITION PARAMETER</td><td colspan="2">Mussel density stocking scenarios</td><td>Benthic Deposition Parameter range (kg/day/100m²) over the benthic zone of influence</td><td>Benthic Deposition Parameter range (kg/day/100m²) over the benthic zone of influence for all farms</td><td rowspan="3">Based on stocking densities in October 2003, the benthic deposition parameter (BDP) measured as kg faeces/day/100m², was compared to the bay-wide range which considers the entire spectrum of BDPs for all farms. With standardised stocking in the renewal boundary , the BDP range expands to correspond to that for the entire bay.

The zone of influence (ZOI) did not overlap with neighbouring farms so no compounded BDP effect can be expected</td></tr>
<tr><td colspan="2">Current stocking</td><td>0.001 to 0.05</td><td>0.01 to 1.25</td></tr>
<tr><td colspan="2">Standardised stocking</td><td>0.03 to 0.75</td><td>0.03 to 1.5</td></tr>
</table>

	Summary Information	Comments

SEDIMENT

Summary Information

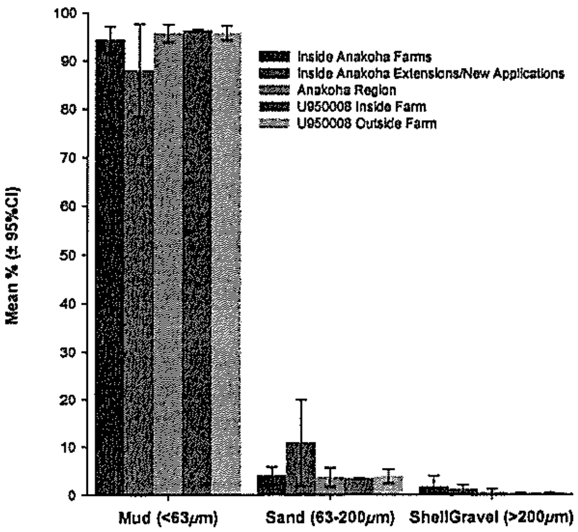


Figure 3.

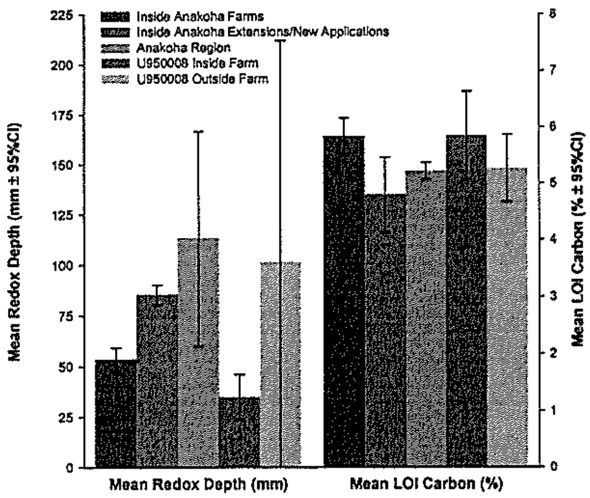


Figure 4. Data presented as mean percentage ± 95% confidence level Raw data on Redox and % organics are given in Appendix 3.

Comments

Station locations are shown in Appendix 2, and co-ordinates of grab samples, drop camera stations and sediment data in Appendix 3.

There was a high percentage of mud at U950008, and a correspondingly low proportion of sand and shell gravel (Figure 3).

Redox depth was shallow (i.e. values of redox depth were small) within the existing farm, and higher but extremely variable outside the farm (Figure 4). Values were slightly below bay-wide averages within the farm, and comparable to bay-wide averages adjacent to the farm.

Loss on ignition carbon values at U950008 were similar to the relevant bay-wide averages, both inside and adjacent to existing farms (Figure 4). Differences between within and adjacent to farms were not significant. This suggests that relatively little organic matter is being deposited beneath the farm, or that it is being processed rapidly.

Side-scan trace of the site indicates no conspicuous features of interest on the inshore boundary of the application site (Appendix 4). Mussel debris is evident beneath the farm (Appendix 5).

Drop camera photographs revealed mussels present in three of the five photographs, and one cushion star (*Patiriella regularis*) (Appendix 8.).

BENTHIC FAUNA

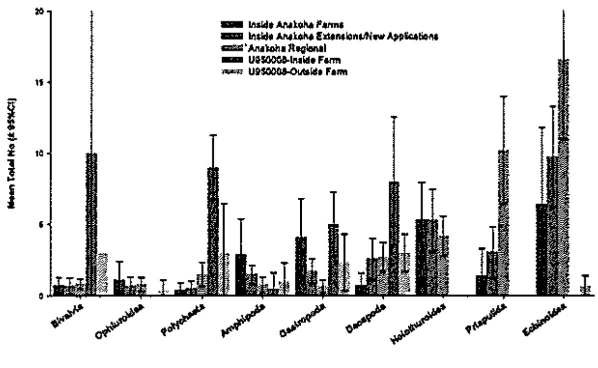


Figure 5. For each taxon, mean abundances are given for samples taken within Anakoha Bay farms, outside (adjacent to) Anakoha Bay farms, and regional samples

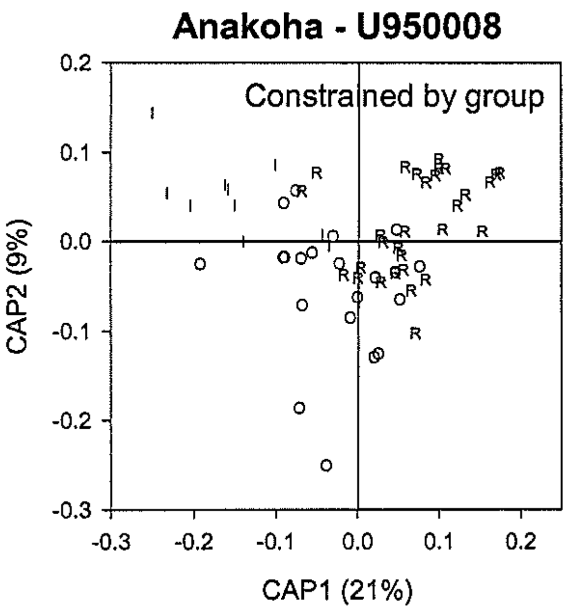


Figure 6. Samples from Licence U950008 highlighted in red. I = sample taken inside farm, O = sample taken outside farm, R = regional samples.

Mean taxon abundances are given for samples taken within Anakoha Bay farms, extension areas (outside farms), and regional samples (Figure 5).

Abundances of bivalves, polychaetes, and decapods were higher inside U950008 (though variable), whereas values for ophiuroids, holothurians, priapulids and echinoderms were lower within the farm than bay wide averages (Figure 5). Holothurians, priapulids, were absent adjacent to the farm, and echinoderms were scarce.

The ordination plot (Figure 6) indicated little variability between samples taken within or adjacent to the farm. The adjacent samples plotted close to the regional samples, suggesting fauna similar to the bay-wide average. The faunas of samples inside the farm were typical of those of farms in the bay.

There were a greater number of individuals inside U950008 with a greater number of species in sample 1 (Appendix 7). The Japanese bivalve *Theora lubrica*, a crab *Macrophthalmus hirtipes*, and the gastropod *Zeacolpus pagoda* dominated samples inside the farm. Grab samples 1 and 2 had higher and lower species diversity and richness than the values for the three outside farm samples which were very similar (Appendix 7).

BENTHIC FAUNA	There are no known areas of reef or cobble, populations of horse mussels, scallops, or other features potentially important for fisheries management, within the application area, as determined during the present and previous studies (Davidson & Davidson 1994) of the application site. From grab samples, number of individuals was higher within the farm than adjacent to it, as was number of species for sample 1, but the differences in species richness and diversity was highly variable inside the farm than outside. There was no evidence of any significant difference in sediment characteristics inside or outside the farm, and the high mud content of all samples demonstrates their suitability over which to site a marine farm. The biological consequences of this mussel farm appear to be an increase in biomass of the crab *M. hirtipes*, the Japanese bivalve *T. lubrica* and the gastropod *Z. pagoda.*
EFFECTS ON FISHING	There was no mention of site U950008 in the Ministry of Fisheries *Fishing Analysis: Area 2 - Anakoha Bay.*
ISSUES	This report suggests there are no biological issues highlighted for this site. It is not known whether there are any fisheries-related issues.

4. References

Anderson, M.J.; Willis, T.J. 2003. Canonical analysis of principal coordinates: a useful method of constrained ordination for ecology. *Ecology 84(2)*: 511-525

Davidson, R.J.; Davidson, J.M. (1994). Description of the macrobenthic community from a proposed marine farm site at Okoha, inner Anakoha Bay, Marlborough Sounds. Davidson Environmental Ltd Research, Survey and Monitoring Report No. 30, prepared for A.B. & J.M. Redwood, May 1994, 8pp.

Hartstein, N. 2003. Supply and Dispersal of Mussel Farm Debris and its Impacts on Benthic Habitats in Contrasting Hydrodynamic Regimes, PhD Thesis, IAAS University of Auckland/NIWA. 181 p

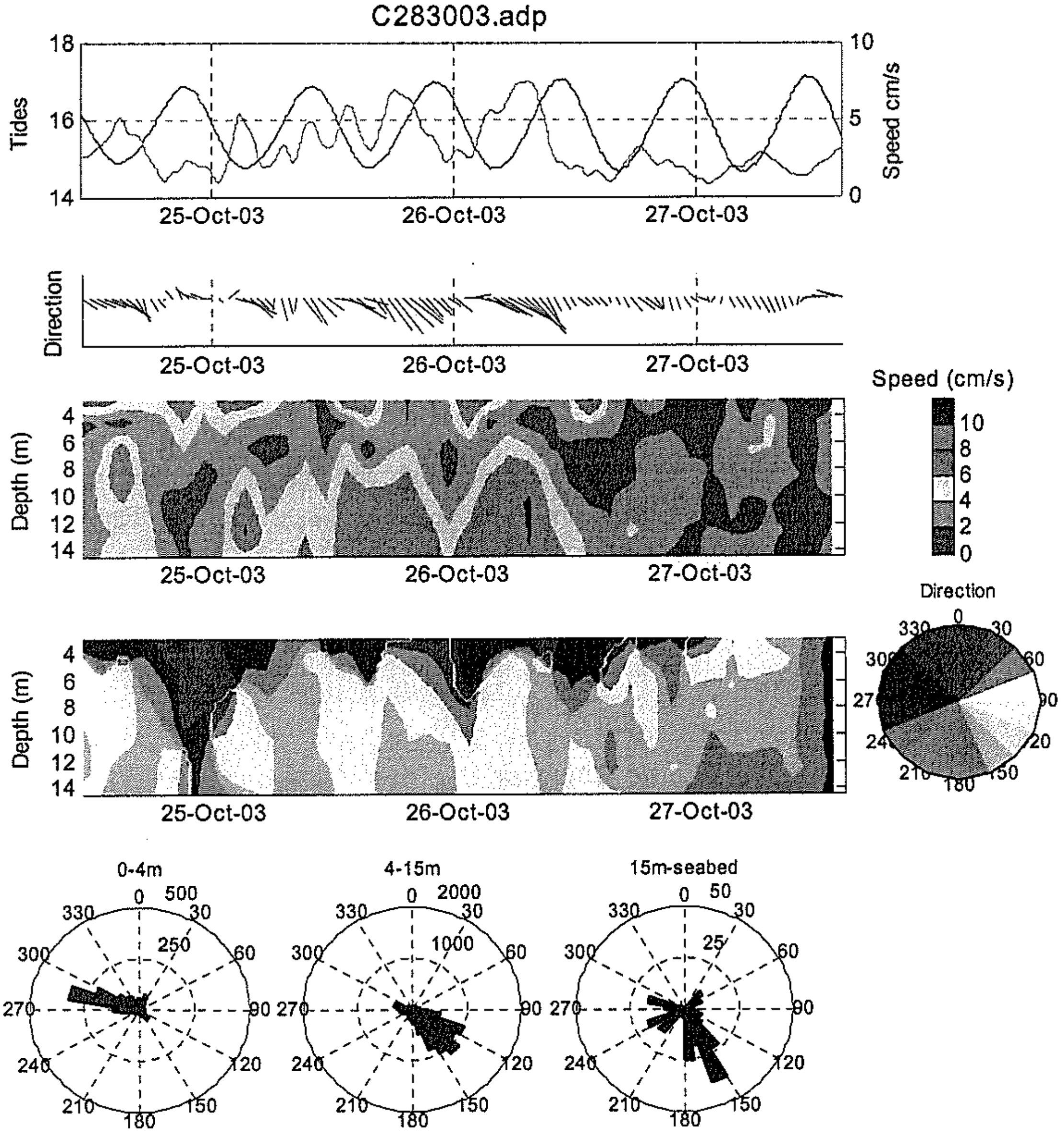
Jackson, G.A.; Winant, C.D. 1983. Effects of kelp forest on coastal currents. *Continental Shelf Research 2*: 75-80

Plew, D.; Stevens, C.; Spigel, R.; Hartstein, N. 2003, Hydrodynamic implications of large offshore mussel farms. Submitted to the *IEEE Journal of Oceanic Engineering Special Issue on Offshore Aquaculture, May 2003*

Ross, A.; Grange, K.R.; Stevens, C. 2003. Review and proposal on fulfilling ecological aspects of the Fisheries Resource Impact Assessment. Proposal to the Ministry of Fisheries, National Institute of Water and Atmospheric Research Ltd, Christchurch, New Zealand: 14 p.

5. Appendix for U950008

Appendix 1: Farm-specific ADP mooring data for U950008, from top: water depth versus time showing the tidal variation; current magnitude versus time; feather plot showing flow vector versus time; speed contours versus time and depth; direction contours versus time and depth; and velocity roses for three depth ranges showing an envelope of the flow vector.



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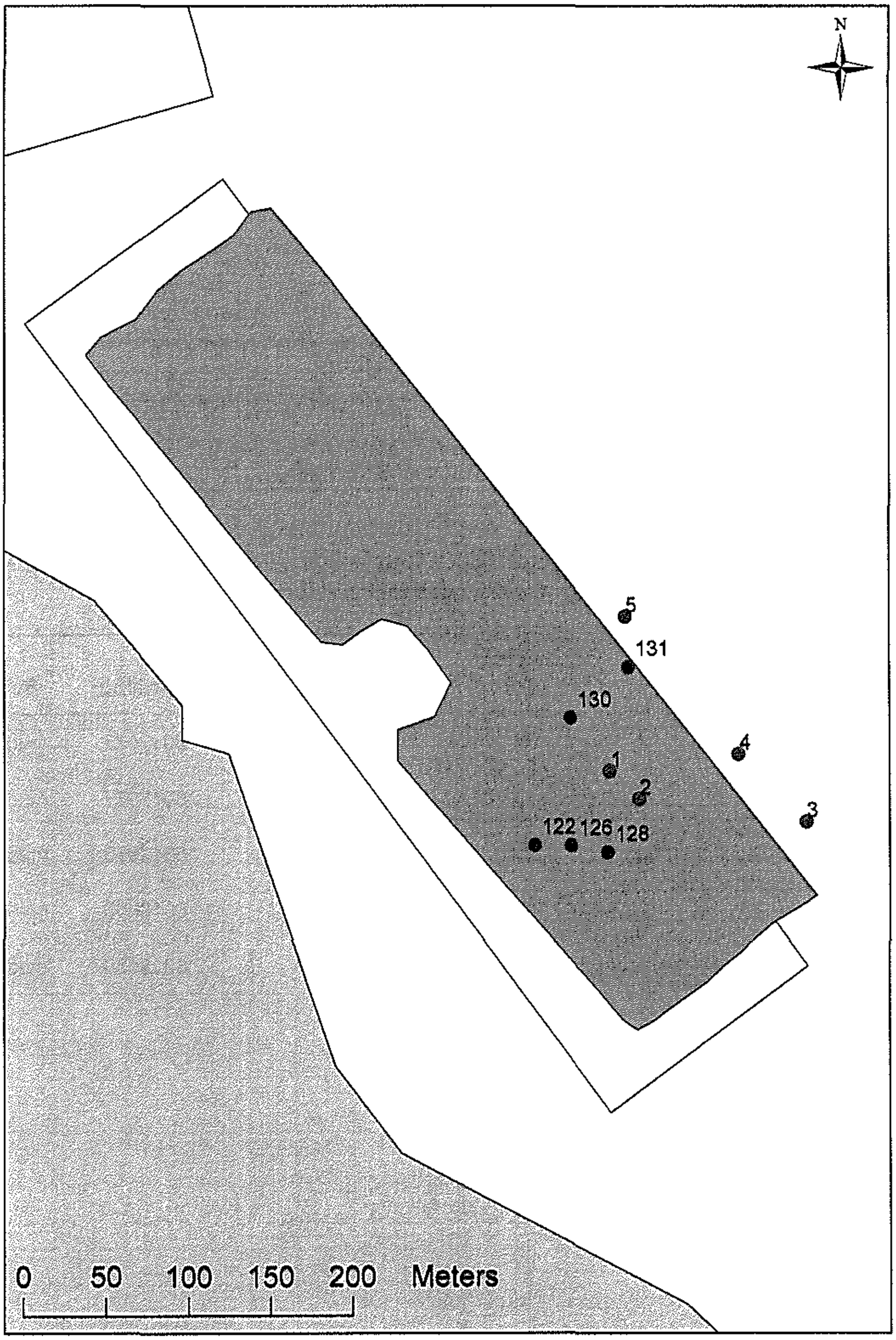
Appendix 2: Location of benthic sampling stations (red dots, 1-5 indicate grab sample positions, blue dots indicate drop camera locations: numbering as in Appendix 3) for Resource Consent U950008, Anakoha Bay. Existing farm = purple, extension site = yellow



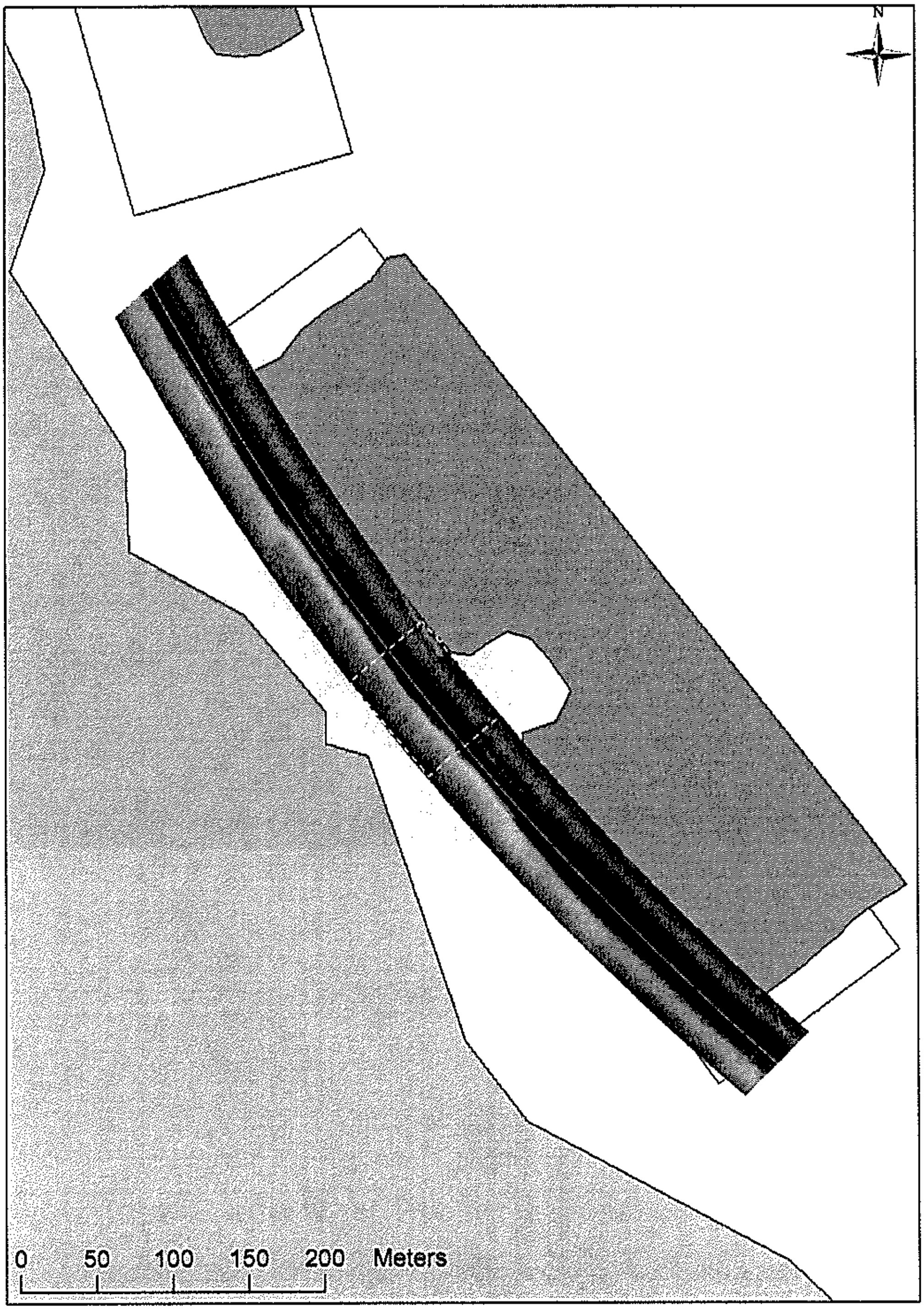
Appendix 3a: Sample position and sediment characteristics at grab sample stations for U950008. Positions are reported in New Zealand Map Grid. 'O' refers to samples taken outside of an existing farm or extension area, 'IE', samples taken within the extension area, 'IF', samples taken within an existing farm.

Grab ID	Sample Location	Easting	Northing	Redox depth (mm)	% Organic Matter	Grain size composition		
						%<63 μm	%63-200 μm	%>200 μm
1	IF	2602365	6018022	40	6.2	96.32	3.42	0.26
2	IF	2602383	6018005	30	5.5	96.49	3.33	0.18
3	O	2602485	6017991	50	5.0	94.58	5.06	0.36
4	O	2602444	6018032	55	5.8	96.79	2.93	0.28
5	O	2602375	6018117	200	5.0	96.20	3.52	0.28

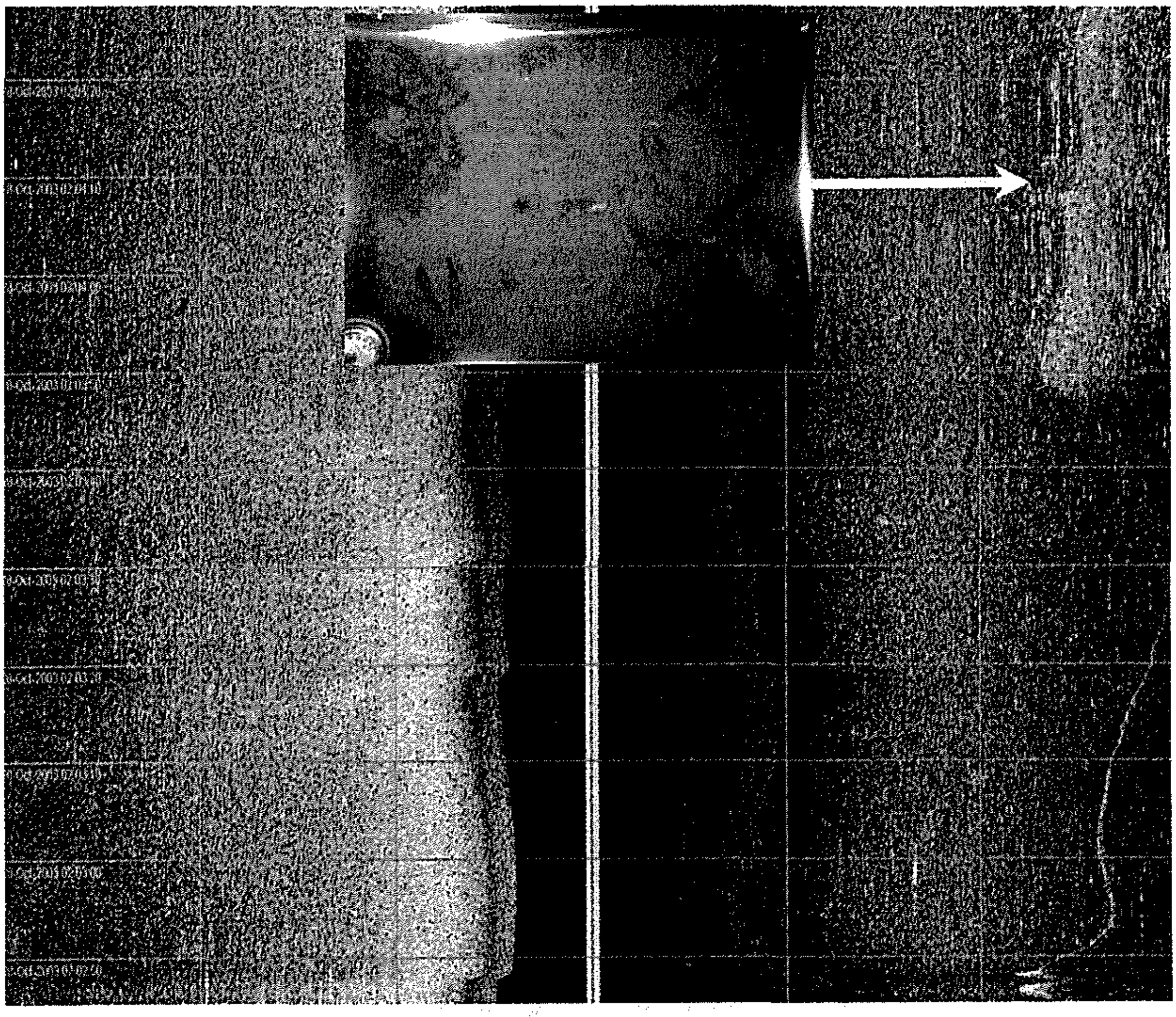
Appendix 3b: Sample position, water depth and substratum type at drop cam stations for U950008. Positions are reported in New Zealand Map Grid.

Photo ID	Sample Location	Depth (m)	Easting	Northing	Substrate type
122	IF	18	2602319	6017977	mud
126	IF	18	2602341	6017977	mud
128	IF	13.5	2602364	6017973	mud/shell
130	IF	14.5	2602341	6018055	mud/shell
131	IF	15	2602376	6018086	mud/shell

Appendix 4: Location of side-scan sampling track for Resource Consent U950008, Anakoha Bay. Existing farm = purple, existing consent area = white, extension site = yellow. Dashed white insert indicates location of Appendix 5 below.



Appendix 5: Side-scan sonar image showing an example of mussel debris beneath the mussel farm (note: photo not from U950008, for example only).



Appendix 6: Summary of information obtained from side-scan sonar records for U950008. GPS coordinates (latitude/longitude and NZ grid references) were taken at the beginning and end of each track, and every 1 minute 50 seconds during the duration of each record. Additionally, coordinates were noted when features of interest were present. Coordinates refer to the central line of the side-scan swath.

Track ID	Latitude	Longitude	Easting	Northing	Sediment Type	Seabed Class	Notes
AB5	S 41 2.464	E 174 5.961	2602415	6017815	Mud/Sand	Soft sediment	Anchor warp visible farm side
AB5	S 41 2.473	E 174 5.896	2602324	6017800	Mud/Sand/Some shell	Soft sediment	Shell debris visible farm side
AB5	S 41 2.426	E 174 5.880	2602302	6017887	Mud/Sand/Some shell	Soft sediment	Shell debris visible farm side
AB5	S 41 2.381	E 174 5.831	2602235	6017971	Mud/Sand	Soft sediment	
AB5	S 41 2.335	E 174 5.795	2602185	6018057	Mud/Sand	Soft sediment	Anchor warp visible farm side
AB5	S 41 2.340	E 174 5.799	2602191	6018047	Mud/Sand	Soft sediment	Anchor block and warps visible farm side
AB5	S 41 2.312	E 174 5.776	2602159	6018100	Mud/Sand	Soft sediment/Shell	Growing line and debris visible farm side
AB5	S 41 2.304	E 174 5.766	2602146	6018115	Mud/Sand/Shell	Soft sediment/Shell	Growing line and shell debris visible farm side
AB5	S 41 2.291	E 174 5.747	2602119	6018139	Mud/Sand/Shell	Soft sediment/Shell	Debris visible farm side
AB5	S 41 2.273	E 174 5.718	2602079	6018173	Mud/Sand	Soft sediment	Some coarser sediment shore side
AB5	S 41 2.198	E 174 5.664	2602005	6018313	Mud/Sand	Soft sediment	
AB5	S 41 2.203	E 174 5.664	2602005	6018303	Mud/Sand	Soft sediment	Anchor warp visible farm side
AB5	S 41 2.191	E 174 5.657	2601995	6018326	Mud/Sand	Soft sediment	

Appendix 7: Species collected by Van Veen benthic grab Anakoha Bay. Numbers are per grab (ca 0.13 m^2). Replicates 1 & 2 are from inside the existing farm (U950008) and samples 3-5 are from outside the farm.

Inside/outside existing farm	Inside		Outside		
TAXON	**1**	**2**	**3**	**4**	**5**
Hydrozoa					
unid thecate hydroid A		1			
Polychaeta					
Glyceridae		1			
Lumbrineridae	1		1		1
Maldanidae	1	4	1	1	
Aglaophamus sp.	1				
Orbiniidae	1				
Sigalionidae	2	2	3		1
Spiochaetopterus sp.		1			
Spionidae	2				
Sternaspidae	1		1		
Trichobranchidae	1				
Gastropoda					
Zeacolpus pagoda	6	4	4	2	1
Bivalvia					
Ennucula strangei	1		2	3	3
Neilo australis			1		
Theora lubrica	4	15			
Isopoda					
Cirolana sp. A					1
Amphipoda					
Ampelisca chiltoni				2	
Proharpinia sp.					1
Torridoharpinia hurleyi	1				
Decapoda					
Macrophthalmus hirtipes	6	10	4	2	3
Ophiuroidea					
Amphiura rosea			1		
Echinoidea					
Echinocardium cordatum				1	1
Total number of taxa (S)	13	8	9	6	8
Total number of individuals (N)	28	38	18	11	12
Margalef's species richness (d)	3.60	1.92	2.76	2.08	2.81
Pielou's eveness (J')	0.88	0.79	0.92	0.96	0.93
Shannon-Wiener diversity (H', loge)	2.27	1.63	2.01	1.72	1.93

Appendix 8: Conspicuous epibenthic species identified from drop camera photos at U950008. Photo locations from Appendix 3b 'Y' indicates present.

Photo No.	122	126	128	130	131
Inside/Outside existing farm			Inside		
Perna canaliculus			Y	Y	Y
Patiriella regularis	1				