Bay of Plenty coastal productivity monitoring - 2010

Bay of Plenty Regional Council
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Cover Photo:
By Stephen Park: Wild mussels that grew on the productivity buoy.

Acknowledgements

The Ministry for the Environment is thanked for their support by way of a grant from the Aquaculture Planning fund which was used facilitate the establishment of the monitoring programme.

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Executive summary

The Bay of Plenty Regional Council has initiated baseline coastal productivity monitoring in anticipation of the expected large scale aquaculture development in coastal waters. A key aim of the monitoring is to create a baseline of the carrying capacity which could be used to safeguard naturally occurring shellfish resources and other filter feeding species. The monitoring is based on recording of growth and condition of green-lipped mussels (*Perna canaliculus*), water chemistry, data logging of phytoplankton fluorescence and quantitative counts of phytoplankton species. In 2009 a monitoring site was set up in the central Bay of Plenty and this report gives the results for the first two years.

Water chemistry results recorded during the first two years of monitoring are within the range previously noted for mid shelf waters of the Bay of Plenty (Park 2005, Longdill *et al*. 2005). Some variation in nitrogen and chlorophyll-a concentrations between the two years was noted but it is unclear whether these are the result of short-term variations associated with tides and currents or more sustained variation induced by climate variation between years.

Chlorophyll-a levels estimated by fluorescence measurements over a 48 day period in late spring averaged around 1.6 mg/m^3 with recorded phytoplankton species from the water samples being typical of those previously noted in the Bay of Plenty shelf waters. Based on the sampled and estimated concentration of chlorophyll-a, the waters can be described as 'moderate to good' for mussel culture (Inglis *et al*. 2005).

The condition and growth rates of mussels measured from the first year of deployment (2010) at the monitoring site compared well to sites elsewhere in New Zealand where conditions are favourable for mussel growth. In the later period of deployment (last 48 days) mussel shell growth averaged 0.2 mm/day.

Contents

Tables and Figures

Part 1: Introduction

Baseline coastal productivity monitoring has been included as part of the Bay of Plenty Regional Council's regional monitoring programme. Monitoring began in 2009 with partial field sampling followed by complete field sampling in 2010. This report presents the monitoring results from 2009 and 2010.

1.1 Scope

The objectives of the monitoring programme are to:

- Provide baseline measurements of environmental conditions and phytoplankton productivity;
- Promote the sustainability of natural shellfish stocks in the Bay of Plenty;
- Support regional aquaculture through the collection of environmental data.

1.2 Background

A number of oceanographic studies of the Bay of Plenty coastal shelf waters have been undertaken by the Bay of Plenty Regional Council. This included a series of seasonal transect surveys in 1996/1997 across the shelf (Park 1998) to establish the general characteristics of water quality. Then later in 2003/04 further field investigations were undertaken to support the development of an integrated productivity and hydrological model of the Bay of Plenty. This "Aquaculture Marine Area" project generated a number of reports detailing the physical, chemical and plankton species in the Bay (Longdill *et al* 2005, Park 2005, Beamsley *et al.* & Park & Longdill 2005) and those relating to model development (Longdill *et al.* 2005*)* and assessment of aquaculture and climate change impacts on the productivity of the Bay of Plenty (Longdill & Black 2006, Black *et al.* 2006).

The research and modelling was financially supported by the Ministry of Economic Development based on the significant contribution the project provides in assisting with the development of aquaculture in the Bay of Plenty. Council's Aquaculture Marine Areas project included a planning component which identified the constraints aquaculture development would face. The results of the planning and science research together identified significant potential for aquaculture development in the central Bay of Plenty area. This area has less constraining factors and more consistent levels of productivity. To date, one resource consent has been granted for shellfish farming, which covers a total area of 3,800 hectares off the coast of Ōpōtiki.

Having established the potential for aquaculture and approved applications for large scale developments, it was also recognised that the productivity of the current wild shellfish resources should be independently protected and assessed in some form. This need was then addressed with the inclusion of an action in Councils' Ten Year Plan. A project plan was set up to initiate and provide for the running of the project which started in late 2008 with the support of a grant from the Ministry for the Environment from its Aquaculture Planning fund.

Part 2: Location and Methods

2.1 Location

The location of the monitoring site is in the central Bay of Plenty, 10 km offshore and around 2 km north of the Rūrima Islands (Figure 2.1). The location was selected as it sits not only centrally in the bay but also in the area that could potentially be developed for aquaculture in the future. The location has rocky reef and foul ground in the area making it unsuitable for trawlers and hence safe to deploy monitoring equipment. Water depth at the site is 25 m with coarse sand and gravels present. Currents are variable and strongly influenced by wind and tide conditions (Beamsley *et al*.2005, Longdill & Black 2006).

Figure 2.1 Location of the coastal productivity monitoring site (BOP720101) north of the Rūrima Island in the central Bay of Plenty.

2.2 Methods

Productivity is monitored using information derived from water sampling, phytoplankton sampling and growth of green-lipped mussels (*Perna canaliculus*) to show the levels of planktonic food available to other shellfish and filter feeders occurring in this area of the bay. Using a naturally occurring shellfish has advantages over most other sampling methodologies in that it is measuring a more relevant end point that comprehensively integrates all factors influencing growth over the time span used.

2.2.1 Mussels

Each year small mussels 70-80 mm in length are deployed at the monitoring site in May and then samples of these are collected monthly from September to December to assess growth rates. The mussels are placed on mussel rope at an industry standard density of 180 mussels per meter of rope. The mussels and rope are attached to a small frame which is attached to a sub-surface buoy mooring line at a depth of 8m. All mussel lengths are measured to an accuracy of 1 mm prior to deployment. Upon retrieval of samples the mussels are then measured for total

length and if obvious from shell growth lines, the additional growth since deployment is directly measured. Mussels are then removed from the shell and measurements taken of flesh wet weight, flesh dry weight (after drying at 60^{o}C for 48 hours) and shell weight.

2.2.2 Water sampling

On each site visit to collect mussels the following parameters are recorded or samples taken for analysis both at the time of arrival and prior to departure;

- Secchi disk (clarity measurement recorded to 0.01m)
- Water temperature (degrees Celsius)
- Conductivity (@ 25^{o}C)
- Salinity

Water samples are collected at eight meters depth using a van Dorn bottle and then poured into clean labelled bottles which are placed in a chilly bin with ice for transport back to the laboratory. Each water sample was analysed for chlorophyll-a, TN, NOx, NH4, TP, DRP, SS and turbidity. Most samples are analysed by the Bay of Plenty Regional Council's IANZ accredited laboratory using the following methods:

- SS (Suspended Solids) – APHA 2540D, sample filtered on pre-weighed glass-fibre filter dried to constant weight at 103-105^{o}C.
- DRP (Dissolved Reactive Phosphate) – Molybdenum blue colorimetry, FIA, APHA 4500-P G, detection limit - 0.001 g/m^{3}.
- TP (Total Phosphorus) – acid persulphate digestion, molybdate colorimetry, FIA APHA 4500-P H, detection limit - 0.001.
- NH4-N (Ammonia Nitrogen) – Phenyl/hypochlorite colorimetry. FIA, APHA 4500-NH3 G, detection limit - 0.001.
- TOx-N (Oxidised Nitrogen) – flow injection analyser, APHA 4500 NO3-I, detection limit - 0.001.
- TN – (Total Nitrate) persulphate digestion, auto cadmium reduction. FIA, detection limit - 0.01.

Chlorophyll-a samples are analysed by NIWA's laboratory by filtering on 1.0 micron filters with acetone pigment extraction and spectrofluorometric measurement.

Chlorophyll-a estimates are also recorded as a time series by the deployment of a "Turner Designs – C3" fluorometer for the period covering the first mussel sample collection through to the last sample being taken. The fluorometer has a mechanical wiper to prevent any bio-fouling occurring on the sensors and records fluorescence of chl-a pigment, turbidity, temperature and depth every six minutes.

2.2.3 **Phytoplankton**

Plankton samples are taken using the same van Dorn water sample used for the chemistry and chlorophyll-a samples. A litre of water is collected in a clean labelled bottle and preserved using 5 ml Lugol's iodine solution per litre of water.

Phytoplankton species identification and quantitative cell counts were undertaken by a phytoplankton taxonomist at NIWA.

Part 3: Results

3.1 Water quality results

The key nutrient parameters, suspended solids (SS) and chlorphyll-a results for samples taken in 2009 and 2010 are provided in Table 3.1 below. Results for nitrogen and phosphorus are within the range previously observed for offshore sites in the upper water column which generally have lower values than inshore. Although there are only two sampling occasions in 2009, oxidised nitrogen values appear to be higher than in 2010 indicating a variation in nutrient dynamics or sources. This difference is also matched by higher chlorophyll-a values in 2009 compared to 2010.

Table 3.1 Results of water sample chemistry analysis from the productivity monitoring site in 2009 and 2010 (all units g/m^3 where none shown).

Date	SS	DRP	TP	NH4-N	NOx	TN	Chl-a mg/m^3
12/11/09	8.9	0.004	0.012	0.003	0.007	0.134	2.5
12/11/09	7.0	0.004	0.012	0.004	0.007	0.135	2.0
8/12/09	34.0	0.002	0.015	<0.001	0.006	0.158	1.0
8/12/09	33.0	0.006	0.017	<0.001	0.006	0.144	2.5
2009 mean	**20.7**	**0.004**	**0.014**	**0.002**	**0.007**	**0.143**	**2.0**
26/10/10	3.2	0.001	0.010	0.006	0.004	0.230	0.9
26/10/10	4.2	0.001	0.080	0.004	0.003	0.270	1.5
26/11/10	9.5	0.005	0.013	0.001	0.002	0.330	0.8
26/11/10	7.3	0.004	0.007	0.002	0.002	0.250	1.4
13/12/10	2.0	0.004	0.005	0.004	0.003	0.340	0.4
13/12/10	4.6	0.004	0.004	0.004	0.003	0.297	0.4
2010 mean	**4.6**	**0.003**	**0.020**	**0.004**	**0.003**	**0.286**	**0.9**

The record of chlorophyll-a fluorescence was matched up with chlorophyll-a pigment values for the water samples taken at the same water depth and time correlated to provide a relationship between the two as follows:

*Fluorometer values = 1244*chl-a (mg/m^3)*

As only six pairs of values were available, the correlation was not particularly tight with an r^2 value of 0.370. However this gives a reasonable relationship for converting the time series of fluorescence values into chlorophyll-a (mg/m^3) estimates. The converted values are displayed in Figure 3.1. The average chlorophyll-a value for the whole period from 26 October 2010 to 13 December 2010 is 1.63 mg/m^3. The time series shows that marked variability occurs over time with a number of days averaging up around 3-4 mg/m^3 with a few values peaking at 8 mg/m^3.

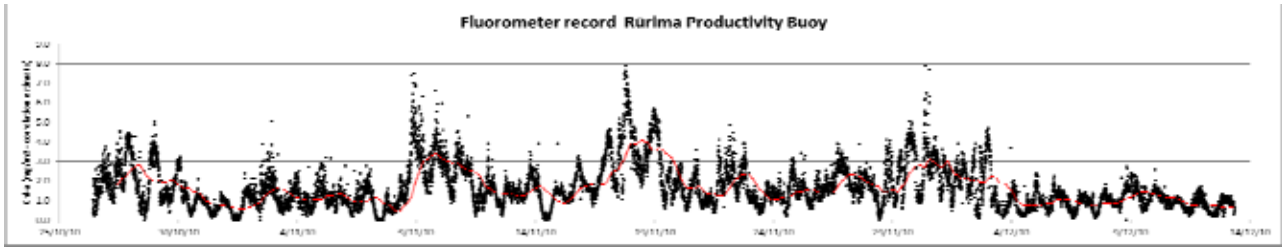

Figure 3.1 *Estimate of chl-a (mg/m3) using phytoplankton fluorescence measured at 8 m water depth at the productivity monitoring site from 26/10/2010 to 13/12/2010.*

3.2 Phytoplankton species and densities

In table 3.2 below the more numerous phytoplankton species recorded in the samples are listed along with the average density. Overall the cell counts were higher in 2010 and dinoflagellates were proportionately more numerous.

Table 3.2 *List of more numerous phytoplankton species recorded at the productivity monitoring site in 2009 and 2010 and average cells per litre.*

	Species	**2009 average**	**2010 average**
Diatoms	Ceratualina pelagica	0	383
	Cosinidiscus sp.	25	33
	Melosira sp.	100	0
	Navicula sp.	0	83
	Nitzschia longissima	0	117
	Nitzschia sp.	175	83
	Odontella mobiliensis	0	150
	Rhizosolenia setigera	0	1100
	Thalassionema nitzschioides	1975	417
	Thalassiosira rotula	150	17
Dinoflagellates	Alexandrium minutum	75	0
	Dinophysis acuta	150	0
	Gonyaulax sp.	0	16667
	Gymnodinium spp.	575	17483
	Gyrodinium spp.	50	317
	Oxytoxum spp.	25	100
	Prorocentrum sp.	0	16683
	Protoperidinium sp.	50	66850
	Scrippsiella trochoidea	125	0
	Cryptomonas sp.	100	66817
	Dictyocha speculum	0	16667
	Phaeocystis pouchetii	0	16667
Total Diatoms		2450	2450
Total Dinoflagellates		1050	118233
Total phytoplankton	**Cell concentrations/litre**	**3600**	**220867**

3.3 Mussel condition and growth

It was intended to deploy the mussels at the monitoring site on 7 May but shortage of time meant that they were temporarily placed below a buoy inshore at Kōhi Point. A series of storms then prevented transfer out to the monitoring site and resulted in the mussel frame being buried in the sand. They were retrieved and transferred to the productivity monitoring buoy on 17 June. Due to burial many of the mussels had died which restricted numbers for each monthly collection.

The mean length of all mussels on 7 May was 78.9 mm. Subsequent sampling in October, November and December resulted in the mean shell lengths shown in Figure 3.2 below. The results show very little if any growth may have occurred in the initial period due to the burial of mussels and resulting poor condition. Mussel condition was not checked after burial due to low numbers. The average growth rate in terms of shell length from 26 October to 13 December 2010 was 0.21mm per day.

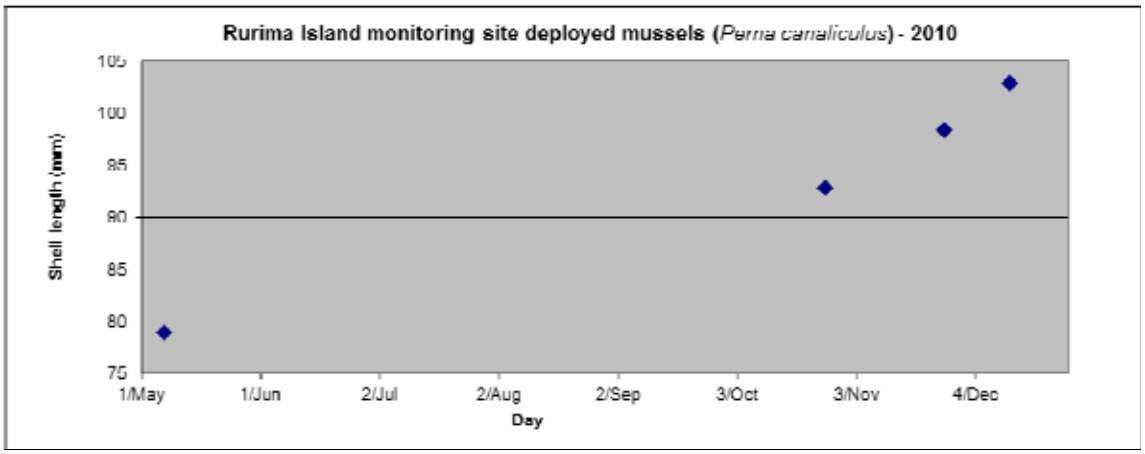

Figure 3.2 Average shell length over time of green-lipped mussels deployed at 8 m water depth at the productivity monitoring site from 17/6/2010 to 13/12/2010.

Measurements of mussel shell length, wet weight and dry weight in each sample collected from October to December were recorded and used to generate condition indices. The following two condition indices are presented in Table 3.3 below.

- The dry:wet weight ratio or CI_{weight} = 100x dry meat weight/whole weight – shell weight (as used by Hickman & Illingworth 1980), and;
- The dry weight:shell weight ratio avoids the variation associated with wet weights and is $CI_{dw:shell}$ = 100 x flesh dry weight/shell dry weight (Lucas & Beninger 1985).

Table 3.3 Mean shell length and condition indices for green-lipped mussels at the Rūrima Island monitoring site in 2010.

	Shell length (mm)			Dry:wet weight ratio			Dry wgt:shell wgt ratio		
Date	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
26/10/10	92.9	88	101	25.9	24.1	27.9	30.0	25.4	36.1
26/11/10	98.4	90	103	26.0	23.3	27.4	30.8	27.9	35.3
13/12/10	102.9	93	107	26.3	22.9	29.1	30.0	23.8	34.6

Both condition indices calculated for the mussels collected from October to December 2010 showed consistent values over this period.

Part 4: Discussion and Summary

4.1 Discussion

The results obtained for water chemistry and phytoplankton are within the range expected for the water depth and location offshore. However, in terms of the differences seen between the two years for nitrogen concentrations and chlorophyll-a, the limited sampling (only two days in 2009) makes it difficult to determine whether this variation represents wider inter-annual or short-term tide and current variation. Four monthly sampling trips to the site are scheduled in the programme and, if achieved in future years, will improve the ability to compare water chemistry from year to year. As intended the deployment and growth of the mussels over the seven month period will effectively integrate the short term variations and highlight any inter-annual climate induced variations.

In the time series record of fluorescence (chl-a estimate) obtained at the site, variability in phytoplankton abundance shows shifts in average levels over periods of days. It is likely that these shifts in average chlorophyll-a levels are related to current direction and hence the varying state of the water depending on where it is coming from. These changes in current direction also influence the water chemistry results.

Guidelines for levels of phytoplankton abundance for sustainable mussel culture defined by Inglis *et al*. (2005) put the conditions seen to date in the moderate to good category. This is confirmed by the observed growth rate (0.2mm/day) of the mussels from the monitoring site over the last 49 days which also compares well to that seen by Ogilivie *et al*. (2004) for cultured mussels in Hallam Cove, Pelorus Sound (0.11mm/day) and the 0.13mm/day maximum recorded by Alfaro *et al*. (2008) for wild mussels at Scott at the north end of Ninety Mile Beach. Condition of the mussels ($CI_{dw:shell}$) from the monitoring site (30) is also higher than values obtained by Alfaro *et al*. (2008) for wild mussels at the north end of Ninety Mile Beach.

Feral mussels which settled on to the monitoring buoy were also collected and measured for their growth and condition. The maximum age that the feral mussels could have been was 421 days at the time of collection. This gives an average growth rate over this whole period of 0.22 mm/day which is very similar to the result seen over the last 48 days for the deployed mussels. Condition of feral mussels was also the same as the deployed mussels. This indicates that the 0.2 mm/day growth estimate of deployed mussels over the last 48 day period is what could be expected over longer periods of time.

It will take a number of years recording the mussel growth rate and condition along with the water chemistry and plankton results to see the degree of inter-annual variation and establish the natural range of productivity expected at this site. Once that has been achieved though, the baseline of data will represent an important data set to assess changes and safeguard the wider ecosystem.

4.2 Summary

Water chemistry results recorded during the first two years of monitoring are within the range previously noted for mid shelf waters of the Bay of Plenty (Park 2005, Longdill *et al*. 2005). Some variation in nitrogen and chlorophyll-a concentrations between the two years was noted but it is unclear whether these are the result of

short-term variations associated with tides and currents or more sustained variation induced by climate variation between years.

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The condition and growth rates of mussels measured from the first year of deployment (2010) at the monitoring site compared well to sites elsewhere in New Zealand where conditions are favourable for mussel growth. In the later period of deployment (last 48 days) mussel shell growth averaged 0.2 mm/day.

Part 5: References

Alfaro, A.C., Webb, S.C. & Barnaby C. 2008: Variability of growth, health and population turnover within mussel beds of Perna canaliculus in northern New Zealand. *Marine biology Research* 4: 376-383.

Beamsley, B., Black, K.P., Longdill, P.C. and McComb, P. 2005: Bay of Plenty Current and Temperature Measurements: Aquaculture Management Areas. Report for the Bay of Plenty Regional Council. ASR Limited P.O. Box 67, Raglan, New Zealand.

Black, K.P., Haggitt, T. & Mead, S., Longdill, P., Prasetya, G. & Bosserelle, C. 2006: Bay of Plenty Primary production modelling: Climate impacts of productivity. Report for the Bay of Plenty Regional Council. ASR Limited P.O. Box 67, Raglan, New Zealand.

Hickman, R.W. & Illingworth, J. 1980: Condition cycle of the green-lipped mussel Perna canaliculus in New Zealand. *Marine Biology 60*: 27-38.

Inglis, G.J., Hayden, B.J. & Ross, A.H. 2000: An overview of factors affecting the carrying capacity of coastal embayments for mussel culture. Report for Ministry for the Environment No. MFE00505.

Longdill, P.C., Park, S. and Black, K.P. 2005: Bay of Plenty Shelf Water Properties Data Report 2003 – 2004: Aquaculture Management Areas. Report for the Bay of Plenty Regional Council. ASR Limited P.O. Box 67, Raglan, New Zealand.

Longdill, P.C., & Black, K.P. 2006: Numerical hydrodynamic modelling: Aquaculture Management Areas. Report for the Bay of Plenty Regional Council. ASR Limited P.O. Box 67, Raglan, New Zealand.

Longdill, P.C., Black, K.P., Haggitt, T. & Mead, S. 2006: Primary production modelling, and assessment of large scale impacts of the Aquaculture Management Areas on the productivity within the Bay of Plenty. Report for the Bay of Plenty Regional Council. ASR Limited P.O. Box 67, Raglan, New Zealand.

Lucas, A., & Beninger, P.G. 1985: The use of physiological condition indices in marine bivalve aquaculture. *Aquaculture 44*: 187-200.

Marsden, I.S. & Weatherhead, M.A. 1999: Shore-level induced variations in condition and feeding of the mussel Perna canaliculus from the east coast of the South Island, *New Zealand. New Zealand Journal of Marine and Freshwater Research 33*: 611-622.

Ogilvie, S.C., Fox, S.P., Ross, A.H., James, M.R. & Schiel D.R. 2004: Growth of mussels (*Perna canaliculus* Gmelin 1791) at a deep-water chlorophyll maximum layer. *Aquaculture Research* 35: 1253-1260.

Park, S.G. 1998: Bay of Plenty Coastal Water Quality 1996 – 1997. Environmental Report 98/5. Environment BOP, P.O. 364, Quay Street, Whakatāne, New Zealand.

Park, S.G. 2005: Bay of Plenty Coastal Water Quality 2003 – 2004. Environmental Publication 2005/13. Environment BOP, P.O. 364, Quay Street, Whakatāne, New Zealand.

Appendices

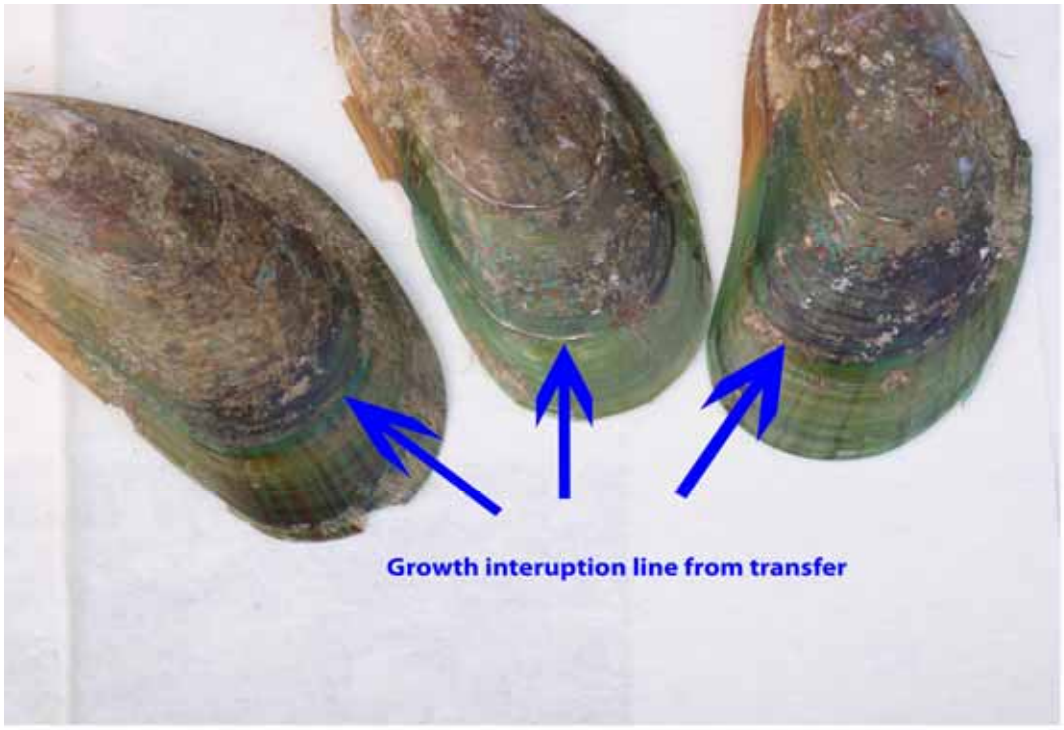
Appendix 1 – Chemistry data

Water chemistry results from samples taken at the productivity monitoring site (BOP720101) in 2009 and 2010.

Date	sample	SS	Turb	Cond	pH	DRP	TP	NH4-N	NNN	TN	Chl-a mg/m^3
12/11/09	09/5475	8.9			8.0	0.004	0.012	0.003	0.007	0.134	2.5
12/11/09	09/5476	7.0			8.0	0.004	0.012	0.004	0.007	0.135	2.0
8/12/09	09/6143	34.0				0.002	0.015	<0.001	0.006	0.158	1.0
8/12/09	09/6144	33.0				0.006	0.017	<0.001	0.006	0.144	2.5
26/10/10	10/5315	3.2	0.52	55.0	8.1	0.001	0.010	0.006	0.004	0.230	0.9
26/10/10	10/5316	4.2	0.58	53.2	8.1	0.001	0.080	0.004	0.003	0.270	1.5
26/11/10	10/6027	9.5	0.40	47.9	8.0	0.005	0.013	0.001	0.002	0.330	0.8
26/11/10	10/6028	7.3	0.52	47.9	8.1	0.004	0.007	0.002	0.002	0.250	1.4
13/12/10	10-6357	2.0	0.27	53.8	8.1	0.004	0.005	0.004	0.003	0.340	0.4
13/12/10	10-6358	4.6	0.37	53.3	8.2	0.004	0.004	0.004	0.003	0.297	0.4

Appendix 2 – Photos of mussels

Green-lipped mussels (*Perna canaliculus*) that had been deployed at the monitoring site which clearly show a growth disruption line as a result of being harvested and relocated. Earlier lines are also present and probably result from an earlier relocation.



Feral mussels from the productivity buoy which also show a minimum average growth rate of 0.2 mm/day over a period of 421 days.