Advice on the Development of Appropriate Monitoring Conditions for Marine Farm Sites in Southland

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Advice on the Development of Appropriate Monitoring Conditions for Marine Farm Sites in Southland

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Environment Southland
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ABSTRACT

The Southland region has a total of 44 existing marine farm sites. As a result of the Aquaculture Reform, Environment Southland (ES) have taken over the compliance of these consents, and a review is underway to vary, add, or delete conditions for the purpose of making the conditions consistent with the RMA, 1991. In February 2008, ES commissioned Cawthron Institute through the FRST Envirolink scheme to provide advice on suitable marine farm monitoring conditions for existing marine farm consents, as well as comment on the nitrogen budget model developed in the 1980s for Big Glory Bay.

An analysis of environmental monitoring conditions for existing marine farm sites revealed that a relatively high proportion (78%) of consents have the requirement to undertake seabed monitoring; whereas a much lower proportion (26%) are required to undertake water column monitoring. Furthermore, 39% of mussel farms and 50% of salmon farm sites (when operational) are required to measure the rate of nitrogen release from sediments to calibrate the nitrogen model developed for Big Glory Bay. Seabed monitoring conditions are currently inconsistent, and collectively include a wide range of physical, chemical and biological properties of the sediment (*e.g.* sediment sorting coefficient, grain size distribution, organic content, infaunal community composition *etc*). Water column monitoring requirements were also inconsistent across the consents, and included the measurement of visual clarity, dissolved oxygen, water temperature, pH, nutrients and chlorophyll *a*.

Following a review of existing environmental conditions and the findings of environmental monitoring reports (provided by ES), it is recommended that a regional marine farm monitoring programme is developed for the Southland region. The regional programme should be adaptive, and as such, it should be reviewed and refined regularly based on environmental performance. Environmental performance should be assessed over a range of indicators, each of which should have an associated trigger value/point that prompts a specified management response (agreed to in advance by the consent holders and ES). A similar approach has been adopted for salmon farm sites in the Marlborough Sounds.

Initially, the focus of monitoring should be water column and seabed environments in Big Glory Bay, due to the higher intensity of farming in this region compared with Bluff Harbour and Ruapuke Island. Water column monitoring at Bluff Harbour farm sites should be discontinued due to the low intensity of farming in this region; however, seabed parameters monitored should be consistent with those adopted for Big Glory Bay. All monitoring at the Ruapuke Island farm site should be discontinued due to the current lack of marine farming occurring at present. Where possible, marine farm monitoring should be coordinated with other consent-related or State of the Environment (SOE) monitoring occurring in the region to increase sampling efficiencies (*e.g.* sharing of reference sites).

A mass balance nitrogen model was developed in the 1980s for Big Glory Bay as a management tool to prevent bay-wide water column effects occurring as a result of marine farming activities. It is likely that the application of a more complex model to the Big Glory Bay system would provide greater predictive power and could be developed to incorporate real-time data (*e.g.* from buoy-moored data collection facilities), enabling much higher spatial and temporal resolution. However, the

development of a more complex model (or the continuation with the mass balance model developed in the 1980s) to assist in the management of nutrient inputs into the Big Glory Bay system would only be required if there is a recent history of water quality issues attributable to nutrients released from fish farms, or there is an expansion in salmon (or other finfish) aquaculture production in the bay.

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1. INTRODUCTION

The Southland region has a total of 44 existing marine farm sites. Since the Aquaculture Reform (Repeals and Transitional Provisions) Act 2004 (ARA 2004), pursuant to Sections 10(1) and 20(2), all leases, licences and marine farm permits are now deemed to be a coastal permit granted under the Resource Management Act 1991 (RMA). As a result, Environment Southland (ES) have taken over the compliance of these consents and a review is underway to vary, add, or delete conditions for the purpose of making the conditions consistent with the RMA, 1991.

In February 2008, ES commissioned Cawthron Institute (Cawthron) through the Foundation for Research, Science and Technology (FRST) Envirolink scheme to provide the following:

- A synopsis of monitoring conditions currently in place for marine farming sites in the region.
- Recommendations on how to monitor the environmental effects of marine farming activities, with specific consideration of how this could be achieved through monitoring conditions on Resource Consents.
- Comment on nitrogen model developed for Big Glory Bay (Roper *et al.* 1988; Rutherford *et al.* 1988).

1.1 Marine farming activities in Southland

There are three main growing regions in Southland; Big Glory Bay (36 farm sites), Bluff Harbour (7 sites) and Ruapuke Island (1 site) (Table 1). Collectively, these sites are consented to culture a range of taxa; including bivalves, salmon, paua, kina, rock lobster, sea snails and algae (Table 2). At present, mussels and salmon are the most commonly farmed species.

Big Glory Bay

Big Glory Bay is an embayment of Paterson Inlet which is approximately 4.8 km long and 2.8 km wide (surface area ~12 km^2). The bay has been used for commercial sea cage rearing of Chinook (Quinnant) salmon (*Oncorhynchus tshawytscha*) since 1981, and long-line culture of green-lipped mussels since 1987. At present, there are 36 consented marine farm sites in Big Glory Bay; which collectively allow the farming of bivalves, salmon, rock lobster and algae.

Bluff Harbour

Bluff Harbour is a tidal lagoon which has a narrow entrance. Due to the high tidal flows within the harbour, poor water clarity is often present. Currently, there are seven consented marine farm sites that collectively allow the farming of bivalves, seaweed, rock lobster, kina, paua, and sea snails.

Ruapuke Island

Ruapuke Island (14.2 km^2) is located in the eastern approaches to Foveaux Strait, approximately 32 km northeast of Oban, Stewart Island. A single paua marine farm is consented for this region, however at present this farm is not operational (K. Galbraith, pers. comm.).

Table 1. Number of existing marine farm consents (by taxonomic group) in Southland.

Farm sites	Bivalve	Salmon	Paua	Kina	Rock lobster	Sea snail	Algae
Big Glory Bay	36	8	0	0	1	0	1
Bluff Harbour	7	0	3	3	1	1	3
Ruapuke Island	0	0	1	0	0	0	0
Total consents	43	8	4	3	2	1	4

Table 2. Complete list of taxa currently consented to be farmed at marine farming sites in Southland.

Taxa group	Taxa	Common name
Bivalve	*Perna canaliculus*	Green-lipped mussel
	Mytilus edulis	Blue mussel
	Tiostrea chilensis	Dredge oyster
	Pecten novaezelandiae	Scallop
	Austrovenus stutchburyi	Littleneck clam
Salmon	*Onchorhynchus tschawytcha*	Quinnant (or Chinook) salmon
	Salmo salar	Atlantic salmon
	Oncorhynchus nerka	Sockeye salmon
Paua (gastropod)	*Haliotis iris*	Blackfoot paua
	Haliotis australis	Yellowfoot paua
Other gastropods	*Cookia sulcata*	Cooks turban
	Turbo smaragdus	Cat's eye
	Astraea heliotropium	
	Tropus sp.	
	Littorina spp.	Periwinkle
Echinoderm	*Evechinus chloroticus*	Kina
Rock lobster	*Jasus edwardsii*	Rock lobster
	Sagmariasus verreauxi	Packhorse crayfish
Algae	*Macrocystis pyrifera*	Bladder kelp
	Lessonia variegata	
	Porphyra columbina	Nori
	Ulva lactuca	Sea lettuce

2. SYNOPSIS OF EXISTING ENVIRONMENTAL MONITORING CONDITIONS

2.1. Overview

A breakdown of existing marine farm monitoring conditions (by taxa cultured) is provided in a spreadsheet in Appendix 1 ("Consent_conditions_synopsis.xls") and is summarised in Table 3. A high proportion (overall mean = 78%) of marine farm consents have conditions to undertake seabed monitoring, while a much lower proportion (*i.e.* only 26%) of marine farm consents require water column monitoring. Furthermore, 39% of mussel farms and 50% of salmon farm sites (when operational) are required to measure the rate of nitrogen release from sediments to calibrate the predictive nitrogen model developed for Big Glory Bay. However, in recent years this has discontinued due to doubts over the value of this model in managing nitrogen loads in the bay (K. Galbraith, pers. comm.).

Table 3. Monitoring required under existing consents for various taxonomic groups.

	Taxa (no. of consented sites)						
Monitoring required	**Bivalves (43)**	**Salmon (8)**	**Paua (4)**	**Kina (3)**	**Rock lobster (2)**	**Sea snails (1)**	**Algae (4)**
Sediment analysis	31	8	3	3	2	1	3
Epibiota	27	8	0	0	1	0	0
Infauna	10	7	0	0	0	0	0
Water samples	17	0	0	0	0	0	0
Nitrogen restriction levels	7	7	0	0	0	0	0
Nitrogen model contribution	14	4	0	0	0	0	0

2.2. Environmental parameters measured

2.2.1. Seabed

Seabed monitoring conditions were not consistent across the marine farming consents; however, there were some patterns evident for applications processed at similar times (*e.g.* parameters measured, frequency of monitoring). Seabed parameters monitored included:

- Depth of oxygenated layer
- Sediment grain size analyses (% gravel, sand and mud)
- Determination of the sorting coefficient
- Measurement of sediment organic (volatile solids) and inorganic material (non-volatile or fixed solids)
- Measurement of sediment nutrients (*e.g.* total nitrogen and total phosphorus)
- Abundance and diversity infaunal taxa
- Abundance and distribution of epibiota (including predatory starfish) and shell litter

- Fourteen mussel farm sites and four salmon farm sites in Big Glory Bay are required to monitor the release of nitrogen from the sediments as part of the nitrogen model developed for the Bay

2.2.2. Water column

As with seabed monitoring, water column monitoring requirements were also inconsistent across the consents. The range of parameters monitored included:

- Nutrient (DIN, PN, PP, DRP)
- Dissolved oxygen
- Chlorophyll *a*
- Water temperature
- pH
- Visual clarity

2.3. Frequency of sampling

The frequency of seabed and water column monitoring was relatively inconsistent across the existing marine farm consents. For example, seabed monitoring at many farm sites is annual, with the Council providing the consent holder an option to apply for a review of the monitoring conditions (at two-yearly intervals). By contrast, the frequency of monitoring at other sites changes with the time of operation (*e.g.* every six months, then at intervals of five and 10 years). For many farm sites in Big Glory Bay, water column monitoring is monthly over the warmer summer months, while the frequency of water column monitoring at several sites in Bluff Harbour decreases with increasing time of operation (*e.g.* every two months until the first harvest cycle, followed by 6-monthly sampling).

3. SUMMARY OF ENVIRONMENTAL MONITORING RESULTS

Environment Southland provided the following environmental monitoring reports from farm sites in Big Glory Bay to assist in the development of appropriate environmental monitoring conditions:

- A NIWA client report describing pre-farming (*i.e.* baseline) seabed and water column environments at mussel farming sites in Big Glory Bay.
- Annual monitoring reports of seabed and water column environments at mussel farming sites in Big Glory Bay (1999-2005).

- A report prepared by the Department of Marine Science (University of Otago) describing sediment texture and composition from sites beneath and adjacent to a farm site used to hold kina and paua.
- A report describing the nature of seabed sediments and biota present beneath the above-mentioned site used to hold kina and paua.
- Results of water column nutrient and chlorophyll *a* monitoring (1998-2006) undertaken by Sanford Limited Bluff (samples analysed by NIWA Christchurch).

Since 1998, NIWA have been monitoring changes in sediment grain size, organic content and nutrients, as well as the composition of epibiota (organisms living on the sediment surface) at sites within Big Glory Bay. The latest NIWA annual monitoring report (September 2005) concludes that there is no evidence to suggest that mussel farming is markedly altering sediments and associated benthos in the region. The most significant change observed has been the accumulation of large numbers of green-lipped mussels on the seabed directly beneath the farm sites. The report also states that "there appears to be no marked change in nutrient and chlorophyll *a* concentrations in Big Glory Bay since monitoring started in 1997, and mussel farming does not appear to have undesirable effects on water quality, such as nuisance blooms of phytoplankton." Furthermore, in a letter (dated 8 October 2003) to Sanford Limited Bluff from Catherine Chaqué-Goff (NIWA Christchurch), it is suggested that Big Glory Bay was becoming nitrogen deficient, and there was no longer the need to re-run the nitrogen model for the bay due to declining salmon farm sites (net producers of nitrogen) coupled with an increase in mussel farming sites (net consumers of nitrogen).

4. PROPOSED APPROACH TO A REGIONAL MARINE FARM MONITORING PROGRAMME

Following a review of existing marine farm consent conditions and the findings of environmental monitoring reports provided by ES, it is proposed that the most efficient way to monitor farms in the Southland region is through a regional marine farm monitoring programme. Developing this programme is outside the scope of the current small advice Envirolink grant; however provided in the following section guidance on what and how to measure the effects of marine farming in the region.

Approach: Rather than monitor each individual marine farm in a region, sampling effort is focused on the representative farm sites to provide an indication of the current health of habitats and associated biota beneath and adjacent to marine farm sites in the region.

Purpose: To ensure that existing marine farms are operating within the assimilation capacity of the marine environment and that effects to seabed and water column environments are not 'more than minor.'

A regional approach to monitoring is likely to be a far more efficient way to measure environmental effects, and it will allow resource managers to gauge whether habitats are stable, degrading or improving. However, for this approach to be successful, it is important that i) representative farm sites and habitats are monitored; ii) appropriate indicators of environmental 'health' are used; and iii) sampling is undertaken at the appropriate frequency and intensity using consistent methods. These requirements are discussed in greater detail in the following section.

4.1. What sites/habitats to sample?

The first step is to group marine farm sites according to the similarity of key environmental (habitat) characteristics (*e.g.* depths, currents, seabed community type). This enables the selection of representative farms that would be expected to perform similarly with respect to environmental impacts. Site groupings can then be evaluated according to the environmental risks that they pose (*e.g.* high, medium and low risk zones), which will influence the intensity and frequency of sampling undertaken. In this way, sites that pose low environmental risk are less intensively monitored, allowing for more effort to be placed on site groupings that are of higher risk.

The second step is allocating effort to the site grouping within each growing region. There are three main growing regions in Southland; Big Glory Bay (36 farm sites), Bluff Harbour (7 sites) and Ruapuke Island (1 site). Sampling effort (*i.e.* number of sites and habitats) should be greatest in areas of highest farming intensity and where environmental effects are likely to be highest due to environmental conditions in the region (*e.g.* water currents and flushing characteristics, water depth, substrate type *etc*). The following is recommended:

Considerations for farming regions

- Greatest monitoring effort should be undertaken in Big Glory Bay due the higher intensity of farming in this region. Indicator farm sites should encompass the range of habitats and environmental conditions in the bay; in particular, areas of low and high currents/flushing. Consideration should also be given to monitoring sites farming the different taxa (*e.g.* finfish, mussels, seaweeds). Sites that have had historically high-level seabed effects (*e.g.* salmon farm sites) should be given particular attention.
- Monitoring of farm sites in Bluff Harbour should initially be consistent with monitoring undertaken in Big Glory Bay. However, it is envisaged that due to the low farming intensity in this region, seabed sampling at these sites will quickly become less frequent and water column monitoring discontinued.
- Environmental monitoring is not required at the Ruapuke Island site unless marine farming resumes at the single consented site.
- Appropriate control sites are established.

General considerations

- Ecologically significant taxa (or habitats), and habitats sensitive to the depositional effects of marine farms (*e.g.* rocky reefs) that are in the immediate vicinity of farm sites, should also be monitored as part of the regional programme. These habitats are likely to already have been identified during the initial site assessment or during subsequent monitoring at the site.
- Consideration will also need to be given to the effects of the marine farm sites in relation to other discharges and activities occurring in the region (*e.g.* Tiwai aluminium smelter in Bluff Harbour).
- Where possible, marine farm monitoring should be coordinated with other consent-related or State of the Environment (SOE) monitoring occurring in the region to increase sampling efficiencies (*e.g.* sharing of reference sites).

4.2. What to measure?

There are numerous approaches to monitoring the effects of marine farming activities on seabed and water column environments. Provided below is a recommended approach based on sampling programmes developed by Cawthron for mussel and salmon farms in the Nelson/Marlborough region. Similar approaches have also been adopted for farm sites in the Firth of Thames, Northland and proposed large offshore marine sites in the Bay of Plenty and Hawkes Bay regions.

4.2.1. Seabed environment

Physical, chemical and biological properties of the sediments
Analyses of the physical, chemical, and biological characteristics of sediment are a proven and reliable method to measure seabed enrichment effects from marine farming activities. While conventional sediment sampling methods are outlined below, it is worthwhile highlighting that less expensive (in terms of processing time and costs) methods to characterise sediment health are emerging, such as sediment profile imagery (SPI), which may be appropriate to replace some of the conventional methods in the future.

Listed below is a suite of indicators recommended for assessing sediment quality; ranging from quick and inexpensive (*e.g.* sediment odour, colour and depth of the oxygenated layer) to more labour intensive and relatively expensive (*e.g.* infaunal community composition):

- Sediment colour (anoxic sediments are black).
- Depth of the oxygenated layer below the sediment surface (*i.e.* above any obvious REDOX layer).
- Occurrence of excess hydrogen sulphide (as indicated by the characteristic rotten egg odour).

- Sediment texture of the upper 2 cm of the sediment (determined from a particle grain size analysis).
- Total organic content of the upper 2 cm of the sediment (determined in the laboratory).
- Infaunal community composition (requires taxonomic expertise).

Increased levels of trace metals (zinc and copper) can be found in sediments beneath fish cages in New Zealand and overseas. Zinc is a nutritional supplement necessary for maintaining fish health, and copper comes from antifouling paint whose use is necessary to minimise the build-up of fouling organisms. Both zinc and copper are likely to bind with sediments and organic material, which will naturally mitigate their risk to the environment. Cawthron currently monitors zinc and copper concentrations beneath salmon farm sites in the Marlborough Sounds, and it is recommended that this is also initially undertaken at the salmon farm site in Big Glory Bay to ascertain present levels.

Shell debris and epibiota

Information obtained from observations of shell debris and epibiota (organisms living on the sediment surface) can provide a useful indication of changes over time, particularly if the same sites are revisited. However, unlike infaunal communities, changes in epibiota composition, abundance and distribution can be difficult to interpret due to the often large natural spatial and temporal variability. This variability makes it hard to attribute changes to the presence of marine farms, and as such, the inclusion of these observations in an 'adaptive' monitoring programme is questionable. If monitoring of epibiota is included in the regional monitoring programme, it is recommend that:

- It is undertaken in a quantitative manner (*e.g.* photoquadrats).
- Fixed sampling locations (reduces the influence of spatial variability for non-mobile taxa).
- High sampling effort (to ensure that the epibiota and shell litter are well represented).
- It is undertaken at a frequency less than that of other seabed sampling (*i.e.* infauna, organic content *etc*).

Sampling frequency

It is recommended that seabed monitoring frequency is adaptive to the results of monitoring. For example, sites in the low risk zone(s) may consistently show low-level effects, and as such monitoring of the seabed does not have to occur as frequently (*e.g.* once every 5-10 years to assess cumulative effects). By contrast, sites in the higher risk zones (including nearby sensitive or ecologically significant habitats) may be monitored more frequently (*e.g.* annually), particularly if monitoring indicates that high level effects are occurring (*e.g.* sediment out-gassing, sediments devoid of taxa *etc*). An adaptive sampling timetable, with clearly identified sampling frequencies for individual seabed parameters, will need to be created if a regional monitoring programme is developed.

4.2.2. Water column environment

Unlike seabed monitoring, there is no strong general consensus on how to monitor changes to water column environments from marine farming activities. Provided below is guidance on monitoring potential water column effects from mussel and salmon farming activities (the two main types of marine farming occurring in the region), as well as a recommended approach to water column monitoring in the Southland region.

Considerations for mussel farms

Mussels feed on suspended organic material including phytoplankton and zooplankton (suspended passive or slow moving microscopic plants and animals respectively), and detritus (non-living organic particles). Suspended organic material plays an important role in the marine food web; therefore its removal may potentially lead to flow-on effects to other organisms, although with the exception of phytoplankton, the scientific understanding of many of these interactions is poor. Quantifying these interactions can be very difficult and attempts to do this generally involve intensive computer modelling exercises, which can be expensive and require a lot of data to validate. An alternative approach is to use environmental performance indicators to gain insight into the level of control that mussel culture may be having on the phytoplankton populations. Cawthron developed a suite of indicators to assist with addressing water column sustainability questions in the Marlborough Sounds (see Gibbs 2007).

There are several approaches that can be taken if water column monitoring is considered to be justified (*e.g.* following the application of the performance indicators). Firstly, the extent and magnitude of chlorophyll *a* depletion both inside and outside of marine farms can be measured by undertaking rapid spatial chlorophyll *a* survey(s) using a flow-through system (see Figure 1 for an example). CTD casts are also undertaken during spatial surveys to obtain a vertical profile of the physical, chemical and biological properties of the water column (*e.g.* water temperature, salinity, chlorophyll *a*, turbidity, dissolved oxygen). Cawthron has used this approach during numerous chlorophyll *a* surveys at marine farm sites throughout the Marlborough Sounds, and can provide a library of such surveys to compare results against. A second approach is the continuous (*e.g.* at hourly intervals) collection of hydrodynamic and water quality information (*e.g.* current velocity and direction, chlorophyll *a*, turbidity) from a buoy-mounted data collecting facility (Figure 2). Information collected at the facility can then be sent via telemetry to a website where it can be monitored and stored. This approach provides a long-term dataset suitable for comparison with data collected during spatial surveys or from other water column monitoring in the region. Cawthron is currently using this approach to monitor water quality in the plume of the Motueka River (Tasman Bay) and this approach will be used to monitor marine farm effects on the water column in Tasman Bay during the development of several large marine farm sites (>200 ha) in the Bay.

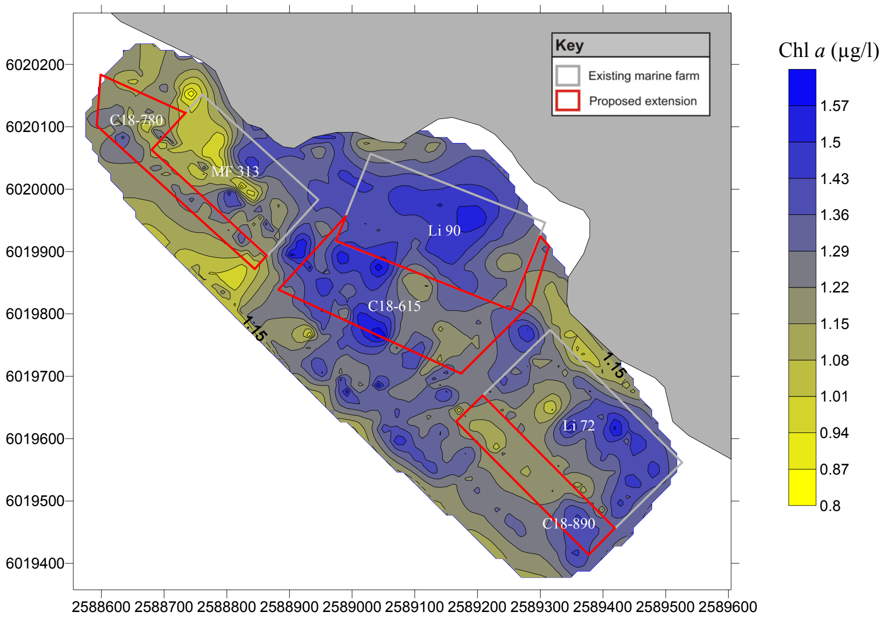

Figure 1. Chl *a* concentrations (µg/l) recorded within and adjacent to existing and proposed marine farm sites in the Marlborough Sounds (Cawthron unpublished data).

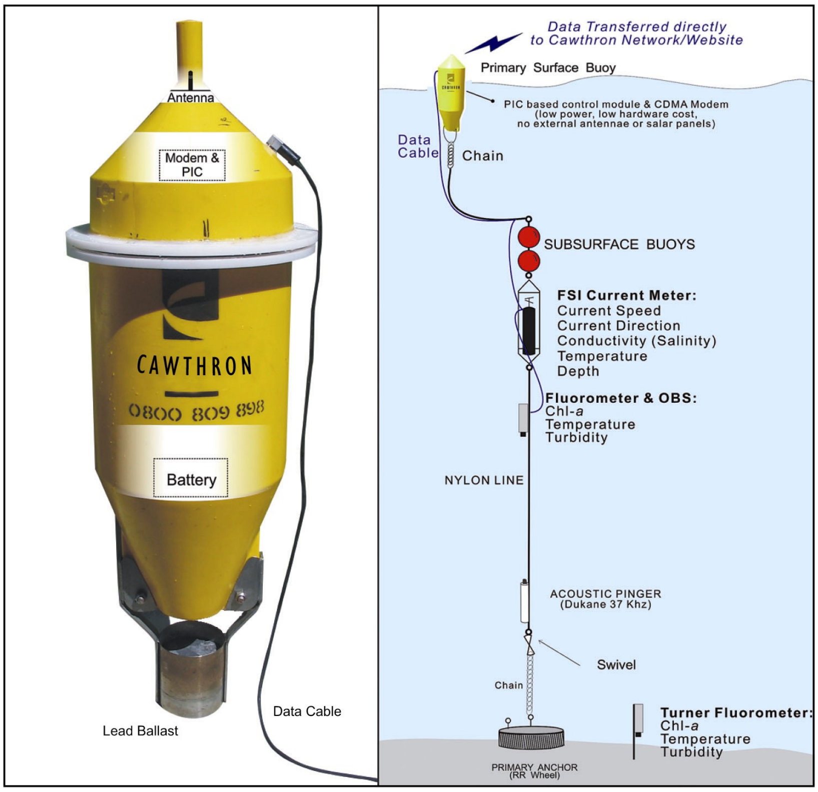

Figure 2. Buoy-mounted data collecting facility currently used by Cawthron to monitor the influence of the Motueka River on water column processes in Tasman Bay. Similar devices are also proposed for large marine farm developments in Tasman and Golden Bays.

An alternative approach (not favoured by Cawthron) is the collection of a large number of water samples to determine water column nutrient concentrations and phytoplankton/zooplankton abundance. While this approach creates a large amount of data, determining the influence of marine farms on these parameters is extremely difficult due to the complex interactions that are occurring (both in time and space) in the water column. An additional consideration for this approach is the large cost associated with collecting, transporting and analysing the water samples.

Considerations for salmon farms

The following section includes text from Forrest et al. (2008), "Review of the ecological effects of finfish aquaculture;" a report prepared by Cawthron for the Ministry of Fisheries.

The depletion of dissolved oxygen (DO) and nutrient enrichment of the water column are the two main issues that need to be considered for salmon farm sites in Big Glory Bay. Depletion of DO can occur within and around finfish farms due to the respiratory activities of the farmed fish and microbial degradation of waste materials in seabed sediments. This issue is of most significance to the farmed finfish stock although it may also be of ecological importance (see below). Excessive oxygen depletion in the water column could potentially stress or kill the fish and other animals (*e.g.* epibiota); with sediment DO depletion resulting in the release of toxic by-products (*e.g.* hydrogen sulphide) into the water, which can also have adverse effects on fish and other organisms. Significant depletion of water column concentrations of DO at finfish farms overseas has usually only occurred when cages are heavily stocked or where they are located in shallow sites with weak flushing. DO depletion is an issue that may need to be considered if, for example, multiple farms in close proximity are proposed. In such instances there is the potential for DO to become increasingly depleted as water currents pass through sequential farms. These types of risks can be avoided by appropriate spacing of sites.

From an ecological perspective, the most important water column issue that should be considered in relation to finfish farm development in New Zealand is the potential 'eutrophication' effect of nutrient enrichment. Eutrophication is the process where excessive nutrient inputs to a water body result in excessive algal growth and flow-on effects to the wider environment such as reduced water clarity, physical smothering of biota, or extreme reductions in DO because of microbial decay of the algal biomass. In marine systems, an additional concern with water column nutrient enrichment is the potential for an increased occurrence of harmful algal blooms (HABs). This includes blooms of species that produce biotoxins. Some biotoxins can be directly toxic to fish, and others can accumulate in shellfish and affect consumers, often leading to restrictions in harvesting shellfish. Salmon farming in New Zealand has not given rise to these types of effects, and such effects are unlikely in the near future unless considerable new development is anticipated.

There is no widely accepted guidance as to what constitutes an acceptable level of nitrogen input to coastal systems. In order to avoid over-enrichment (*i.e.* eutrophication), the input must not exceed the assimilative capacity of the receiving environment at local scales and more broadly. However, the assimilative capacity is a complex function of a system's biotic and abiotic characteristics and includes such factors as flushing rate, light and temperature regime, several nutrient cycling processes (*e.g.* microbial remineralisation and denitrification rates), and grazing pressure.

Although there is general consensus that fish farms cause localised nutrient enrichment, the effects on phytoplankton communities in general (*e.g.* species composition and abundance) are not well understood for coastal waters. Monitoring results for salmon farms in the Marlborough Sounds suggest that nitrogen concentrations sufficient to cause significant enrichment have not been reached as a result of farm inputs (Hopkins *et al.* 2004). Although within-cage nitrogen concentrations may become measurably elevated, these are likely to be diluted to near-ambient levels within a period of hours. In such instances, it is unlikely that nutrient releases from within the cages would stimulate development of phytoplankton blooms, as the generation time required for phytoplankton to respond is 1-3 days. Hence, at sites where flushing and mixing rates are sufficient to dilute locally elevated nutrient concentrations to near ambient levels before phytoplankton are able to reproduce, blooms are not likely to be generated.

In New Zealand, no link has been made between salmon farm nutrients and HABs. Where HABs have occurred in the vicinity of salmon farms their cause has been attributed to natural processes. Similarly, phytoplankton monitoring in the Marlborough Sounds has not revealed an increased phytoplankton biomass or incidence of HABs in the vicinity of salmon farms. While blooms of phytoplankton have been recorded and harmful species detected throughout the Sounds, these appear to be regional phenomena and driven by processes that are unrelated to salmon farming activities. Nonetheless, any nutrient discharge into a nutrient-limited environment will result in an increase in phytoplankton biomass. Where this enhanced production occurs over a wide area, is rapidly diluted, or mitigated by other forms of aquaculture (*e.g.* shellfish farming), it is unlikely to cause adverse effects. However, it is theoretically possible for incremental increases (*i.e.* in addition to those from other sources) in nutrient concentrations from finfish farms to affect the magnitude or duration of natural bloom events.

The range of water column monitoring typically undertaken at finfish sites ranges from 'no monitoring' (*e.g.* in areas with low farming intensity) to frequent monitoring of parameters such as water clarity, DO (and water temperature), nutrients (particularly nitrogen), chlorophyll *a* and phytoplankton community composition. In the Marlborough Sounds, New Zealand King Salmon Ltd (NZKSL) routinely measure DO, water temperature and water clarity. NZKSL also participate in the Marlborough Shellfish Quality Programme (MSQP), where water samples are collected on a frequent basis at sites throughout the Sounds to monitor phytoplankton community composition and abundance in an effort to detect and monitor HABs in this mussel farming region.

Recommended approach to water column monitoring of marine farms in the region

Mussel farming activities

Water column monitoring should initially be undertaken at indicator farm sites in Big Glory Bay and in Bluff Harbour to estimate levels of phytoplankton depletion occurring. A different approach to water column monitoring than that presently adopted (or consented) is proposed, and the following steps are recommended:

1) Apply sustainability performance indicators (PIs), such as those developed by Gibbs (2007), to evaluate any obvious ecosystem risks associated with existing or proposed levels of marine farming in the two main growing regions (Big Glory Bay and Bluff Harbour).
2) Undertake spatial surveys of chlorophyll *a* concentration at fully stocked indicator sites in both regions at different times of the year; encompassing sites across a range of environmental conditions (*e.g.* tides, currents, water depth).
3) If the sustainability PIs and spatial surveys indicate that there are low levels of phytoplankton depletion occurring in the growing region, water column monitoring can be discontinued indefinitely, unless of course significant new development of mussel farms occurs in the region.
4) However, if either 1) and 2) above indicate that existing mussel farming activities are likely to be significantly depleting phytoplankton concentrations within farm sites (*i.e.* farm-scale effects) and beyond (bay-wide effects), it is recommended that water column parameters (including chlorophyll *a*) are monitored on a regular basis. The most informative and cost-effective method (at present) to achieve this is the use of a moored data collection facility coupled with rapid spatial surveys of chlorophyll *a* concentrations (described in Section 4.2.2).

Fish farming activities

In terms of nutrient monitoring, it is unlikely that discharges from the single operational salmon farm (out of the eight sites consented for salmon farming) are beyond the assimilation capacity of Big Glory Bay. This is supported by NIWA's monitoring observations, where it appears that Big Glory Bay may be nitrogen deficient (rather than eutrophic). As such, there is no present need to undertake nutrient monitoring at this farm site. Water column nutrients (or preferably phytoplankton community composition) can be monitored in the future if salmon farming activities increase in the Bay or signs of eutrophication (*e.g.* excess algal production) become evident. All finfish growing regions should be included in the national phytoplankton monitoring network in order to identify any aquaculture-related increases in harmful algal bloom (HAB) incidence.

4.2.3. Mammals and seabirds

For aquaculture, potential effects on marine mammals include entanglement, displacement, alteration of trophic pathways, and disruption of migration pathways in the case of large cetaceans (Watson-Capps & Mann 2005). New Zealand fur seals are a problematic predatory species around salmon farms, leading to use of predator exclusion nets around most sea-cages.

There are very few documented cases of entanglement of seals and marine mammals in finfish farm predator nets in New Zealand, and appropriate management responses by the industry (*e.g.* changes to net design, development of protocols for net changing) mean that entanglement is unlikely to be a significant ongoing issue. Another potential effect of aquaculture generally is the location of marine farm structures in critical cetacean (dolphin and whale) habitat. Adverse effects are highly unlikely at present given the small scale of farming in the region, and could be minimised in the future by appropriate site selection. For seabirds a range of potential effects are recognised, but none are well understood. Avoidance of foraging areas as a result of farm operations (*e.g.* noise and boat traffic) is possible, although a New Zealand study that examined potential effects on endemic King shags (*Phalacrocorax carunculatus*) from the development of a large mussel farm concluded that such concerns were largely unfounded (Lalas 2001, unpublished client report).

Based on the information available, there appears to be no need for consent holders in the Southland region to monitor effects to mammals and seabirds. However, farmers should continue to report any entanglements (fatal and non-fatal) to the Department of Conservation and ES. Specific monitoring conditions (*e.g.* recording interactions with farm structures and associated vessels) may be appropriate for farm sites located along known migratory routes or important marine mammal habitats.

4.3. Management responses to monitoring results

Monitoring undertaken as part of resource consent conditions is intended to ensure that impacts to the environment from the consented activities are *no more than minor*. It could be argued that monitoring is only required where sufficient uncertainty exists over the likely environmental effects. However, it appears that marine farm consents in Southland have included environmental monitoring conditions in order to be consistent, rather than be tailored to reflect the uncertainty surrounding potential environmental effects. As such, the consent monitoring conditions are very prescriptive and non-adaptive (*e.g.* measure *x* every *y* months). Furthermore, there is a lack of clear management response(s) outlined for environmental performance (good or bad) demonstrated by the monitoring, other than the clause to review monitoring conditions after a certain period of time.

In order for any monitoring programme to be adaptive, there needs to be clearly defined *triggers* for management responses. Cawthron has developed such triggers for a range of marine farming activities; including mussel farming (Hopkins *et al.* 2005), salmon farming (Hopkins *et al.* 2004) and shellfish spat-catching (Hopkins & Robertson 2002). Cawthron is confident that meaningful triggers could also be developed for both seabed and water column monitoring parameters for existing and future marine farm sites in Southland.

4.4. Implementing the environmental monitoring programme

It is envisaged that ES could replace existing environmental monitoring conditions with a requirement to participate in the regional marine farm monitoring programme. This would allow the monitoring programme to remain a living document, and as such, be modified and improved over time as monitoring data become available. Provided here is an example of consent conditions imposed on a recently consented salmon farm site in Marlborough Sounds. Relevant sections of the resource consent conditions are provided in Appendix 1. Conditions 34 through to 37 identify environmental quality standards (developed by Hopkins *et al.* 2004) that specify three impact zones (see Table 4). These standards (or bottom lines) have been adopted for all New Zealand King Salmon (NZKS) farm sites to ensure that the environmental effects of the farm sites are within agreed limits (*i.e.* are considered 'no more than minor'). Conditions 38 to 47 outline environmental monitoring and reporting requirements. Conditions do not specify what and where to monitor; however, include the requirement to submit a monitoring programme, annual monitoring reports, and the provision for external peer review if considered necessary by the Council.

Table 4. Environmental Quality Standards (EQS) developed for New Zealand King Salmon (NZKS) farm sites in the Marlborough Sounds.

Zone	Spatial extent	Description and 'bottom line'
1	Beneath the cages and out to 50 m from their outside edge	Sediments become highly impacted and contain low species diversity, dominated by opportunistic taxa (*e.g.* polychaetes, nematodes). It is expected that a gradient will exist within this zone, with higher impacts present directly beneath the cages.
2	From 50 m to 150 m from the outside edge of the cages	A transitional zone between Zones 1 and 3. Within this zone, some enrichment and enhancement of opportunistic species may occur, however species diversity remains high with no displacement of functional groups. It is expected that a gradient will also exist within this zone.
3	Beyond 150 m from the outside edge of the cages	Normal conditions (*i.e.* background or control conditions).
All zones	These conditions are not permitted beneath any NZKS farm	Sediments that are anoxic and azoic (*i.e.* no life present) will not be permitted.

5. OTHER CONSIDERATIONS

5.1. Nitrogen model

The nitrogen model for Big Glory Bay was developed in the 1980s as a management tool to prevent Bay-wide water column effects occurring as a result of marine farming activities. This simple mass balance model calculated nitrogen inputs from a range of sources (*e.g.* excretion from fish stock, release from sediments *etc*) as well nitrogen export out of the system (*e.g.*

harvesting of mussel stock, uptake by phytoplankton *etc*). However, advances in computer technology and water column monitoring devices (*e.g.* methods to measures phytoplankton abundance) have led to the development of far more complex models. It is likely that the application of a more complex model to the Big Glory Bay system would provide greater predictive power and could be developed to incorporate real-time data (*e.g.* from buoy-moored data collection facilities), enabling much higher spatial and temporal resolution.

However, the development of a more complex model, or the continuation with the mass balance model developed in the 1980s would only be required if there is likely to be an expansion in finfish aquaculture activities in the Bay to the extent that water quality issues attributable to nutrient release from fish farms develop.

5.2. Management of marine biosecurity risks

Human activities in New Zealand coastal areas are a significant mechanism for the dispersal of marine pests, particularly the movements of recreational and commercial vessels, and aquaculture activities. Awareness of this issue in New Zealand was largely precipitated in the late 1990s by concerns regarding the human-mediated spread and ecological effects of the Asian kelp *Undaria pinnatifida*. Around this time, fouling also became recognised as a significant threat to aquaculture when a population explosion of the sea squirt *Ciona intestinalis* resulted in the mussel crop losses in parts of the Marlborough Sounds. Subsequently, other fouling pests have emerged whose potential for adverse effects on the aquaculture industry and the wider ecosystem have been recognised, such as the sea squirts *Styela clava* and *Didemnum vexillum*. While many of these pest organisms have reached problematical densities only on artificial structures in New Zealand, overseas evidence also reveals their potential to be highly invasive in natural habitats (*e.g. Didemnum*).

The propensity for aquaculture activities to facilitate the spread fouling pests arises from the fact that suspended cultivation methods, and their associated structures and materials (*e.g.* ropes, floats, pontoons) provide ideal habitats that allow such organisms to proliferate at high densities. From a biosecurity perspective, ecological risks arise because the infested farm or other structures act as a 'reservoir' for the further spread of the pest.

At local scales (*e.g.* within bays), spread from infested reservoirs is facilitated by microscopic life-stages (*e.g.* seaweed spores or animal larvae) that are released by adult populations and drift with water currents as part of the plankton. For some species dispersal can also occur via the drift of reproductively viable fragments. These types of processes can lead to the establishment of the pest on adjacent structures such as other marine farms, jetties and vessel moorings. In this way such structures can act as 'stepping stones' for the spread of pest species. For many fouling organisms, however, natural dispersal is limited, and spread across large areas or between regions occurs via inadvertent transport due to human activities. For example, infested structures deployed at a marine farm (*e.g.* ropes, floats, pontoons), or temporarily associated with it (*e.g.* vessels), may be transferred to other localities as part of routine aquaculture operations. There is a high likelihood that associated fouling organisms will survive where such transfers occur without the application of measures to reduce biosecurity risks.

While monitoring of pest species is not recommended as part of the regional monitoring programme, consent holders should be encouraged to contribute to the effective management of fouling pests (*e.g.* as part of the marine farming industry Code of Practice). They can:

- Identify existing and future pests that threaten the aquaculture industry, and develop coordinated response plans for high risk species before they become established.
- Prevent incursions of new pests onto aquaculture structures. For vectors of spread such as service vessels, this could include maintenance of effective antifouling coatings, hull inspections to check for the presence of target pests, and hull cleaning as necessary.
- Eradicate pests from farm structures before they become well established. This approach may only be worthwhile if the risk of reinvasion can be managed, and pests can be detected before they become widespread.
- Contain the further spread of pests from infested aquaculture structures if eradication is not possible. Fouling could be reduced to a level that minimises the risk of natural dispersal to other vectors (*e.g.* vessels) or nearby structures, and pests could be eliminated from aquaculture vectors (equipment, vessels) before transport to other regions.

6. REFERENCES

Forrest B, Keeley N, Gillespie P, Hopkins G, Knight B, Govier D 2007. Review of the ecological effects of marine finfish aquaculture. Cawthron Report No. 1285. 73 p.

Gibbs MT 2007. Sustainability performance indicators for suspended bivalve aquaculture activities. Ecological Indicators 7:94-107.

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Hopkins G, Clarke M, Butcher R 2005. Fisheries Resource Impact Assessments (FRIAs) for eight proposed marine farm extensions in Kauauroa Bay, Marlborough Sounds. Cawthron Report No. 931. 143 p. plus appendices.

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Roper DS, Rutherford JC, Pridmore RD 1988. Salmon farming water right studies, Big Glory Bay, Stewart Island. A report prepared for the Southland Catchment Board. Consultancy Report T7074/2. Water Quality Centre, DSIR, Hamilton. 60 p.

Rutherford JC, Pridmore RD, Roper DS 1988. Estimation of sustainable salmon production in Big Glory Bay, Stewart Island. A report prepared for MAFFish. Consultancy Report T7074/1. Water Quality Centre, DSIR, Hamilton. 36 p.

Watson-Capps JJ, Mann J 2005. The effects of aquaculture on bottlenose dolphin (*Tursiops* sp.) ranging in Shark Bay, Western Australia. Biological Conservation 124:519-526.

7. APPENDICES

Appendix 1. A breakdown of existing farm monitoring conditions ("Consent_conditions_synopsis.xls," provided on CD).

Appendix 2. Relevant environmental monitoring consent conditions for a recently developed salmon farm site in Tory Channel, Queen Charlotte Sound.

Conditions of Consent

Pursuant to Section 108 of the Resource Management Act, 1991 the decision is subject to the following conditions:

Coastal Permit

1. This consent shall expire on 31 December 2024 (being the expiry of MFL537).

Occupancy and Activity

2. That the occupancy be limited to the area illustrated on the plan attached to this consent, and confined to the area specified within the schedule of New Zealand map grid co-ordinates.

Structures

3. That the structures be limited to anchors, ropes, cages and barges, floats, lights and other necessary navigational aids associated with the marine farming of the approved species. All structures shall be situated and secured so as to remain within the boundaries of the consent area at all times. The number of lines shall be at the discretion of the consent holder, but shall not exceed the total allowed. The structures overall shall not occupy an area of more than 2.0ha.

4. The 2 hectare area in which structures are to be located will be contained wholly within licence area MFL537 and shall be identified on a survey plan specifying co-ordinates of each corner of the farm area in NZ Map Grid and shall be supplied to Council within one month of the date of this consent..

5. That the placement of marine farm lighting and marking shall be approved by the Harbourmaster under his Maritime Delegation from the Director of Maritime Safety pursuant to Sections 200, 444(2) and 444(4) of the Maritime Transport Act 1994. The approved lighting plan will be forwarded in due course.

6. No more than two barges shall be located on the site. The maximum floor area of any building on those barges is not to exceed 550m^2 in total. This includes any building with two storeys.

7. The anchoring system to be used shall be that specified by Ocel Consultants and configures as per the plan attached hereto.

8. The anchoring system shall thereafter be maintained in accordance with the Clay Point Salmon Farm Mooring Maintenance Schedule prepared by Ocel Consultants and attached hereto or any subsequent review thereof.

9. That the consent holder maintain all structures to ensure that they are restrained, secure and in working order at all times so as to not create a navigational hazard and take whatever steps are reasonably necessary to retrieve any non-biodegradable debris lost in or from the permit area. The anchoring systems shall be installed and maintained in accordance with the anchoring plan and maintenance schedule prepared by Ocel Consultants and attached hereto.

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10. That the applicant notifies the Chief Hydrographer/Topographer of Land Information New Zealand and the Marlborough District Council within 3 months of the establishment of the marine farm structures.

Use of Underwater Lights

11. Underwater lights will be permitted to be used by the applicant for the primary purpose of controlling maturation in salmon stocks at this location. A specific approval as to underwater lighting will be required from the Harbourmaster under Sections 200, 444(2) and 444(4) of the Maritime Transport Act 1994.

12. A detailed site plan will be supplied to Council and Harbourmaster clearly identifying where lights will be used on the site within 1 month of underwater lights being switched on.

13. The ongoing use of underwater lights shall be subject to the survey and monitoring regimes which form part of this coastal permit and may be reviewed if it becomes evident that their use is causing any adverse effect on the Clay Point environment.

Coastal Permit (Discharge to Seawater)

14. This consent shall expire on 31 December 2024 (being the expiry of MFL537).

15. Only extruded pellets or similar shall be fed at the marine farm.

STAGING OF DISCHARGE VOLUMES

STAGE 1

16. For the first 1 year of the operation of this consent the maximum volume of feed to be discharged shall be 2500 metric tonnes per annum.

17. Within the period September to November after commencing discharge at the 2500 metric tonnes per annum maximum specified above, the consent holder shall monitor the sea floor in accordance with the environmental monitoring programme to be agreed, as specified under conditions 39 to 44.

18. A full report detailing the state of the sea floor shall be submitted to the Council within 3 months of the monitoring being completed.

19. On receipt of the monitoring report, the Council shall if necessary, within 1 month, initiate a review of the conditions of this consent, including the maximum volumes to be discharged, in accordance with Sections 128 and 129 of the Resource Management Act 1991, and as further specified under condition 45.

STAGE 2

20. Following receipt by Council of the monitoring report specified under stage 1 above and subject to any review of conditions of this consent specified in condition 45, the consent holder may for the following year discharge a maximum of 3000 metric tonnes per annum.

21. In the period September to November following commencement of discharge at the 3000 metric tonnes per annum maximum the consent holder shall prepare a monitoring report on the state of the seabed using the environmental quality standards and the

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environment monitoring and reporting requirements specified in conditions 39 to 44 of this consent.

22. This report shall be submitted to Council within 3 months of completion.

23. Within 1 month of receipt of the report, Council shall review the conditions of this consent, including the maximum volumes to be discharged in accordance with condition 45.

STAGE 3

24. Following receipt by Council of the monitoring report specified under stage 2 above and subject to any review of conditions of this consent specified in condition 45, the consent holder may for the following year discharge a maximum of 3500 metric tonnes per annum.

25. In the period September to November following commencement of discharge at the 4000 metric tonnes per annum maximum the consent holder shall prepare a monitoring report on the state of the seabed using the environmental quality standards and the environment monitoring and reporting requirements specified in conditions 39 to 44 of this consent.

26. This report shall be submitted to Council within 3 months of completion.

27. Within 1 month of receipt of the report, Council shall review the conditions of this consent, including the maximum volumes to be discharged in accordance with condition 45.

STAGE 4

28. Following receipt by Council of the monitoring report specified under stage 3 above and subject to any review of conditions of this consent specified in condition 45, the consent holder may for the following year discharge a maximum of 4000 metric tonnes per annum.

29. In the period September to November following commencement of discharge at the 4000 metric tonnes per annum maximum the consent holder shall prepare a monitoring report on the state of the seabed using the environmental quality standards and the environment monitoring and reporting requirements specified in conditions 39 to 44 of this consent.

30. This report shall be submitted to Council within 3 months of completion.

31. Within 1 month of receipt of the report, Council shall review the conditions of this consent, including the maximum volumes to be discharged in accordance with condition 45.

IMPLEMENTATION OF STAGES AND DISCHARGE VOLUMES

32. For the avoidance of doubt in interpreting the above conditions, there shall be a review of conditions prior to each of the above stages where monitoring indicates the development may give rise to adverse effects on the environment. The consent holder shall not increase the discharge of feed until the Council confirms that the subject stages are not individually or cumulatively creating any adverse effects.

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33. Should the consent holder not discharge feed to the maximum volume permitted under any stage, then the increase in feed permitted within the next stage shall be 500MT above the maximum feed volume discharged under the previous stage.

ENVIRONMENTAL QUALITY STANDARDS

34. The environmental quality standards (EQS) that shall be applied for seabed effects follow the model as presented in the application i.e. seabed effects are 'zoned' around the cages to allow for a mixing or transition zone. Outside this zone no adverse effect on the seabed is allowed. Three 'zones' under and around the marine farm shall be established as follows:

    (a) Referred to as 'Zone 1' – Beneath the cages and out to 50 m from the cages.

    (b) Referred to as 'Zone 2' - From 50 m to 150 m from the outside edge of the cages.

    (c) Referred to as 'Zone 3' - Beyond 150 m from the outside edge of the cages.

35. The zones shall be distorted to allow for the action of tidal currents such that the total area of each zone remains the same as if concentric zones were around the marine farm.

36. In this instance the zones shall be distorted as shown in Figure 2 of the Proposed NZKS Clay Point Monitoring Programme 2006 prepared by Cawthron dated 13 November 2006 and attached.

37. The EQS in each zone is as follows:

Zone	Spatial Extent	Description and Bottom Line
1	Beneath the cages and out to 50 m from their outside edge	Sediments become highly impacted and contain low species diversity, dominated by opportunistic taxa (e.g. polychaetes, nematodes). It is expected that a gradient will exist within this zone, with higher impacts present directly beneath the cages.
2	From 50 m to 150 m from the outside edge of the cages	A transitional zone between zones 2 and 4. Within this zone, some enrichment and enhancement of opportunistic species may occur, however species diversity remains high with no displacement of functional groups. It is expected that a gradient will also exist within this zone.
3	Beyond 150 m from the outside edge of the cages	Normal conditions (i.e. background or control conditions).
All Zones	These conditions are not permitted beneath any NZKS farm	Sediments that are anoxic and azoic (i.e. no life present) will not be permitted.

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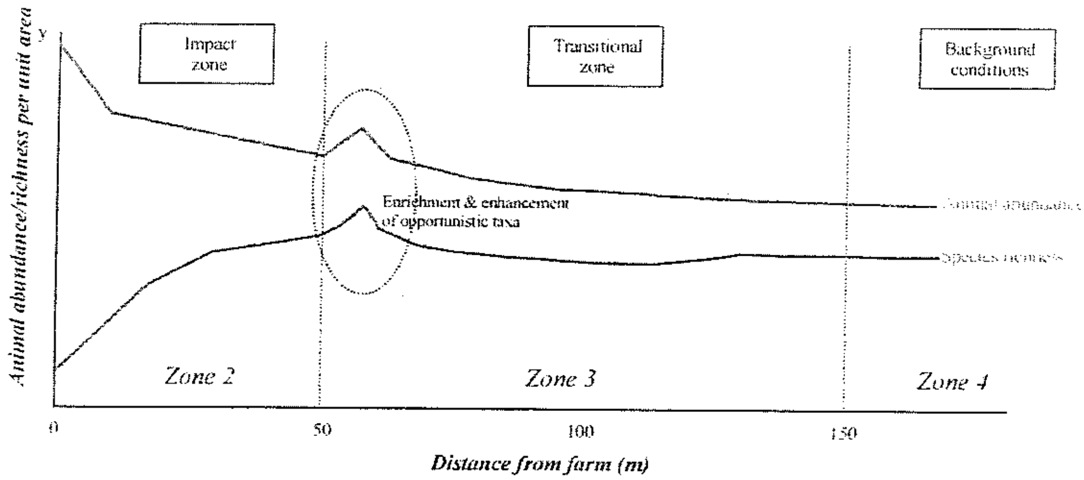

ENVIRONMENTAL MONITORING AND REPORTING

38. Prior to exercising the consent, the consent holder shall prepare an environmental monitoring programme to show compliance with the Environmental Quality Standards set out in conditions 34 to 37 of this consent.

39. This monitoring programme shall be submitted to the Council for approval and shall address, but not be limited to, the following effects within the boundary of the marine farm and in the immediate vicinity beyond the boundary of the marine farm:
    (a) effects on water quality;
    (b) seabed deposition (sedimentation and crop loss) and oxygen depletion;
    (c) effects on benthic community composition and abundance;
    (d) potential water column effects on Marine Farm Licence 464 in Ngaruru Bay; and
    (e) effects of underwater lighting on benthic and pelargic species.

40. For the sake of clarity the recommendations contained within the Cawthron "Proposed NZKS Clay Point Monitoring Programme 2006" as attached shall form part of this permit. Where there is any conflict with the conditions of this permit the conditions shall prevail.

41. The survey/monitoring programme shall describe:
    (a) the surveys, baseline and/or ongoing, to be undertaken;
    (b) location and extent of any environmental features within the vicinity and potential impacts on these features;
    (c) the environmental performance indicators that are to be used to assess effects;
    (d) methods, location and frequency of sampling, including reference sites;
    (e) a definition of species diversity and what comprises the transitional zone; and
    (f) recording and reporting requirements.

42. A monitoring report is to be prepared at least annually, and will include:
    (a) presentation of monitoring results;
    (b) a comprehensive and integrated report on the effects of the development and operation of the farm to date, including maximum biomass of fish and feed volumes discharged over that year;

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(c) an assessment as to whether or not the farm is having a significant adverse effect on the environment or not;

(d) recommendations as to how any adverse effects on the environment can be avoided, remedied or mitigated; and

(e) the adequacy of the monitoring programme.

NB: The monitoring programme shall be public record.

43. The consent holder shall commission an independent person (or persons) with appropriate expertise in environmental monitoring to undertake the monitoring and reporting work required by the conditions of this consent.

44. The Council may require an independent peer review of the surveys, monitoring and reporting required under conditions 34 to 43 above. Such a peer review will be at the cost of the consent holder.

45. That in accordance with sections 128 and 129 of the Resource Management Act 1991, the consent authority may review the conditions of this consent by serving notice of its intention to do so for one or more of the following purposes:

PURPOSE(S)	TIME(S) OF SERVICE OF NOTICE
To modify the monitoring programme.	Within 2 months of receipt of any monitoring report as required by the conditions of this consent.
To deal with any adverse effects that may become apparent as a result of the exercise of this resource consent.	Within 2 months of receipt of the monitoring report required by conditions 4 and 5 of this consent (Stage 1). Within 2 months of receipt of the monitoring report required by conditions 8 and 9 of this consent (Stage 2). Within 6 months of receipt of any other monitoring report required under the conditions of this consent.
To require the consent holder to adopt the best practicable option to avoid, remedy or mitigate any adverse effect on the environment relating to the activity.	Within 2 months of receipt of the monitoring report required by conditions 4 and 5 of this consent (Stage 1). Within 2 months of receipt of the monitoring report required by conditions 8 and 9 of this consent (Stage 2). Within 6 months of receipt of any other monitoring report required under the conditions of this consent.

46. Pursuant to section 36 of the Resource Management Act 1991 and Marlborough District Council's Schedule of Fees, the consent holder shall pay all actual and reasonable costs associated with any review of this resource consent.

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47. Inspection and monitoring by Council's Resource Management and Regulatory Department in respect of the conditions of this consent may take place annually or more frequently in the event that a previous inspection or complaint indicates the need for more frequent inspection and monitoring.

The costs of these inspections and any formal monitoring programme established in consultation with the Consent Holder will be charged to the Consent Holder in accordance with Council's Schedule of Fees approved pursuant to section 36 of Resource Management Act 1991.

Important Notes

1. The Committee considered that the granting of this application may give the applicant the option to temporarily retire the Otanerau Bay farm to provide time to address the problem of Didemnum Vexillum.

2. That the consent holder be aware that the Harbourmaster will carry out a navigation safety risk assessment in relation to this site. The costs of the assessment will be borne by the consent holder.

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13 December 2006

Mark Gillard
New Zealand King Salmon Company Ltd
10-18 Bullen St
Tahunanui, Nelson

Proposed NZKS Clay Point Monitoring Programme 2006

Prepared by the Coastal & Freshwater Group,
Cawthron Institute

1. INTRODUCTION

Cawthron has been asked by NZKS to recommend an environmental monitoring strategy for the proposed Clay Point site in Tory Channel. NZKS already have in place a detailed annual monitoring programme for their existing five sites, which is revised and provided to council for approval prior to implementation, on an annual basis. If consent for the Clay Point site is granted, it is envisaged that the monitoring for this site will be approached in a similar manner and incorporated into this wider sampling programme.

However, Clay Point differs from the existing sites in that it comprises a slightly more complex array of habitats (*e.g.* a greater portion of rocky reef), which will necessitate some new and additional monitoring methods. In particular, the rocky reef habitats and hydroid communities that were identified as 'potentially sensitive' to farm-related discharges during the AEE survey, will require special monitoring. Determining the exact positions of these sites and the most appropriate methods will, however, first require a more detailed baseline survey. Such a survey would aim to further delineate the boundaries of these habitats in relation to the proposed position of the cages. It will also provide other interested parties with a better picture as to the nature and spatial distribution of the habitats at Clay Point and can be used to assist NZKS in best positioning the farm relative to any sensitive habitats.

This proposal includes the following:

- A brief overview of existing knowledge for the proposed Clay Point site and the operational Te Pangu Bay farm site.
- A proposed baseline habitat mapping survey.

- A proposed monitoring strategy for the Clay Point site - to be incorporated into the NZKS annual monitoring programme.
- Annual monitoring reporting requirements.

2. EXISTING INFORMATION

In recent years, a considerable amount of environmental information has been collected from the five existing NZKS sites and the proposed Clay Point site, both as part of the resource consent application process and through subsequent monitoring. Refer to Table 1 for a summary of the information collected for the Clay Point and nearby the Te Pangu Bay site. This information includes: 1) results from sampling of the seabed beneath and adjacent to the salmon farm cages; 2) the identification of habitats and communities with special ecological value, or that are sensitive to enrichment/sedimentation impacts; 3) results of synoptic surveys of seabed habitats and water column nutrients, and 4) modelling of the predicted sedimentation footprints.

Table 1. Summary of existing knowledge relating to seabed and water column environments within the vicinity of the Clay Point and Te Pangu Bay farm sites along Tory Channel, Marlborough Sounds.

Farm Site	Depositional & Ecological effects footprints	Areas of ecological significance	Sediment properties (*e.g.* organic content, infauna)	Water column nutrients
Clay Point	• Estimated using current data recently collected from the site.	• Areas of special ecological value have been identified in the vicinity of the site; including rocky reef habitat, hydroids and kelp beds.	• 'Pre-development' sediment properties within the proposed farm site have been described in the AEE.	• No 'pre-development' water column nutrient data has been collected at the Clay Point site, but water column nutrients are expected to be similar to those observed at the nearby Te Pangu Bay site.
Te Pangu	• Estimated using current data recently collected from the site.	• Areas of special ecological value have been identified in the vicinity of the site; including kelp beds, hydroids and biogenic reef-like communities (Brown 2000). • The spatial extent and distribution of the biogenic reef-like communities has been further investigated.	• Sediment properties beneath and adjacent to the cages have been well described and are monitored annually. • Seabed impacts are typically low to moderate at this site (refer Hopkins et al. 2006).	• Water column nutrients were measured in 2004 at three water depths within the cages, 50 m from the farm and at a reference site. • These data suggest localised enrichment of the water column that poses a low risk to the environment at the present level of production.

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3. BASELINE MAPPING SURVEY

3.1 *Objectives:*

1. To further delineate spatial boundaries for reefs and other significant habitats in the vicinity of the proposed farm site.

2. To identify candidate monitoring sites and methods for incorporation into the NZKS long-term annual monitoring programme.

3.2 *Methodology*

Site survey

The deep and high energy environment at Clay Point site presents some challenges for the conventional sampling techniques such as video sled, SCUBA diving, remotely operated vehicle (ROV) and sidescan sonar. Therefore, the most effective way to conduct additional habitat mapping is likely to be with the use of a high resolution, remotely operated drop-camera. This method allows the researcher to take multiple photographs of the seabed distributed strategically over a wide area, irrespective of depth and currents. The remote aspect of the sampling also ensures a certain amount of randomness with respect to quadrat placement. The images can be analysed for substrate type (*i.e.* rock, boulder, sand, mud, *etc.*) and habitats, including species identification and abundance estimates (if necessary). This information can then be spatially displayed in mapping software (*e.g.* ArcMap) to delineate approximate habitat boundaries.

In order to achieve sufficient spatial coverage, we envisage taking somewhere between 100 and 200 photographs of the seabed in the vicinity of the AMA area. The survey area should encompass the spatial extent of the maximum predicted deposition footprint (*i.e.* >300m from cages, see Keeley *et al.* 2006), and include the adjacent coastal habitats up to and including the intertidal zone. Extra effort will be allocated to areas of variable habitat (*e.g.* reefs & steeply sloping shores) and to defining the seaward boundaries of reef structures and/or ecologically sensitive habitats.

Identifying long-term seabed monitoring sites

The habitat map that is generated from the above methods will be overlaid with the predicted depositional area from the proposed cages (from Keeley *et al.* 2006). Any reef or sensitive areas that are likely to be exposed to depositional effects can be identified for long-term monitoring. The long-term monitoring sites will be tagged to enable the precise location to be revisited for reassessment. This will be accomplished by either drilling and inserting tags into rocky substrate, or deploying tagged concrete blocks (*e.g.* near hydroid beds).

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The distribution of soft sediments can also be examined with respect to the best placement of monitoring sites, as per the methods adopted for monitoring the other NZKS farm sites (*e.g.* 'under cage', '50m', '100m', '150m' & 'reference' – see below).

4. MONITORING STRATEGY FOR THE CLAY POINT SITE

4.1. Seabed monitoring

Seabed impact zones concept

It is proposed that environmental 'bottom lines' be developed and adopted for monitoring of the seabed at Clay Point, in the same way that has been applied to the other NZKS sites. This approach provides transparency and certainty to all parties (consent applicants, objectors and regulators), and a framework for assessing compliance. The basis of this approach is a conceptual model that identifies an acceptable level of seabed impact, both in terms of severity and spatial extent, based on narrative environmental quality standards. The model identifies three zones around a salmon farm, reflecting the work of Brown et al. (1987), as shown in Table 2 and illustrated in Figure 1. Zone shapes can be modified to reflect site-specific conditions, while ensuring that the inshore habitats (such as cobble/rocky areas) are protected. This would involve an alteration to the shape of the impact zones to recognise the dispersion pattern of farm wastes, while still ensuring that the total area of seabed affected within each zone is no more than would be allowed under the conceptual approach. In the case of Clay Point we can use the shape of the predicted depositional footprint (Figure 2, see Keeley *et al.* 2006) to delineate the approximate zones. The results of the baseline survey (described above) will then provide the necessary guidance in terms of best farm position and the exact location of monitoring sites.

Table 2. Proposed impact zones model (based on a 2.0 ha farm).

Zone	Spatial extent	Area affected in each zone (ha)	Acceptable impact criteria
2	Beneath the cages and out to 50 m from their outside edge	5.8	Low species diversity dominated by opportunistic species (*e.g.* polychaete worms)
3	From 50 to 150 m from the outside edge of the cages	12.2	Transitional between Zone 2 and unimpacted Zone 4
4	Beyond 150 m from the outside edge of the cages	0	Normal conditions (*i.e.* reference or control)

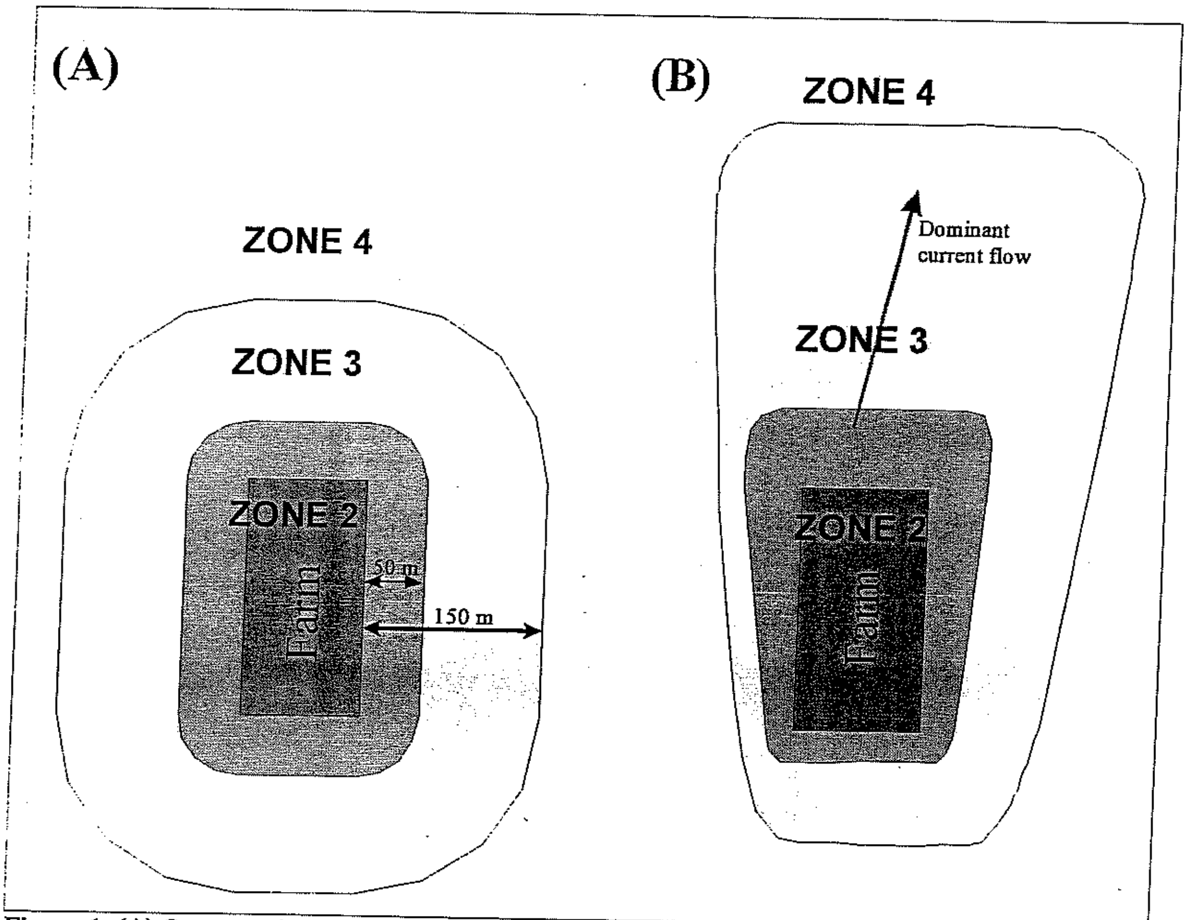

Figure 1 (A) Conceptual approach to defining seabed impact zones for NZKS salmon farm sites, and (B) A proposed method for adapting the impact zones to the environmental conditions at the salmon farm sites.

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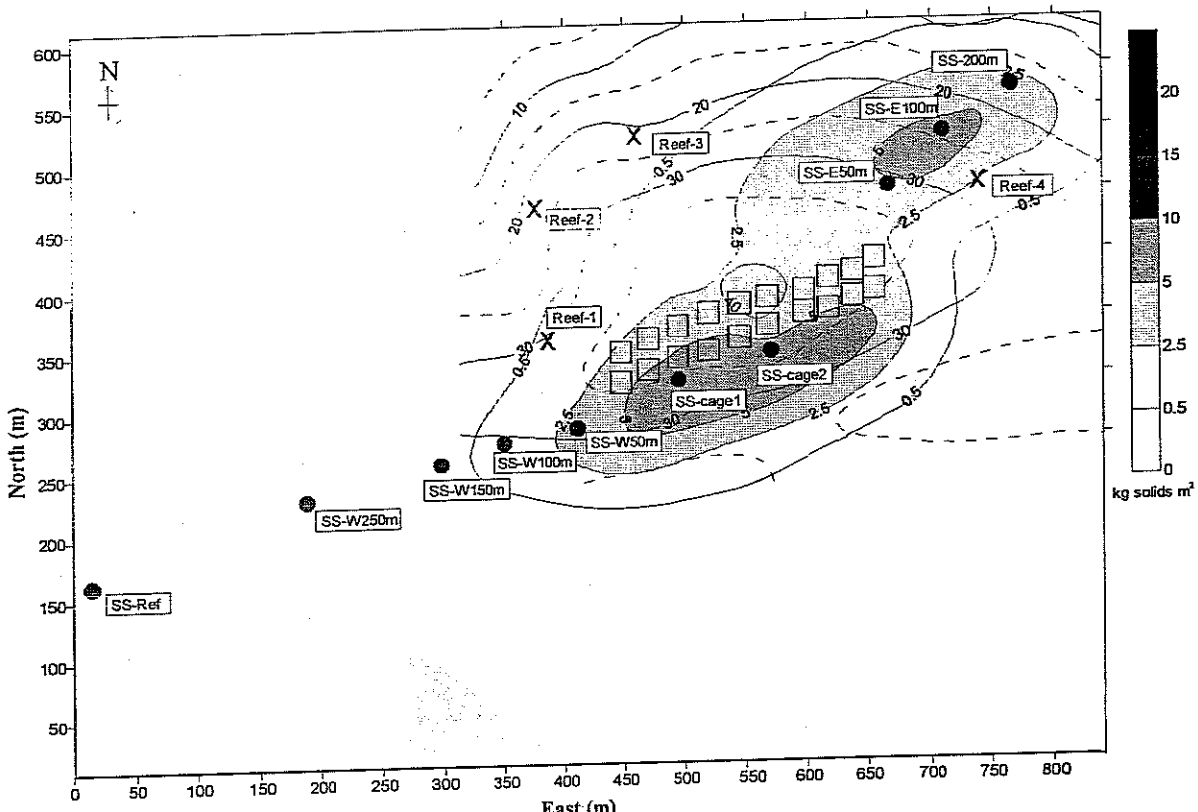

Figure 2 Likely sample site configuration based on predicted annual depositional footprint (see Keeley *et al.* 2006). SS=soft sediment monitoring sites, Reef=rocky reef monitoring sites.

Sampling locations and parameters to be measured

Potentially sensitive or ecologically significant habitats, at sites identified during the baseline mapping survey, will be monitored using visual surveillance and/or quantitative assessment techniques.

As with the wider monitoring programme, sediment sampling will be undertaken at two sites beneath the proposed cages sites and at a series of sites down-current of the farms (*e.g.* 50 m, 100 m, 150 m, 250 m and reference). To assist in assessing the spatial extent and magnitude of impact, sites covering both flood and ebb tide flows will initially be evaluated. Long-term monitoring sites representative of the existing zones can then be designated. At each sampling site, three replicate sediment grab samples will be collected. Two sub-samples will be collected from each quantitative grab sample: (1) a sediment core for the determination of particle grain size and organic content, and (2) a macrofaunal core to identify and count infaunal taxa present.

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Visual observations and semi-quantitative assessments will be undertaken on all sediments collected; *e.g.* depth of the redox potential discontinuity (RPD) layer, sediment odour and texture.

A composite sample of sediments collected from beneath the cages at each farm site will also be analysed for zinc concentrations, as previous monitoring at some NZKS farm sites found elevated concentrations within the sediments beneath the cages.

Every two years, surveys will be conducted along two transects inshore of the farm which extend up into the shallow subtidal/intertidal region.

4.2 *Water column monitoring*

Dissolved oxygen

NZKS routinely measure dissolved oxygen (DO) concentrations in the water column, as part of their fish health monitoring programme. Monitoring to date suggests that oxygen depletion by fish stocks at the sites is unlikely to pose a significant environmental concern. The health of the salmon stock itself provides a useful guide to the general quality of water in the cages, since juvenile salmonid fish have been shown to be particularly sensitive to effects of low DO (USEPA 1986). Further, the fish are continually exposed to changes in water quality (which can be significant over daily to longer-term time scales); hence they provide a more integrated and environmentally relevant measure than can be obtained by direct water sampling.

We can infer from the presence of a bacterial mat on the seabed, and the presence of nitrate in bottom waters at sites of lower current energy than Clay Point, that anaerobic conditions do not occur in the water column. A significant reduction in DO levels may nonetheless occur at or near the sediment-water interface in some cases, and this will be assessed as part of the annual monitoring programme at the proposed Clay Point site. This will involve lowering a DO probe in the water column profile or collecting surface and near-bottom water samples using a van Dorn sampler and measuring the DO using a DO meter.

Nutrients

Salmon farms represent a significant point-source of plant nutrients to the coastal environment. Therefore some consideration should be given to the enrichment potential of the Clay Point farm. Since nitrogen is likely to be the most limiting nutrient for plant production in New Zealand coastal waters, this will be the main focus of nutrient water quality monitoring at the Clay Point site. The overall contribution of nitrogen from the Clay Point salmon farm can be viewed in a wider context by comparing mass loads with other point-and non point-sources in the region (Table 3).

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Table 3. Estimated mass load of nitrogen (T/yr) from the Clay Point salmon farm compared with other inputs in the wider Marlborough Sounds and Nelson Regions. Figures are approximate only.

Nitrogen source	Dissolved inorganic nitrogen (DIN)	Total nitrogen (TN)
NZKS SALMON FARMS		
Otanerau	51-63	95
Forsyth/Waihinau	58-71	106
Ruakaka	69-85	127
Te Pangu	86-104	158
Proposed Clay Point site	**105-130**	**195**
OTHER WASTE-WATER DISCHARGES[1]		
Picton sewage pre-upgrade	5.1	11.3
Picton sewage post-upgrade	0.7	3.7
Bells Island sewage (Richmond/Nelson)	NA	97.1
Nelson City sewage	63.9	101.8
Nelson fisheries processing	18.6	70.4
RIVERINE AND MARINE INPUTS[2]		
Pelorus and Kaituna Rivers	500-600	
Net input from Cook Strait (to Pelorus and Kenepuru Sound)	12,000[3]	
Net input from Cook Strait (to Queen Charlotte Sound)	No estimate available[4]	

Notes:
1. Figures for other wastewater discharges revised from those reported in Hopkins & Forrest (2002), using data from MDC, Gillespie et al. (2001), and Barter & Forrest (1998).
2. Riverine and marine inputs from MacKenzie (1998).
3. Rough estimate only, from MacKenzie (1998).
4. Large and probably of a similar magnitude to the oceanic input to Pelorus Sound.

It was estimated that an average of approximately 105 to 130 tonnes of ammonium (~equivalent to DIN) and 195 tonnes of total nitrogen (TN) would be produced by the Clay Point farm, per annum. This estimate was based on biomass estimates for a 2 ha farm using a feed loading of 4000 T/yr with a 1.7 food conversion ratio. The DIN contribution assumed that ammonium excreted per tonne of fish ranged from 45 kg to 55 kg (Gowen & Bradbury 1987), and that approximately 83 kg of TN is discharged to the environment per tonne of fish produced each year. While the approach is relatively simplistic, it suggests that the mass load of nitrogen from the Clay Point salmon farm would be comparable to other salmon farms in the Sounds and of the same order as that produced from a medium-sized municipal wastewater discharge (*e.g.* Nelson City). It is worthwhile noting that there are no major freshwater inflows to Queen Charlotte Sound (including Tory channel). Thus the existing salmon farms presently represent a significant source of 'new' nitrogen to the receiving environment. However within the context of other major nutrient sources to Queen Charlotte

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Sound (*i.e.* benthic recycling and Cook Strait oceanic inflow), the 'new' nitrogen contribution of the farms is reasonably small, particularly when considering the wider Sounds region.

Monitoring of the Clay Point site will include spatial surveys of dissolved inorganic nitrogen and phosphorus concentrations to confirm that the rate of dilution down-current from the farm is sufficient to preclude adverse enrichment effects. Drogues will be used to confirm water flow direction, and the water column will be sampled at various positions up- and down-current from the cages (*e.g.* 50 m above and 50, 100 and 250 m below the cages). The samples will be analysed for nitrate-N, nitrite-N, ammoniacal-N, and dissolved reactive phosphorus. The surveys will be repeated in conjunction with farm management such that the effects of any significant increases in feeding rates/production can be assessed.

Phytoplankton

A primary concern regarding nutrient releases from salmon (and other fish) farms is the potential for increased incidence of algal blooms, and in particular harmful algal blooms (HABs). The risks of increased incidence of HABs from salmon farms and other point sources of nutrients are still poorly understood (Anderson *et al.* 2002). While there is a general consensus that fish farms can cause localised nutrient enrichment in the vicinity of farm cages, consequent effects on phytoplankton communities in coastal waters have not been documented. A recent review for Scottish waters by Tett & Edwards (2002) concluded that there was no evidence for a link between HABs and fish farming and suggested that nutrient enrichment by fish farms would be insufficient to have such effects, except possibly in enclosed basins where water exchange was poor. Nonetheless we recommend that phytoplankton should be monitored at the Clay Point site in conjunction with the other NZKS sites.

Phytoplankton data are routinely collected from the NZKS farm sites as part of their phytoplankton monitoring programme, and similar data are also collected weekly from sites throughout the Marlborough Sounds as part of Ministry of Health (MoH) and Marlborough Shellfish Quality Programme (MSQP). The water samples collected under these monitoring programmes are analysed by Cawthron for counts of phytoplankton; specifically those that can produce toxins of various types. The target species are assigned a risk category (low, moderate, high, very high) according to the number of potentially harmful algal cells observed. Different levels of risk activate different management responses (*e.g.* further sampling, shellfish flesh testing, public health warning) depending on the species. Phytoplankton biomass is also categorised (as low, medium or high) according to the density of cells. Although access to the MSQP data may be restricted, we recommend similar monitoring (*e.g.* fortnightly) at the Clay point site and selected reference sites in Queen Charlotte Sound/Tory Channel.

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5. REPORTING

As in previous years, an annual monitoring report will be produced and submitted to the Marlborough District Council, in accordance with the NZKS AMP. The report will provide the following:

- Presentation and interpretation of the monitoring results.
- An assessment on whether the farms are operating within the zones concept proposed (*i.e.* not exceeding environmental 'bottom-lines').
- Recommendations to avoid, mitigate or remedy environmental effects (if required).
- Recommendations on changes to the annual monitoring programme (*e.g.* frequency, parameters to be measured *etc.*).

6. DETERMINING COMPLIANCE

Sediment physical, chemical and biological data will be displayed graphically with previous baseline and monitoring data to determine trends. Analyses of animal abundance and species richness data will be used to assess compliance with the zones concept. Compliance within Zone 1 is easily determined (*i.e.* is life present?); however, compliance within zones 2-4 is less clear and requires expert opinion to interpret the data. Macrofauna count data will be analysed using multivariate statistical analyses (*e.g.* SIMPER analyses) to assess the 'similarity' of community assemblages sampled beneath and adjacent to the salmon farm cages and the control site samples. These analyses, coupled with sediment physical and chemical data, will be used to determine whether or not Zone 2 and Zone 3 conditions are being met down-current of the farms sites. At sites where the environmental bottom-lines are being approached, or are likely to be exceeded in the future (*e.g.* determined from assessing trends in the data), recommendations on increasing the frequency of the monitoring may be made. Similarly the monitoring results may provide sufficient assurance that the low level of observed impacts (at a given production level) will warrant recommendations for a reduction in monitoring frequency or the parameters assessed. Some flexibility in the long-term monitoring design will be required in order to accommodate both the increasing knowledge base and changes in farm management practices.

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Clay Point Farm – Mooring Maintenance Schedule

Version Log

VERSION	DATE	APPROVED BY
Clay Point Mooring Maintenance Schedule version 1	2/3/07	Gary Teear - OCEL

Clay Point Farm – Mooring Maintenance Schedule

This document outlines the requirements for the monitoring and management of moorings at the Clay Point salmon farm. This location experiences higher current flows and this requires additional vigilance in terms of managing the moorings at this site location.

The approved mooring plans for the site are attached at appendix A1 to A8
The mooring line detail is attached at appendix B

Copies of these mooring details and any approved changes are to be updated in this document and supplied to Council.

Routine Mooring Observations:
On a weekly basis every mooring will be visually checked and verified as being attached to the farm as per the current mooring plan (appendix A). The visual check will verify that the moorings are sloping away from the farm as expected under tension, with no marked differences between the inclination of each line to the horizontal.

The site team will note that moorings have been checked and the results of these checks will be noted in the farm manager's weekly farm report.

Mooring Tension:
Each mooring line will be held at a tension of between 1.0MT +/-5% as measured during neap tides.

Every mooring will have the tension measured at least once every 6 months. This may be timed to coincide with times when temporary cages are removed or added to the farm.

Every mooring will have the tension measured within 2 weeks of when alterations are made to the farm layout in terms of removing or adding temporary changes.

The results of this survey will be recorded in the Clay Point mooring log. One copy will be held on the farm and a master copy held in the Picton Aquaculture Office.

Mooring Tension Automatic Monitoring System:
A mooring tension monitoring system will be installed onto 1 to 3 moorings. This will automatically record the tension in the mooring line. The mooring tension log will be checked on a weekly basis and if the mooring tension increases or decreases by 15% above or below the normal maximum or minimum tension for that mooring a review will be initiated.

If this occurs the site team will immediately undertake an immediate review of all moorings to verify that the farm is secure. The site team will immediately inform:

- The Clay Point Site Manager (incumbent: not known at this time)
- The Seawater Manager (incumbent: Mark Preece)
- The Engineering and Facilities Manager (incumbent: Mitch Rowe)
- The General Manager – Aquaculture (incumbent: Stewart Hawthorn)

Within 48 hours all individual moorings will be assessed using the mooring tension measuring system and results recorded. Where required moorings will be reset/adjusted to ensure that they are within the agreed guidelines.

Annual In-water Inspection:
Once per annum every mooring will be inspected from surface to the seabed floor using either divers or a remotely operated vehicle. This inspection will assess each of the mooring components. All moorings and mooring components will be checked to ensure that they are set-up as per the attached design in appendix B:

> **The mooring attachment to the farm:** shackles moused and tight. No more than 10% wear. Replaced if required.
>
> **The top chain:** no area with more than 10% wear. Replaced if required.
>
> **The chain anode:** anode in place and securely attached. Replaced if required.
>
> **The chain to rope attachment:** Eyes and shackles with no more than 10% wear. Shackles moused and tight. Replaced if required.
>
> **The intermediate warp:** all strands intact. If any strand is broken the rope must be replaced.
>
> **The intermediate warp to anchor warp attachment:** Eyes and shackles with no more than 10% wear. Shackles moused and tight. Replaced if required.
>
> **The anchor warp to seabed:** all strands intact. If any strand is broken the anchor and mooring rope must be replaced.

The results of this annual inspection will be recorded in the Clay Point mooring log.

2-yearly Inspection:
Every two years the Clay Point moorings will be individually inspected by detaching from the farm and lifting the chain, intermediate warp and intermediate warp/anchor warp attachment assembly to the surface. Each mooring will then be reattached to the farm and re-tensioned to the required level. (This replaces the annual in-water inspection and is not in addition to this.) All moorings and mooring components will be checked to ensure that they are set-up as per the attached design in appendix B.

> **The mooring attachment to the farm:** shackles moused and tight. No more than 10% wear. Replaced if required.
>
> **The top chain:** no area with more than 10% wear. Replaced if required.
>
> **The chain anode:** anode in place and securely attached. Replaced if required.
>
> **The chain to rope attachment:** Eyes and shackles with no more than 10% wear. Shackles moused and tight. Replaced if required.
>
> **The intermediate warp:** all strands intact. If any strand is broken the rope must be replaced.
>
> **The intermediate warp to anchor warp attachment:** Eyes and shackles with no more than 10% wear. Shackles moused and tight. Replaced if required.
>
> **The anchor warp to seabed:** all strands intact. If any strand is broken the anchor and mooring rope must be replaced.

The results of this two-yearly inspection will be recorded in the Clay Point mooring log.

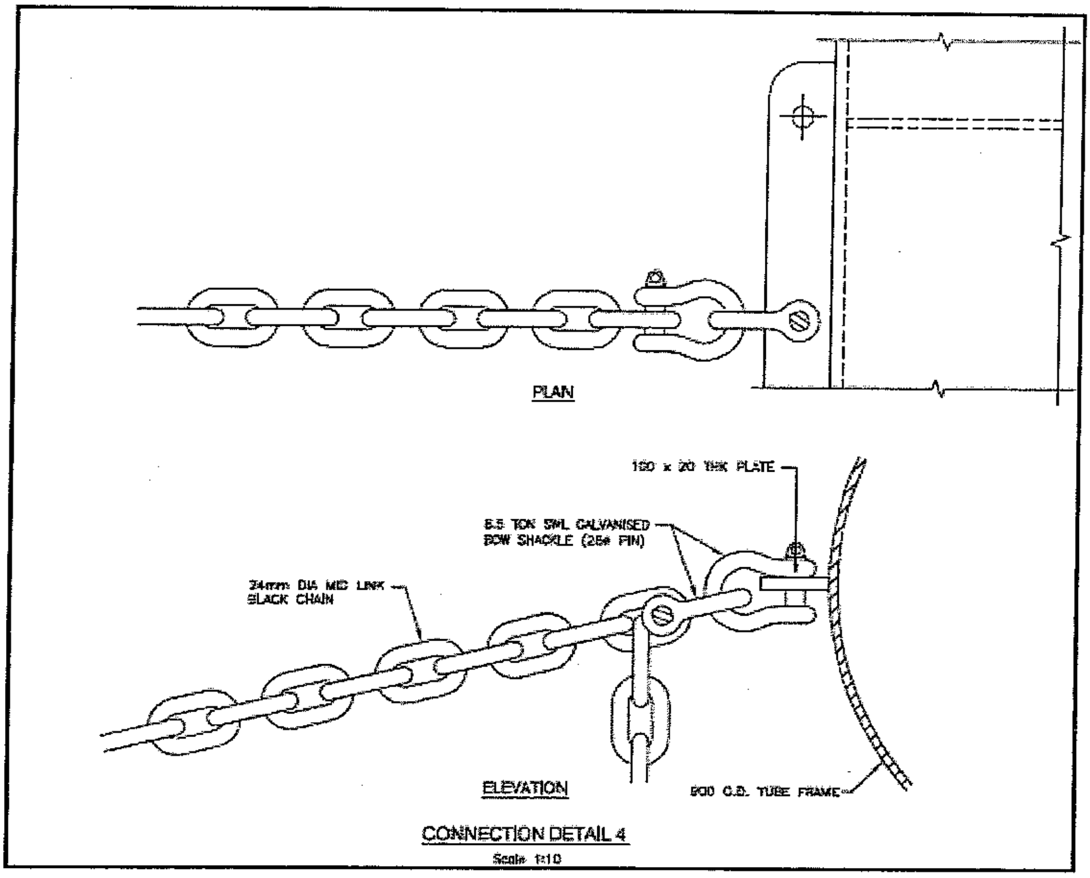
5-yearly Stress Test:
Every 5 years a representative anchor pair will be proof load tested to a 100kN. This will verify the integrity of the below seabed components.

Appendix A:

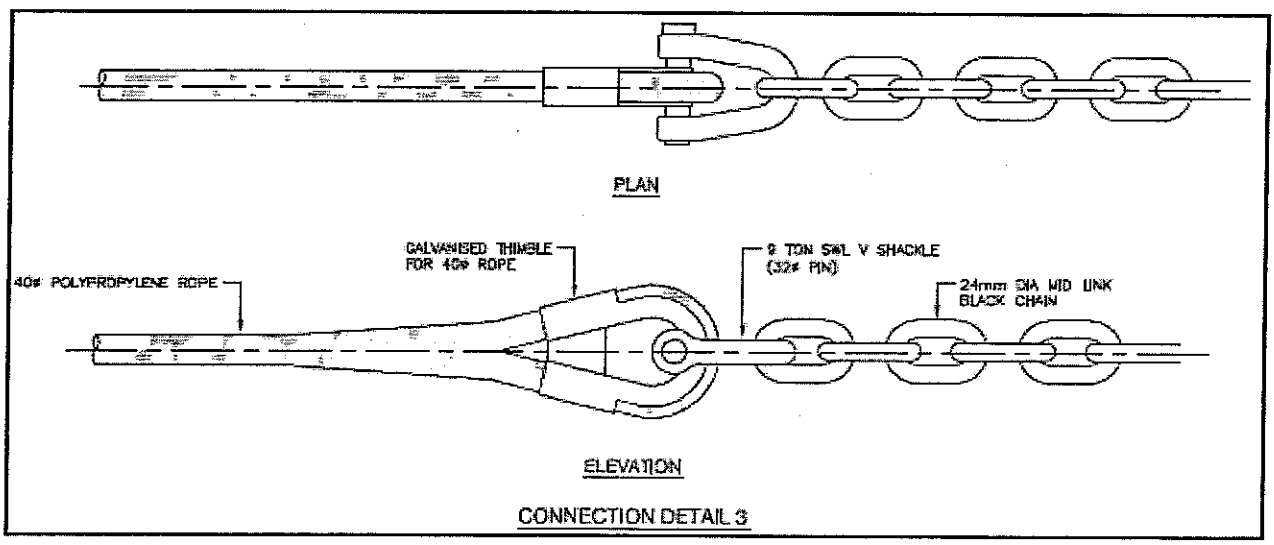
Approved Mooring Layouts:

Appendix B – Mooring Assembly Design

Chain attachment to farm:

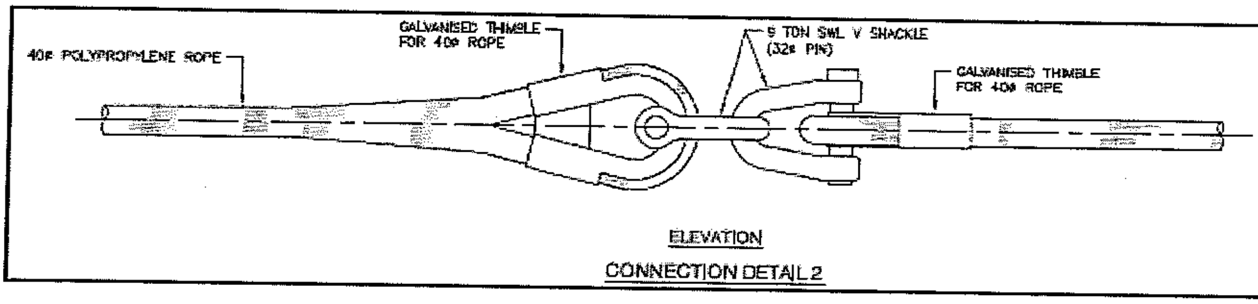


Chain to intermediate warp connection detail:

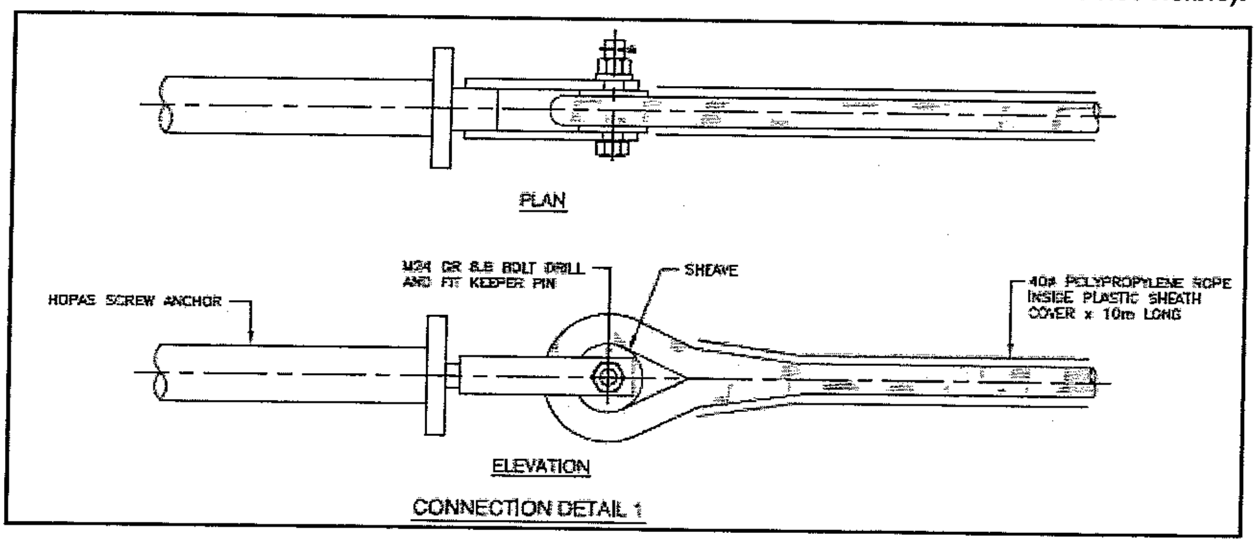


Appendix B – Mooring Assembly Design (continued)

Intermediate warp to anchor warp connection detail:



Anchor warp to anchor connection detail (below the surface of the seabed therefore not visible):



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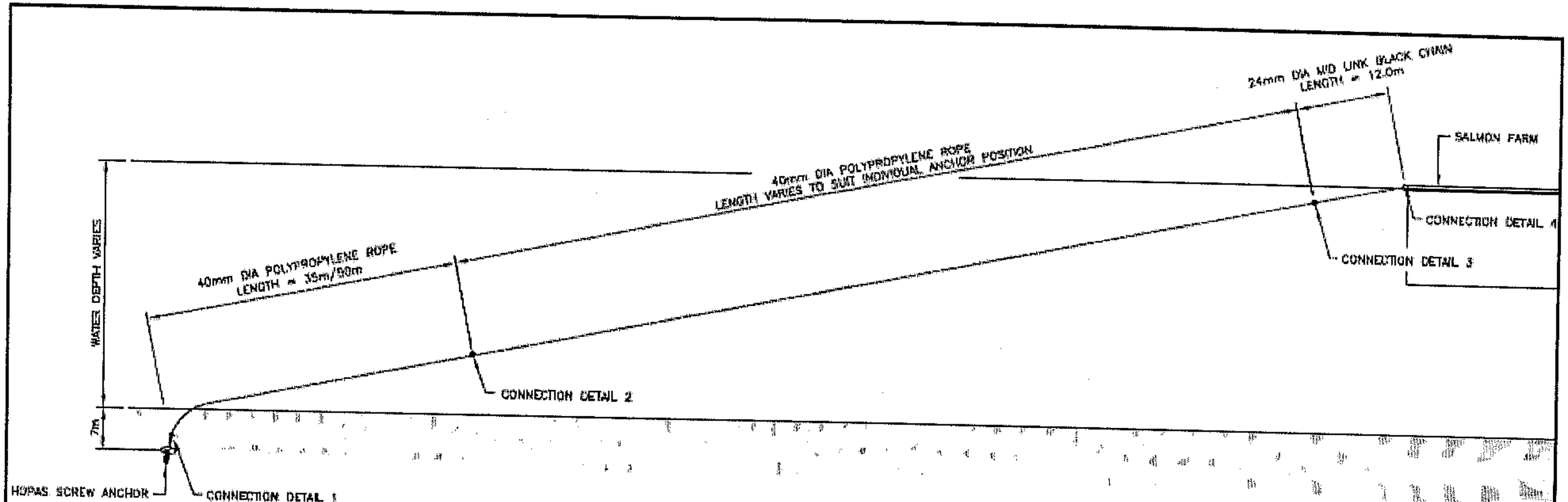
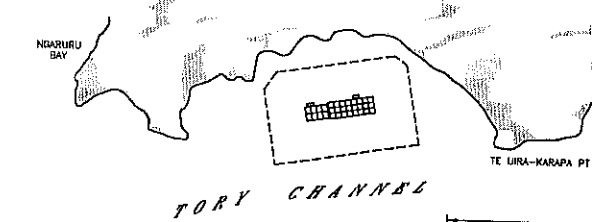
New Zealand King Salmon

Appendix B – Mooring Assembly Design (continued)

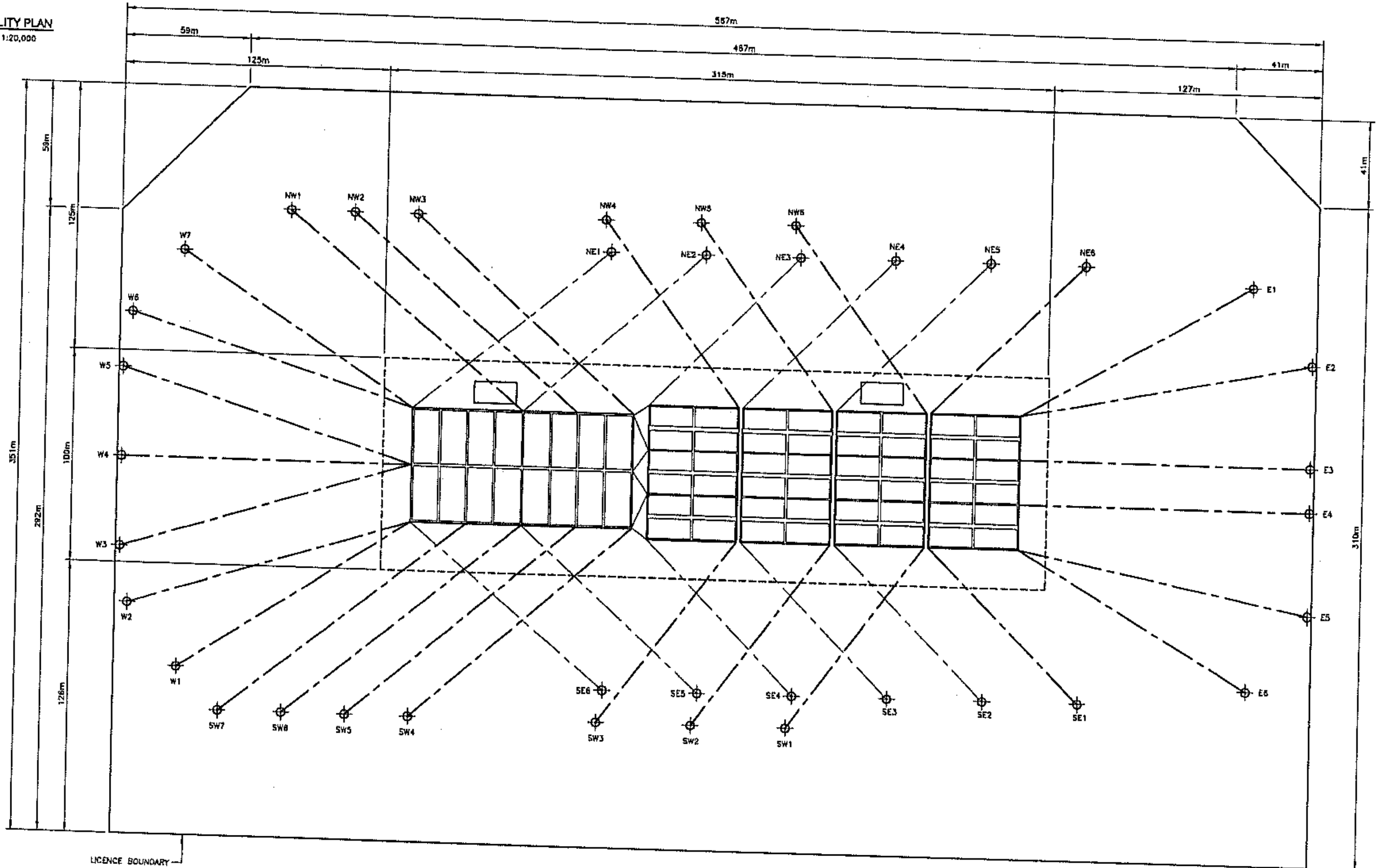
Complete anchor warp assembly:



ELEVATION OF TYPICAL ANCHOR WARP



LOCALITY PLAN
Scale 1:20,000



PLAN OF PROPOSED UBM6M6M6M6 CONFIGURATION
Scale 1:2000

LEGEND

- WARPS PASSING OVER
- WARPS PASSING UNDER
- NEW HOPAS SCREW ANCHORS

NOTE

1. ALL ANCHORS TO BE TESTED AFTER INSTALLATION
2. ALL ANCHOR WARPS TO BE TENSIONED EQUALLY
3. CURRENT VELOCITIES IN LICENCE AREA ARE YET TO BE DETERMINED

PRELIMINARY

PRELIMINARY ISSUE	C	23/11/06	RVE	PRELIMINARY		
Amendments	Rev'n	Date	Drawn	Issued for	Checked	Approved

Drawn	PN
Checked	
Traced	
Approved	
Date	08/06

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NZ KING SALMON CO. LTD
CLAY POINT SALMON FARM ANCHOR MODIFICATIONS
PLAN OF PROPOSED UBM6M6M6M6 CONFIGURATION

Scale (A3)	ACAD Filename	
AS SHOWN	051103/DR-051103-020C	
Drawing No.		Rev.
DR-051103-020		C