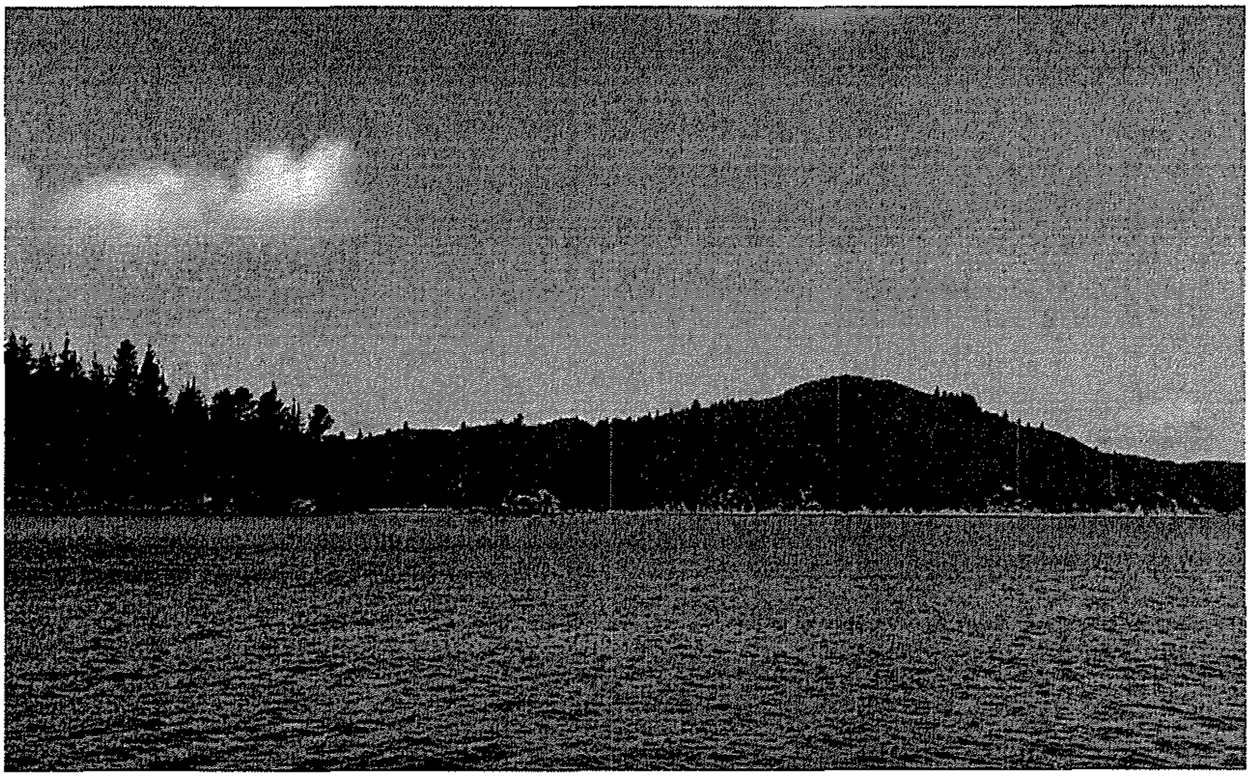
Cawthron Report No. 880

CAWTHRON

Fisheries Resource Impact Assessments (FRIAs) for three marine farms in Catherine Cove, D'Urville Island.

Part A: Site-Specific Assessments



Prepared for

Rangitoto Mussels Ltd
Kapua Marine Farms Ltd
Paul Marine Farms Ltd

April 2004

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by

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Cover Photo: Catherine Cove, Cawthron 2004.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

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SECTION 1 GENERAL INTRODUCTION

1.1 Background

Marine farming activities currently require a Coastal Permit under the Resource Management Act 1991 (RMA), and a Fisheries Permit under the Fisheries Act 1983. The RMA stipulates that proposed activities will have a '*no more than minor impact on the environment*' and an assessment of effects on the environment (AEE) must be prepared and submitted with an application to occupy coastal space. The Fisheries Act requires that marine farming activities have '*no undue adverse effect on fishing or the sustainability of any fisheries resource*'.

The Cawthron Institute (Cawthron) was commissioned in August 2003 by Rangitoto Mussel Ltd (RML), Kapua Marine Farms Ltd (KMF) and Paul Marine Farms Ltd (PMF) to provide additional information for their proposed marine farm sites in Catherine Cove (D'Urville Island), which will allow an appropriate assessment of the fisheries resources and to address sustainability issues as required by the Fisheries Act. In November 2002 the Ministry of Fisheries produced a guide to preparing a Fisheries Resource Impact Assessment (FRIA) for marine farming and spat catching permit applications (MFish 2002). The information requirements outlined in this document will be the basis of this report.

1.2 Catherine Cove farm management

At present, there are eight existing mussel farms operating within the Catherine Cove region. A unique feature of this Cove is that all eight farms, and the two new farms proposed, are all owned and operated by members of the Ngati Koata iwi. This has provided a unique opportunity for this iwi to manage the Cove with the intention of maintaining environmental sustainability in line with cultural values. The applicants see this present project as an opportunity to assess the present and predict the future sustainability of the Cove, and have asked Cawthron to develop an adaptive management plan (AMP) to ensure that the proposed expansions, and any future expansion of marine farming activities in the Cove, do not have an adverse effect on the cultural and environmental values of this area.

1.3 Structure of this report

The FRIA for the two proposed new marine farms and the renewal of MFP 231 consists of two parts (Part A & Part B), which have been provided as two separate documents:

Part A (*Cawthron report No. 880* – this document) is a single document that provides site-specific impact assessments for each of the three proposed marine farm sites. Due to the close proximity of the three farms, and the relationship between the three farm owners, all three assessments have been provided within the single document. This report provides the following for each of the proposed sites:

- An overview of the Catherine Cove marine (seabed) environment.
- A summary of the environment quality and site history.
- A description of the intended activities.
- An assessment of knowledge gaps.
- Characterisation of potentially affected areas, including the results of the site specific assessment undertaken between September 2003 and February 2004.
- An assessment of effects on the sustainability of fisheries resources.
- A discussion on options to avoid, remedy or mitigate adverse impacts.

Part B is a wider-encompassing assessment (Cawthron Report No. 881) that explores the potential impacts of the three proposed marine farms on fisheries resources and fishing in the region. A key component of this document is a proposed adaptive management plan (AMP) for Catherine Cove, which has been developed to avoid, minimise and mitigate adverse impacts to fisheries resources in the region. Part B provides the following:

- Characterisation of the wider Catherine Cove water column environments.
- An assessment of wider impacts to fisheries resources within the Cove; with specific reference to phytoplankton and zooplankton communities.
- An adaptive management plan (AMP) for the Cove, including details of the environmental monitoring system (EMS).

SECTION 2 CATHERINE COVE MARINE ENVIRONMENT

The following section is a literature review summarising the available ecological information on Catherine Cove and the surrounding marine environment. Existing knowledge gaps (with respect to the FRIA knowledge requirements) have been identified and are addressed for each farm in their respective sections.

2.1 Location

Catherine Cove is a relatively small (3.98 km^2), partially enclosed embayment on the eastern side of D'Urville Island, in the Outer Marlborough Sounds region (Figure 1). D'Urville Island is the largest island in the Marlborough Sounds (116 km^2), and forms the north-western extent of the Sounds. D'Urville Island is separated from the mainland by French Pass. The coastline is typically steep and rugged with cliffs, rock walls and headlands, and the subtidal environment typically contains a high diversity of seaweeds, fish and invertebrates (Davidson *et al.* 1990). The coast is exposed to strong currents from Cook Strait, particularly noticeable in the narrow French Pass area.

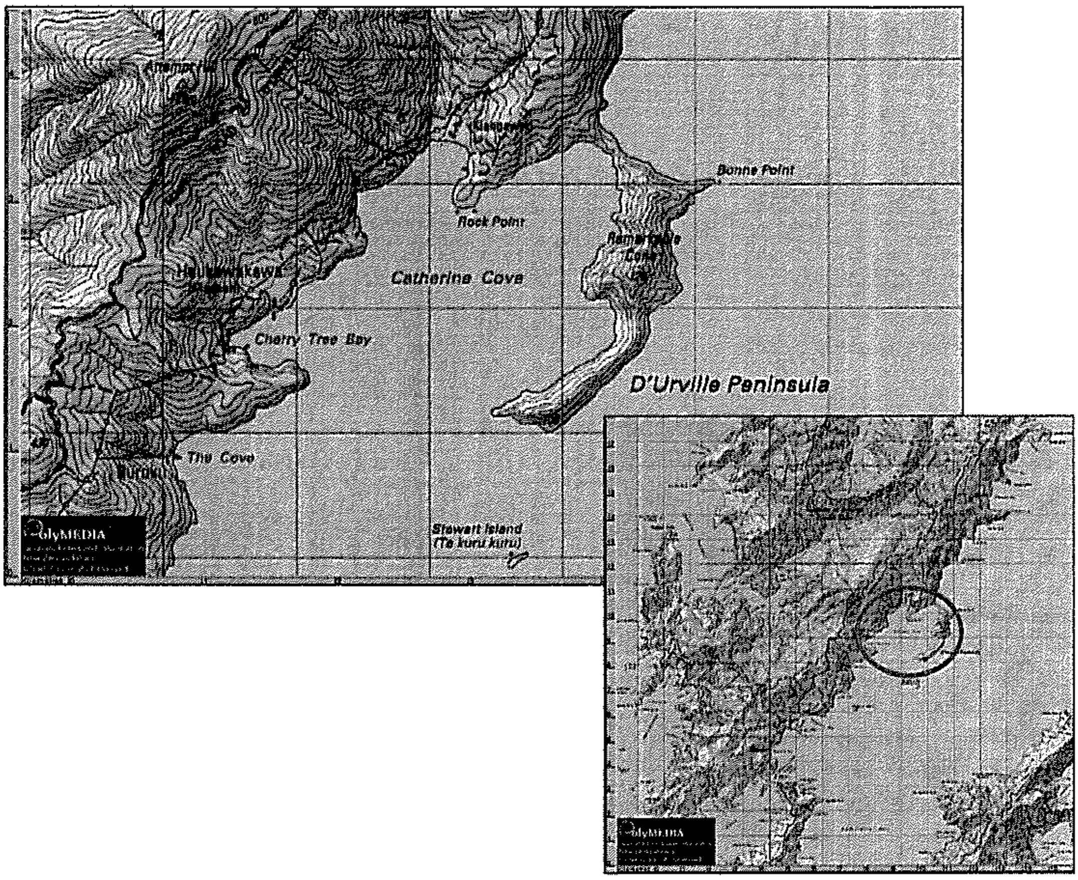


Figure 1: Map of D'Urville Island, showing the location of Catherine Cove.

2.2 Water column environment

There has been limited research on the water column processes within Catherine Cove, with most of the information coming from site-specific water column assessments for existing or proposed marine farms. Gibbs (2002) investigated aspects of the water column environment (tides, currents, water temperature, chlorophyll *a*) in June 2002 to address potential sustainability issues and other impacts from two proposed marine farms in the centre of Catherine Cove. Near-surface phytoplankton levels were measured by chlorophyll-*a* (chl *a*), and were shown to be variable (~0.5–1.5 $\mu g\ l^{-1}$), with the southern part of the cove generally having higher chl *a* concentrations, thought to be from the influence of oceanic water (Gibbs 2002). Surface currents were strongly wind-driven, with tidal reversal evident in deeper waters. The study found that there was very little vertical stratification in the bay at that time of year (winter).

Prior to the assessments presented in Part B of this report, there have been little or no documented investigations into the phytoplankton or zooplankton communities within Catherine Cove, other than the assessment of chl *a* by Gibbs (2002). Water entering the bay is likely to be oceanic Cook Strait water and the phytoplankton and zooplankton communities can be expected to be similar to those described in the Tasman Bay region by Bradford-Grieve *et al.* (1994) and MacKenzie & Gillespie (1986).

2.3 Recreational and commercial fisheries

Results from a 12-month survey (Bell 1998) in the Marlborough Sounds, which involved interviewing fishers, showed that the most important method of recreational fishing was rod/line from private boat, followed by diving from private boat, rod/line from shore and then set netting/gill netting A total of 23 species were caught during the period of survey and majority of the fishing trips were targeting blue cod.

There is evidence that fish densities can be greater and more diverse in or beneath mussel farms than in adjacent areas (Grange 2002). The most abundant fish species identified by Grange (2002) in and around mussel farms in Pelorus Sound were spotties, leatherjackets and blue cod, while less common fish species recorded within mussel farms were opal fish, triplefins, John Dory, scarlet wrasse, yellow-eyed mullet, koheru and red gurnard. Forrest (1999) reported that blue cod and spotties were the most abundant fish observed during a benthic survey within Catherine Cove, while opalfish were found to be fairly common by Brown (2000) (refer section 2.4.1).

There is no specific information regarding the commercial fishery in Catherine Cove. In the wider statistical area 017, a total of 58 species were captured during the last five fishing years, however, this may not reflect the fishery status in Catherine Cove. A comprehensive summary of the commercial, recreational and customary catch in Catherine Cove, if the information is available, will be provided in part B, the bay wide assessment for Catherine Cove (Cawthron Report No. 881).

2.4 Seabed ecology

2.4.1 Catherine Cove

Knowledge of the benthic (seabed) ecology of Catherine Cove is relatively limited, and based predominantly on ecological investigations conducted for proposed marine farming sites, which provide a detailed description of the local environment of the sites in question. Forrest (1999) undertook a predominantly qualitative site assessment of an existing mussel farm on the west side of D'Urville Peninsula within Catherine Cove. The seabed at shallower depths was described as cobble with occasional rocky outcrops, coarse sediments and shell hash, which gave way to soft muddy sediments with some shell hash with depth. The inshore rocky habitat featured common epibiota, such as 11-arm sea stars (*Coscinasterias muricata*); cushion stars (*Patiriella regularis*), sea cucumbers (*Stichopus mollis*) and kina (*Evechinus chloroticus*). Dog cockle (*Glycymeris* sp.) shells were abundant along mid-depth and shallow transects, and sponges were occasional on the rocky substrate. Blue cod (*Parapercis colias*) and spotties (*Notolabrus celidotus*) were the dominant fish species seen in the area. Kina and cushion stars were occasionally observed at ~30 m, while hydroids, horse mussels and brachiopods (*Terebratella sanguinea*) were less-frequently encountered. There was no visible epifauna on the muddy seabed along the deepest transect (up to 37 m deep).

A benthic survey of two proposed marine farms in the centre of Catherine Cove was undertaken by Brown (2000). The water depth at these sites ranged from 34-43 m, and was surveyed by a variety of remote sampling techniques; such as depth sounding, video transects, dredging and sediment grabs. The sediment on the seafloor was composed of well oxygenated grey/brown sandy mud (~30% sand particles and nearly 70% mud). There was a rocky reef identified to the north of the proposed farm site, extending offshore of Rock Point, a promontory on the northern coast of the cove. A total of 37 taxa were identified from video, dredge and grab samples. There were few conspicuous epifauna, mainly consisting of hydroids, sponges and cushion stars (*Patiriella regularis*) at low densities. Dredge contents were dominated by the small bivalve *Nemocardium pulchellum*, the brittle star *Amphiura rosea*, the heart urchin *Echinocardium cordatum*, the gastropods *Struthiolaria papulosa* and *Amalda australis*, the bivalve *Dosinia lambata*, bamboo worms (Maldanidae) and the sea mouse (Aphroditidae).

The infaunal community was relatively diverse and dominated by the bivalve *Ennucula strangei*, *A. rosea*, amphipods and a variety of polychaete worms, including the deposit feeding Cirratulidae worms and the predatory worm *Aglaophamus* sp. Opalfish (*Hemerocoetes monopterygius*) was the most common fish species, and a single dogfish was observed. The benthic community assemblage described by Brown (2000) is typical of relatively deep, mud habitat in the Marlborough Sounds, and is not considered to be of any special ecological value (*e.g.* Estcourt 1967; Forrest 1995). No other features were identified during the survey as being ecologically significant (Brown 2000). Recent site-specific seabed and nearshore ecological assessments were undertaken in Catherine Cove as part of this application, and are presented in later sections of this report.

2.4.2 D'Urville Island region

An ecological assessment was conducted at Bonne Point (north of Catherine Cove on the eastern coast of D'Urville Island) for a proposed marine farm site (Forrest & Barter 1999). Sediments were described as soft, grey/brown mud or sandy-mud, with one distinct area of shell hash. Brachiopods (*Terebratella sanguinea*), dog cockles (*Glycymeris* sp.) and scallops (*Pecten novaezelandiae*) were found associated with the shelly and sandy sediment zones of the site, as well as other epifauna typical for this habitat such as occasional kina, cushion stars, sea cucumbers, 11-arm sea stars and spiny murex (*Poirieria zelandica*). Muddy sediments featured abundant brittle stars (*Amphiura rosea*) and heart urchins (*Echinocardium cordatum*), with small mounds of Sabellidae tube worms, gastropods (*e.g. Struthiolaria* spp.), spiny murex (*Poirieria zelandica*), sea mouse (Aphroditidae), hermit crabs (*Pagurus* sp.) and compound ascidians encrusting the tube worms. Opalfish (*Hemerocoetes monopterygius*) were seen occasionally, and flatfish and spotties were rare. The infaunal community was dominated by brittle stars, heart urchins and small bivalves, predominantly *Nemocardium pulchellum*, *Neilo australis*, and *Ennucula strangei.* The presence of other bivalves, such as *Gari lineolata* and *Tawera spissa*, was likely due to the sandier sediments at the site compared to sheltered Sounds sites, and infaunal worms and sea cucumbers were also notably less diverse and abundant at the Bonne Point site than at more sheltered Sounds sites (Forrest & Barter 1999).

Davidson & Brown (1994) described the ecology at four marine reserve options around the east coast of D'Urville Island and the western entrance to Pelorus Sound. The coast from Bonne Point on the outer coast of D'Urville Peninsula up to Whareatea Bay, including Penguin Island, was surveyed, although no offshore soft bottom sites were investigated. Brown algae, sponges, barnacles and a variety of fish species, including blue cod, scarlet and banded wrasse, spotties, leatherjackets, and blue moki were characteristic of much of the rocky reef habitats. Dog cockles (*Glycymeris* sp.) were found in high densities around Penguin Island and the adjacent coast amongst cobble/shell, although decreased with depth (>12 m). Bonne Point reef was well covered with macroalgae (*Carpophyllum maschalocarpum*, *C. flexuosum*, *Caulerpa geminata*), sponges and anemones. Dog cockles were also located in soft bottom substrates around the reef (Davidson & Brown 1994).

Another study of the western outer Marlborough Sounds described five subtidal soft bottom sites on D'Urville Island and on the mainland south of French Pass (Davidson & Davidson 1994). Although none of the sites were located close to or within Catherine Cove, their descriptions may assist in understanding the Catherine Cove ecology. These proposed marine farm sites were located on the north-east, north, and western aspects of D'Urville Island and in Papawai Bay on the mainland, north of Croisilles Harbour. All sites were relatively exposed, especially from the north. Sediments from the sites were aerobic and predominantly silty sands, although the site at the northwest of D'Urville had a greater proportion of coarse sand. There were few conspicuous epifauna present on the seabed, with the exception of the Puangiangi Island site, which featured a well established horse mussel (*Atrina zelandica*) bed. There was considerable variation in the diversity and abundance of the seabed biota between sites, but the most common species in the samples were sabellid and spionid polychaetes, the small bivalve *Scalpomactra scalpellum*, and amphipods. Four sites were deemed fairly similar in assemblage and comparable to the outer Sounds sandy muds fauna; however, the north western D'Urville site had fewer individuals and taxa and a dissimilar assemblage. The rocky subtidal habitat fringing the coastline of the sites was typically well covered by macroalgae, especially the brown algae *Ecklonia radiata, Marginariella urvilliana.,* *Carpophyllum maschalocarpum* and *C. flexuosum*) (Davidson & Davidson 1994; Gillespie 1994).

2.4.3 Admiralty Bay

As Davidson & Davidson (1994) highlighted, there can be considerable variation in the benthic fauna of the D'Urville Island region. Much of the exposed north and west sides of D'Urville Island (described above) are not likely to closely approximate Catherine Cove, which is sheltered on the east coast. Admiralty Bay, however, lies directly to the south of Catherine Cove in the Outer

Sounds region, and surveys of the seabed in Admiralty Bay may be useful to provide further descriptions of the likely benthic environment of Catherine Cove.

Brown & Gillespie (1999) undertook a site assessment for a proposed mussel farm in southern Admiralty Bay. The site was positioned over flat, grey/brown aerobic mud, at depths ranging between 44-48 m. Video and dredge transects revealed a commonly encountered faunal assemblage for the Marlborough Sounds. The sparse epifaunal community was dominated by brittle stars (*Amphiura rosea*), heart urchins (*Echinocardium cordatum*) and the bivalve *Nemocardium pulchellum*. Also present were other small bivalves, Cirratulid worms, Maldanid tube worms (*Asychis* sp.), sabellid worms and spiny murex. The opalfish (*Hemerocoetes monopterygius*) was commonly observed across the site, with other fish species (including flatfish, dogfish, blue cod and spotties) less common. No features of special ecological interest were identified at the site (Brown & Gillespie 1999).

Forrest & Barter (1999) surveyed two proposed marine farm sites on the east and western sides of Admiralty Bay, near French Pass. Both sites were in relatively deep water (42-46 m) and positioned over flat, muddy seabed. Similar to Brown & Gillespie (1999), a typical *Amphiura-Echinocardium* dominated assemblage was found on a relatively barren seafloor. Tubeworms were common in most dredge samples, and other taxa, including small bivalves, the larger brittle star (*Ophionereis* sp.), spiny murex (*Poirieria zelandica*), olive shells (*Amalda mucronata*), scallops (*Pecten novaezelandiae*), polychaetes and sea cucumbers, were occasional or rare. Opalfish, dogfish, juvenile flatfish, and red gurnard were observed. Forrest & Roberts (1995) also surveyed two sites in Admiralty Bay for marine farm assessments, and described a similar faunal assemblage to that of numerous other reports of the Marlborough Sounds subtidal slope (*e.g.* Forrest 1995).

2.5 Mammals and seabirds

The endemic king shag (*Leucocarbo carunculatus*) is confined to the outer Marlborough Sounds region, and is ranked as 'vulnerable' on the IUCN Red List (Lloyd 2003). The king shag has a roosting site at the tip of D'Urville Peninsula (Davidson *et al.* 1990). Additionally, there is the largest of four colonies of king shag on the Trio Islands (~5 km east of D'Urville Island), as well as very dense populations of other breeding seabirds, including fluttering, sooty and flesh-footed shearwaters (*Puffinus* spp.), diving petrels (*Pelecanoides urinatrix*) and the fairy prion (*Pachyptila turtur*) (Davidson *et al.* 1990). Gulls, terns and shags also use the islands around D'Urville for breeding and roosting. Seabirds from the offshore islands are likely to visit the eastern D'Urville coast region.

A wide variety of dolphins and whales have been recorded from the outer Marlborough Sounds area, including the Dusky dolphin (*Lagenorynchus obscurus*), Hector's dolphin (*Cephalorynchus hectori*), bottlenose dolphin (*Tursiops truncatus*), orca (*Orcinus orca*) and New Zealand fur seals (*Arctocephalus forsteri*) (Davidson *et al.* 1990). There is a paucity of published data on marine mammal sightings in Catherine Cove. However, Dusky dolphins have been observed by Cawthron personnel within the cove during recent visits.

SECTION 3 GENERAL SAMPLING APPROACH

3.1 Seabed sampling

Benthic surveys of the proposed marine farm extensions were carried out by Cawthron staff using a range of remote sampling techniques. Physical, chemical and biological properties of the seabed were assessed using a combination of four sampling techniques (sidescan sonar, video, dredge, and sediment grab samples), as well as diver observations which together encompassed a wide range of spatial scales (Figure 2). General details of the sampling methods are provided below, specific sampling information (*e.g.* sample locations and number of samples collected) is provided in the respective sections of this report.

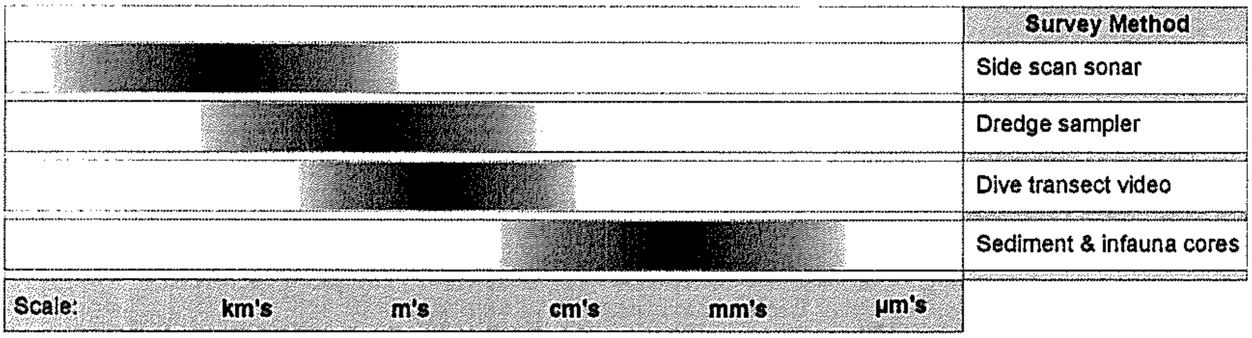


Figure 2: Sampling methodologies adopted in the present study and approximate scales of use.

3.2 Physical and chemical properties of the sediments

3.2.1 Bathymetric survey

Continuous depth readings were taken with a Garmin FF100 Fish Finder within, around and inshore of the proposed extensions, up to the shallow subtidal/intertidal zone, and sent to a PC via a RS232 serial output. The PC simultaneously collected separate RS232 serial output of latitude and longitude from a GPS, and both data streams were incorporated into Windows Dynamic Data Exchange (DDE) server using custom design communications software. Depths were standardised to chart datum and plotted in 3-dimensions using Surfer v.7 surface mapping software. The 2-dimensional graduated colour contour maps and the 3-dimensional wire frame plots were gridded using the kriging method. The position of the proposed farms/extensions were generated as base maps and overlaid on the 3-D plots.

3.2.2 *Sidescan sonar survey*

Sidescan sonar outputs were used to depict the topography of the seafloor and enable detection of any low-resolution changes in substratum texture beneath and adjacent to the proposed sites (where possible). A Tritech™ sonar 'fish' was towed at a speed of approximately 2.4 knots, and had a swathe width set to 60 m (30 m either side of the fish). GPS positions were simultaneously logged with the sidescan sonar output on an onboard laptop computer using Tritech™ software, allowing the relocation of any areas of interest for verification.

3.2.3 *Sediment grain size distribution and organic content*

Sediment cores (63 mm diameter x 70 mm deep) were collected from the contents of a van Veen grab at stations both within and around the proposed extensions. The colour of the mud and the presence/absence of any anoxic patches within the sample were recorded and the redox potential discontinuity (RPD) layer[1] was measured. The top 25 mm of cores were collected for analyses of sediment grain size distribution and organic matter content. In the laboratory, sediment samples were wet sieved and the proportion of gravel (≥2 mm), sand (≥63 μm) and silt/clay (<63 μm) was determined gravimetrically after drying at 105°C. The organic content was assessed by measuring the Ash Free Dry Weight (AFDW) of sediments by drying at 105°C, then ashing at 550°C to a constant weight.

3.3 Biological properties of the sediments

3.3.1 *Epibiota*

Epibiota and associated habitats within and around the proposed sites were characterised using three methods:

1) Digital video sled: An underwater video camera and light was attached to a sled and tethered via cables to a VCR and television on the boat. Transects were undertaken by lowering the sled and camera to the seabed and towing it in the desired direction. GPS positions and depths were recorded for each transect, along with observations on conspicuous epibiota and substrate type.
2) Dive transects: Dive transects provided an opportunity to ground-truth the remotely collected video footage, and to further elucidate the depositional footprint of existing marine farms in the vicinity of the proposed sites. Transects were undertaken inshore of the proposed sites, from a depth of approximately 25-30 m, extending up into the shallow

[1] The boundary between oxygenated and un-oxygenated sediments is often distinct, and is termed the redox potential discontinuity (RPD) layer.

subtidal/intertidal region of the shore. During each transect video footage of the seabed was obtained.

3) Dredging: A dredge with a 250 mm x 500 mm throat fitted with a 10 x 10 mm stainless wire mesh was used to sample benthic epifauna[2]. Dredge tow start points were generated using GIS software (Arcview™) and a stratified random sampling design. For each dredge tow, the start and stop GPS position, water depth and time of sampling were recorded. Dredge contents were identified and recorded on site where possible, or preserved in 70% ethanol and transported back to Cawthron for identification.

3.3.2 *Infauna*

An additional sediment core (130 mm diameter x 100 mm deep) was extracted from each grab sample collected to determine the physical/chemical properties of the sediments (refer Section 3.2.3). Infauna retained on a 0.5 mm mesh were preserved in 70% ethanol and transported back to Cawthron for identification.

3.4 Water column sampling

Gibbs (2002) provided a comprehensive assessment of water column properties within Catherine Cove; including the characterisation of water currents and chlorophyll-*a* concentrations within the Cove. In addition to this assessment, a FSI current meter was deployed at the Kapua Marine Farms site to obtain site-specific current data to allow a detailed prediction of the depositional footprint. This was particularly important due to the presence of inshore reef habitat identified in a previous survey (Davidson 1999).

[2] Epifauna are large-bodied (visible to the naked eye), sediment surface-dwelling species.

SECTION 6 PAUL MARINE FARMS LTD

6.1 Introduction

Paul Marine Farms Ltd (PMF) own and operate a 1.25 ha marine farm (MFL 231) in Catherine Cove, which is an extension to an existing marine farm (MFL 435) (Figure 34). The permit for this extension expires in February 2004. In August 2003, PMF commissioned the Cawthron Institute to describe the ecological values of the seabed and the water column in the vicinity of the farm site, and to assess the potential ecological impacts from the proposed activity, in accordance with the FRIA guidelines (MFish 2002).

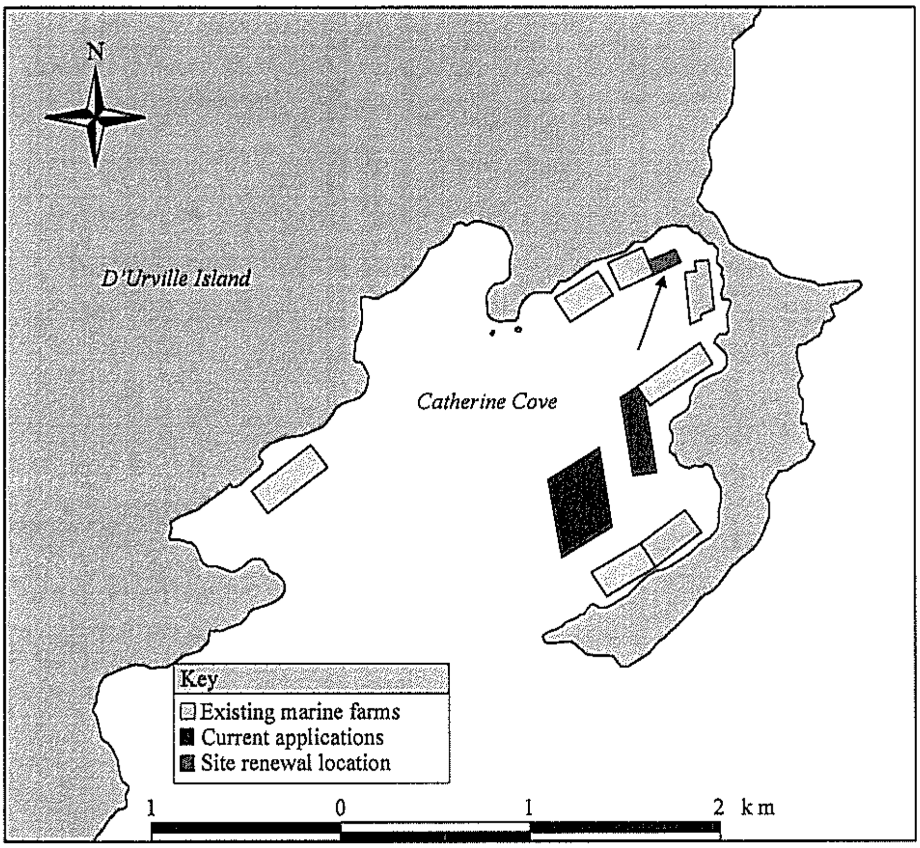


Figure 34: Location of the PMF site in Catherine Cove, D'Urville Island. Refer to Appendix A for the GPS coordinates of the proposed site.

6.1.1 Overall environmental quality and site history

Mussels have been farmed at the PMF site for approximately eight years, which has resulted in a significant modification of the seabed at the site; including the deposition of organic matter and shell debris to the seafloor (refer Section 6.2). Commercial fishing does not occur within the site, due to the presence of the marine farm.

6.1.2 *Description of the proposed activity*

PMF are presently culturing Greenshell™ mussels (*Perna canaliculus*) at the farm site. However, PMF are also applying for a permit to culture several other species at the site; including bivalves, algae and Kina. Details of culture methods, species, stocking densities, estimated production and source of stock are provided in Table 17.

Table 17: Summary culture details of the proposed PMF marine farm.

Farm information	**Details**
Farm size	A 1.25 ha existing extension to MFL 435.
Culture methods	Baskets and racks for kina, scallops, paua, oyster and cockle. Conventional long line for the other species.
Structures	Limited to anchors, ropes, weights, floats, lights and other necessary navigational aids associated with mussel farming.
Species to be cultured	**Bivalves:** Greenshell™ mussels (*Perna canaliculus*), Blue mussel (*Mytilus galloprovincialis*), Scallop (*Pecten novaezelandiae*), Kina (*Evechinus chloroticus*), Paua (*Haliotis iris, Haliotis australis*), Dredge oyster (*Tiostrea chilensis*) and Cockle (*Chione stutchburyi*). **Algae:** *Ulva lactuca,* Bladder kelp (*Macrocystis pyrifera*), *Ecklonia radiata, Lessonia variegata, Gracilaria* sp., agar weed (*Pterocladia lucida*).
Stocking densities	Seeding density of 150-180 mussels per metre.
Estimated farm production	35,000-45,000 kg of mussel (*Perna canaliculus*)/crop cycle (18 months).
Source of stock	Local (Tasman and Golden Bay) and from Kaitaia.

6.1.3 *Assessment of knowledge gaps*

A review of both published and unpublished literature was undertaken as part of the assessment of knowledge gaps for the present application. Existing information for the proposed site was available from two main sources:

1) A water column assessment undertaken by Cawthron, as part of the Rangitoto Mussels Ltd (Section 4) resource consent application:

> Gibbs, M. 2002. Assessment of the water-column environment, production sustainability and impacts of a proposed marine farm at Catherine Cove, D'Urville Island. Report prepared for Rangitoto Marine Farms Ltd. *Cawthron Report No. 740.* 21p + appendices.

2) Raw data and summary results from benthic and water column research conducted in Catherine Cove by Mr Neil Hartstein, a PhD student working with NIWA.

Knowledge gaps identified were stated in a letter (dated 29/7/2003) provided to the Ministry prior to the additional sampling outlined in this report (Appendix C). The review of available information identified several knowledge gaps, including the lack of the following:

- Depth profiling to chart datum.
- A quantitative infaunal community investigation.
- A semi-quantitative investigation of epifaunal communities and pelagic/demersal fisheries resources.
- Characterisation of the physical properties of sediments.

These knowledge gaps were addressed in the additional fieldwork undertaken at the site between September 2003 and February 2004.

6.2 Characterisation of potentially affected areas

6.2.1 Methods

Seabed sampling

Section 3 outlines the general methodologies used to characterise the seabed beneath and adjacent to the PMF site. A summary of the seabed sampling undertaken between September 2003-February 2004 at the PMF site is provided below in Table 18 and displayed in Figure 35.

Table 18: Summary of seabed sampling undertaken at the proposed PMF farm site between September 2003 and February 2004.

	Grab-Infauna	Grab-AFDW	Dive transects	Video tows	Sidescan sonar transects
Present study	13	13	2	5	1

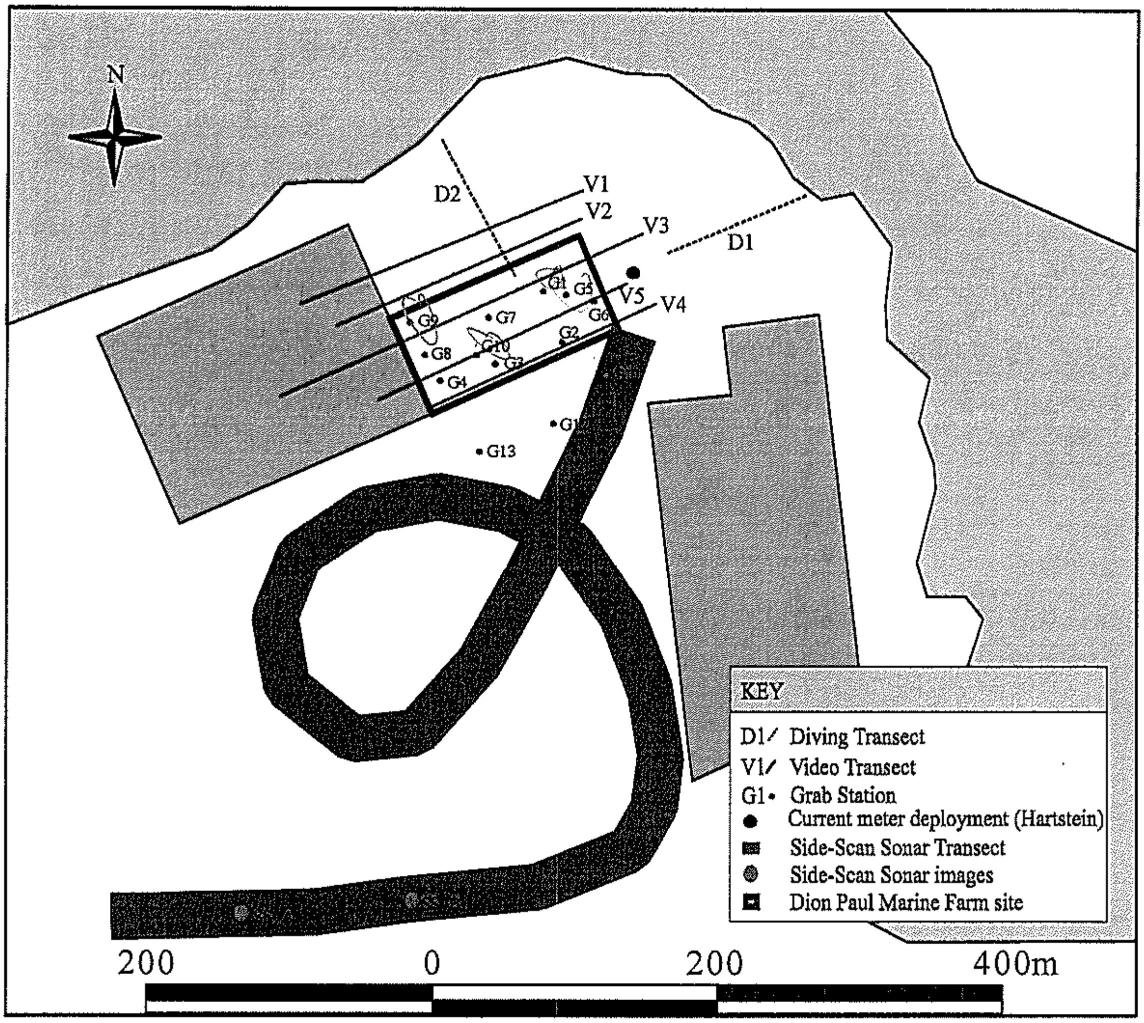


Figure 35: Site map showing the seabed sampling stations of the present study at the PMF site in Catherine Cove, D'Urville Island.

Water column sampling

No additional water column data was collected from the PMF site, as there was sufficient data available from a comprehensive water column assessment undertaken within Catherine Cove by Cawthron (Gibbs 2002, Refer to part B Cawthron Report No. 881), and current data collected at the PMF site by Neil Hartstein (Hartstein, unpublished data 2002) in Catherine Cove (Appendix B).

6.2.2 Results

The following section describes the results of an ecological assessment undertaken by Cawthron between September 2003 and February 2004. Results from Gibbs (2002) and data provided by Neil Hartstein (a PhD student studying benthic effects of marine farms, unpublished data) have also been incorporated, for comparative purposes.

Site bathymetry

The PMF site is located in relatively deep water, ranging from 32 m along the offshore boundary to 15 m along the inshore boundary. As Figure 36 illustrates, the inshore boundary of the site is positioned over the subtidal slope, a habitat in commonly associated with cobble/gravel substrate (Forrest 1995).

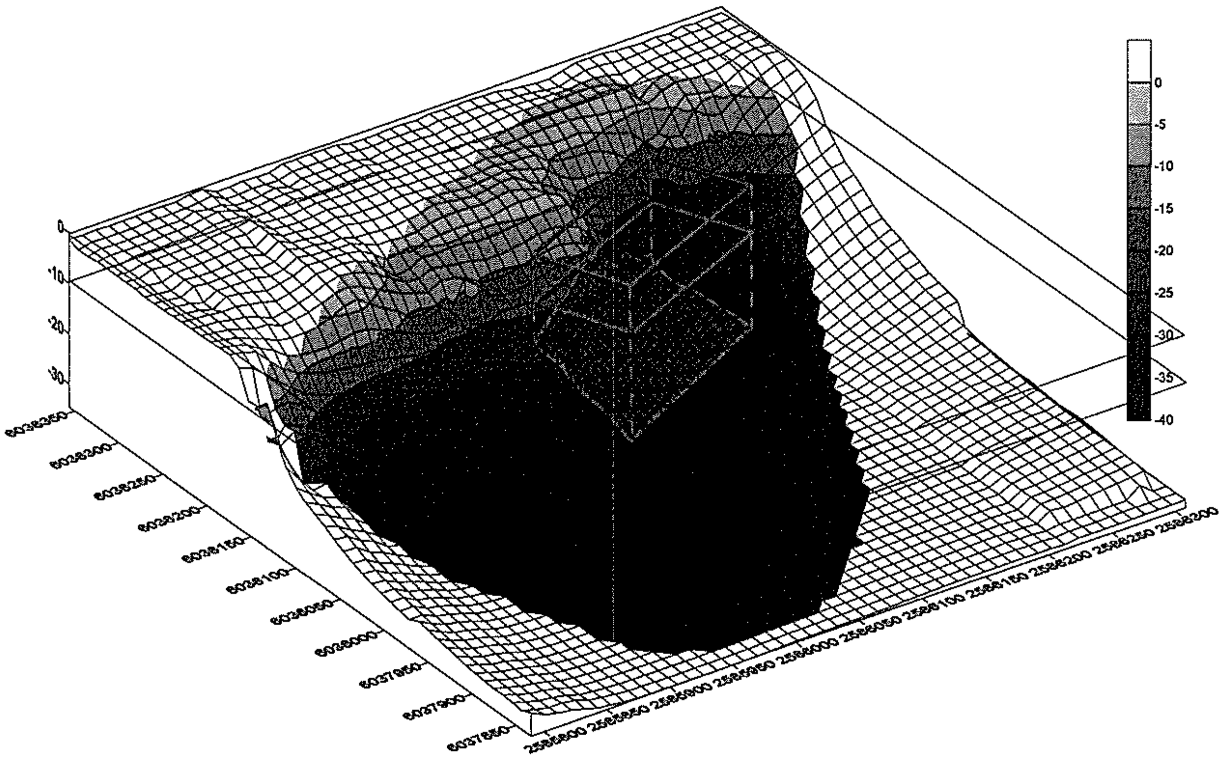
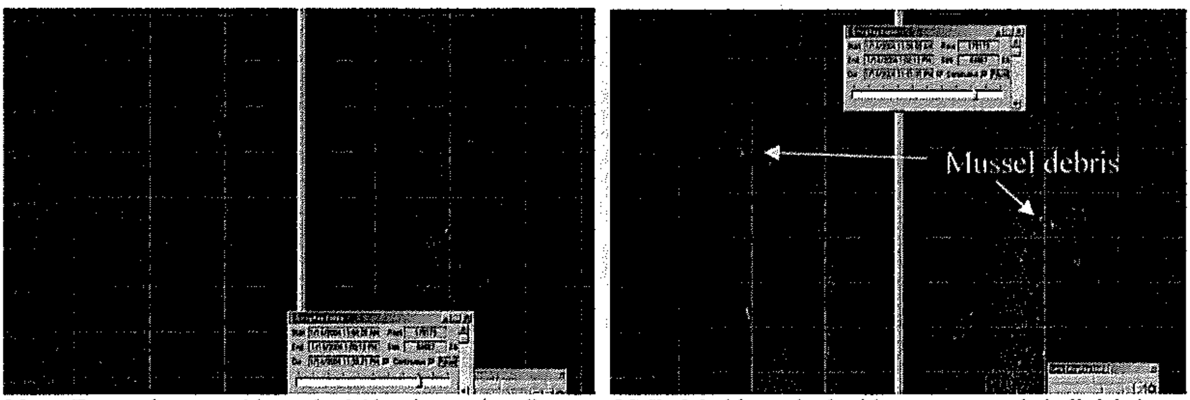


Figure 36: A 3-dimensional bathymetry plot of the existing PMF site in Catherine Cove, D'Urville Island.

Seabed composition

The seabed offshore and adjacent to the PMF site is flat, relatively featureless mud (Figure 37, SS-A), the dominant bottom type found in water depths of 35+ m in Catherine Cove. Some mussel clumps were detected sparsely distributed approximately 370 m to the south of the site (Figure 37

SS-B), which were most likely mussel debris from a nearby farm. As the application is for a renewal, and the farm was operational at the time of sampling, sidescan sonar footage of the seabed directly beneath the site was not obtained due to the risk of gear entanglement. However, the substrate type was depicted from grab samples and visual observations. Sediment samples collected from beneath the farm were variable in grain size composition (Figure 38), and, on average, composed of 47.5% mud, 34.3% sand and 18.2% gravel. Cobbles were present in Grabs 1, 5, 9 and 10; which were distributed throughout the farm. Interestingly, grabs 2, 3, 8 and 10 had a very shallow redox potential discontinuity (RPD) layer (1-5 mm), with a thin brown layer of sediment overlying black anoxic mud below. All grab samples contained shell material, while G4 contained so much shell that a sample for grain size and AFDW was not possible. The offshore grabs (G11, G12, and G13) appeared to be less enriched, and were composed of a higher proportion of mud.



SS-A: Featureless, muddy seabed (dominant signal) **SS-B:** Muddy seabed with some mussel shell debris

Figure 37: Sidescan sonar images of the seabed offshore of the PMF site.

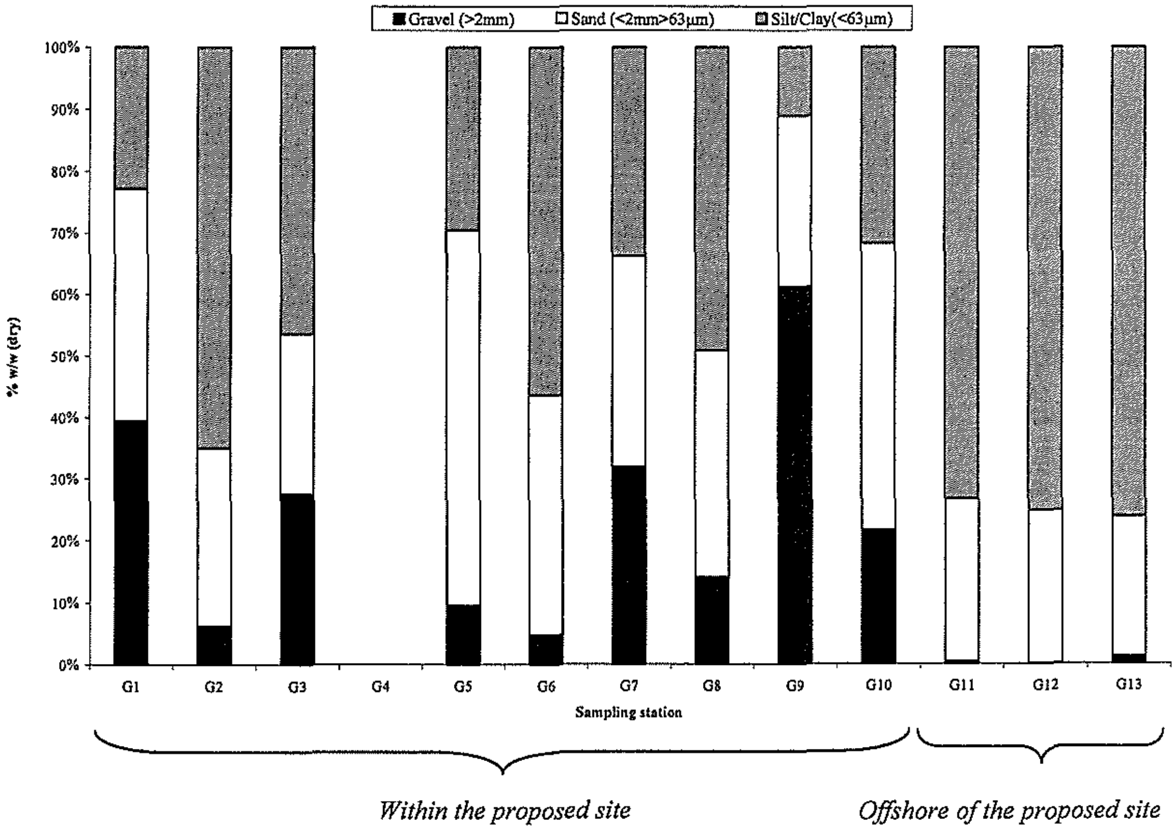


Figure 38: Grain size classes of sediment sampled from stations within and around the PMF site.

The organic content (AFDW) of the sediments beneath and adjacent to the site ranged between 3.8-7.7% (average=6.2%), which suggests an existing slight to moderate enrichment of the seabed at the site (Figure 39). This was not unexpected, as the PMF site has been operating at this site since 11 July 1996.

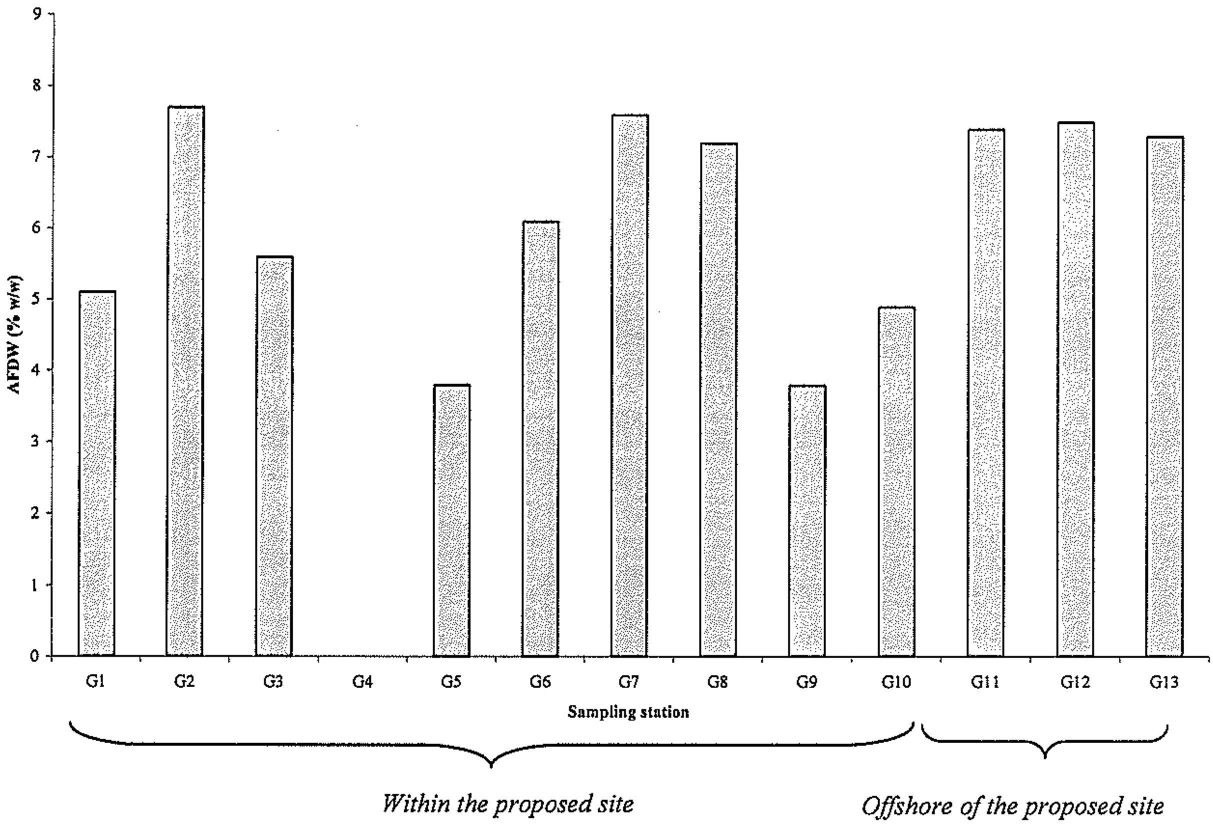


Figure 39: Organic content (AFDW) of sediments sampled from stations within and around the PMF site.

Biological properties of the seabed

Epibiota

The substrate beneath the farm site varied from soft mud to a cobble habitat (Figure 40). The epibiota associated with the mud habitat (video tows 4 & 5) were relatively sparse, consisting mainly of turret shells (*Maoricolpus roseus roseus*), sea cucumbers (*Stichopus mollis*) and saddle squirts (*Cnemidocarpa bicornuata*). Scallops (*Pecten novaezelandiae*) and horse mussels (*Atrina zelandica*) were also present, but in very low densities. As mentioned previously, there was a relatively large amount of shell material on the seabed beneath the farm, which is common beneath mussel farms in the Sounds region (Cole & Grange 1996). The mud habitats which had high shell debris content had a slightly more complex community structure than mud without shell material. The epibiota associated with the mud/whole shell habitat consisted of the same species as above, with the addition of kina (*Evechinus chloroticus*), cushion stars (*Patiriella regularis*), 11-armed sea stars (*Coscinasterias muricata*), live mussel clumps (*Perna canaliculus*) and calcareous tube worms (Serpulidae sp). Video transects 1, 2 and 3 were undertaken along substrates that contain sandy, cobbles and at times rocks. Interestingly, while species complexity did not change in the harder substrates, animal abundance appeared to be higher. Dredge samples were not collected from beneath the existing farm due to the risk of entanglement with long line structures and farm debris (*e.g.* ropes, blocks) and the presence of relatively large amounts of mussels (live and shell debris) on the seabed (as determined from the video footage).

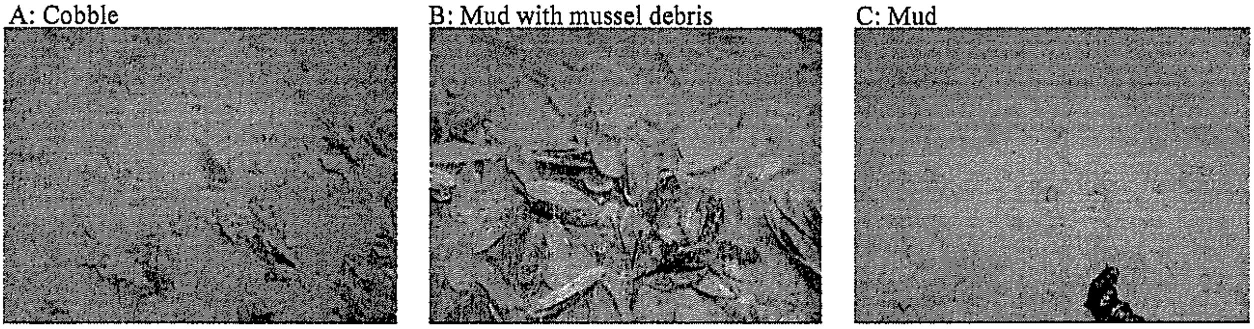


Figure 40: Habitat types beneath the PMF site within Catherine Cove.

Epibiota inshore of the PMF site are summarised in Figure 41 & Figure 42. The shallow subtidal/intertidal zone contained bedrock with occasional boulders. Three species of macroalgae (*Hormosira banksii*, *Cystophora torulosa* and *Carpophyllum flexuosum*) were attached to the hard substrate, and conspicuous epifauna included small gastropods, barnacles and chitons. At water depths, >6-8 m the substrates varied; with transect #1 identifying a muddy habitat, while transect #2 contained sand gravel with occasional rock. The epifaunal communities below the shallow subtidal/intertidal zone along both transects were similar; despite the difference in substrate consisting of saddle squirts, scallops, turret shells, 11-arm sea stars, cushion stars and kina. Spotties (*Notolabrus celidotus*),) and triple fins (*Forsterygion* sp.) were observed at both sites, however blue cod (*Parapercis colias*) was only present at the shallow subtidal zone along transect #2.

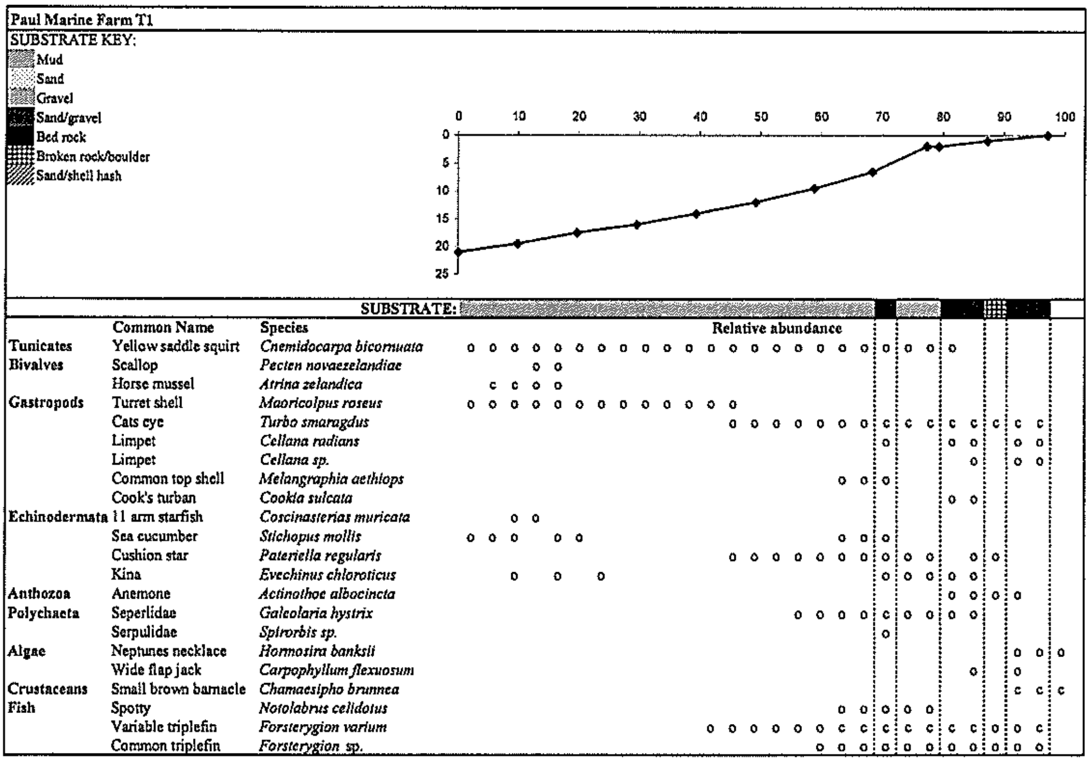


Figure 41: Habitat types and conspicuous epibiota observed along diver transect #1 at the PMF site. (Relative abundance scale used, C=common & O=occasional).

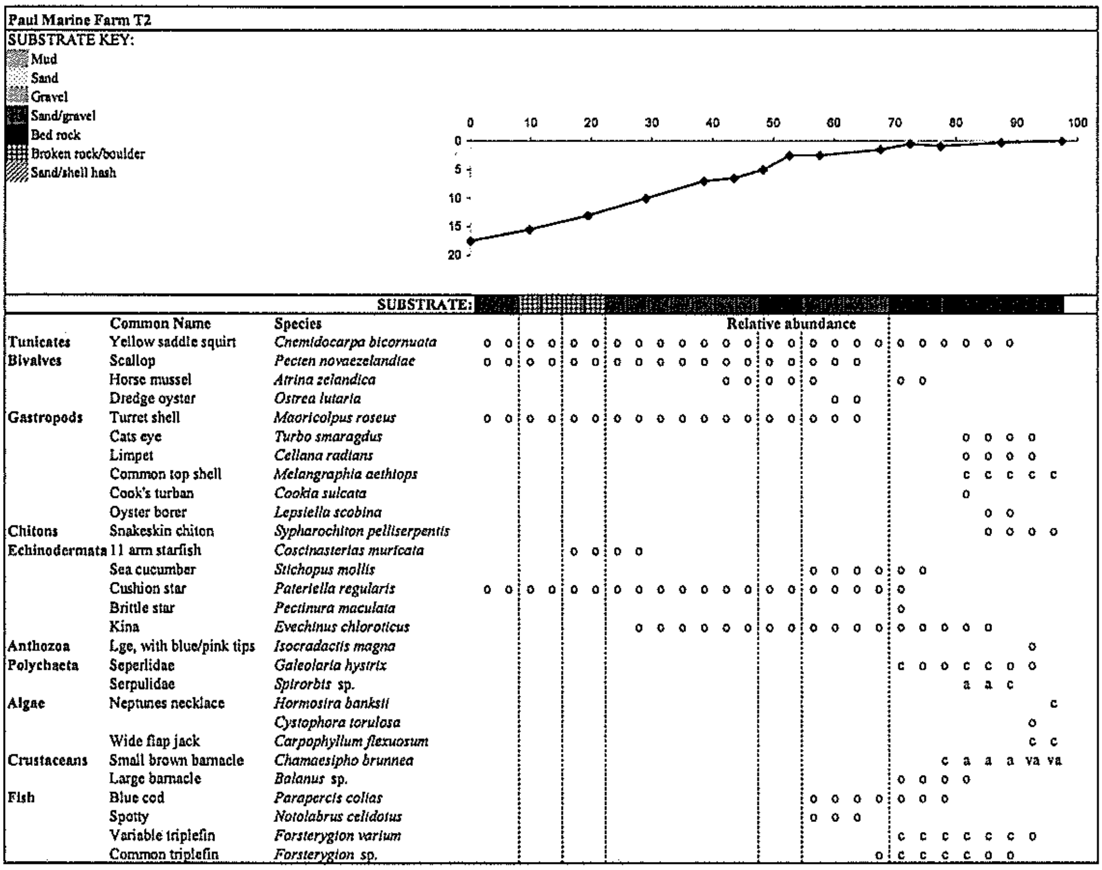


Figure 42: Habitat types and conspicuous epibiota observed along diver transect #2 at the PMF site. (Relative abundance scale used, C=common & O=occasional).

Infaunal communities

A total of 96 taxa were identified from the 13 infauna grab samples collected from within and outside the existing farm site (refer Appendix D for the complete species list). Grabs 1, 3, 4, and 9, and to a lesser extent 7, had relatively high animal abundance and species richness which was most likely due to the increased elevated levels of gravel, sand and shell material below the marine farm at these sites (Figure 43). Samples collected were dominated, in terms of abundance and number of taxa, by polychaetes, amphipods, nematodes, ostracods and brittle stars (Ophiuroidea) (Table 19). The chiton (*Leptochiton inquinatus*) was present in 5 of the 13 grab samples in moderate abundances. This chiton species is small (<4 mm) and is found on hard substrates, including shell debris (*e.g.* mussel and strawberry cockle shells), which is common at the site and is likely to be providing the required hard substrate.

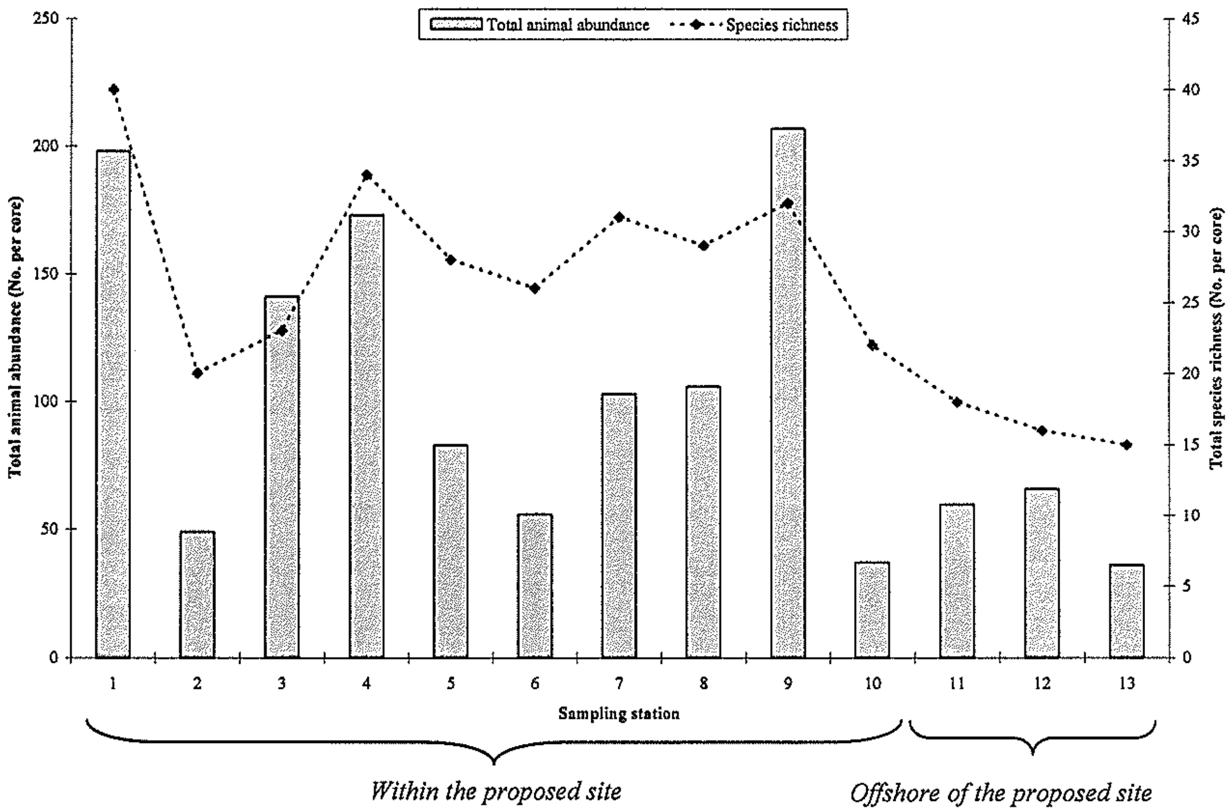


Figure 43: Animal abundance and species richness of sediments sampled within the proposed farm site.

Table 19: Average[7] and relative abundance[8] of infaunal species sampled from within and adjacent to the PMF site.

Taxa	Common name	Average abundance	Relative abundance (%)
Dorvilleidae	Polychaete	15.5	15.3
Sphaerosyllis hirsula	Polychaete	11.5	11.4
Amphipoda b	Amphipod	6.5	6.5
Ostracoda	Ostracod	5.5	5.5
Nematoda	Roundworm	4.8	4.7
Ophiuroidea	Brittle star	4.1	4.0
Theora lubrica	Bivalve	3.9	3.9
Amphipoda a	Amphipod	3.5	3.5
Prionospio sp.	Polychaete	3.2	3.1
Hesionidae	Polychaete	3.2	3.1
Paraonidae	Polychaete	3.0	3.0
Cumacea	Cumacean	3.0	3.0
Lumbrineridae	Polychaete	2.4	2.4
Cirratulidae	Polychaete	2.2	2.1
Leptochiton inquinatus	Chiton	2.1	2.1

6.3 Assessment of effects on the sustainability of fisheries resources

The PMF site is an existing mussel farm site, and therefore, the discussion on potential effects to the marine environment will include observations and results of sampling undertaken at the site during the present survey.

6.3.1 Depositional impacts

Benthic impacts from mussel farms on the marine environment result from the sedimentation of organic-rich, fine-grained particles (mussel faeces and pseudofaeces), and the deposition and accumulation of live mussels, mussel shell litter and other biota attached to the ropes, floats and the mussels themselves. The waste material settles on the surface sediments and can alter the physical, chemical and biological nature of the seabed. The spatial extent and severity of these impacts are only known in a relatively general sense due to the very limited amount of monitoring data available. Despite this, the information available on longline farms in both New Zealand and overseas (Dahlbäck & Gunnarsson 1981, Mattsson & Lindén 1983, Kaspar *et al.* 1985, De Jong 1994, Chamberlain *et al.* 2001, Grange 2002, Christensen *et al.* 2003) indicates that seabed impacts do occur below farms. The extent and severity of these impacts depend on management practices (*e.g.* stocking densities, line orientation, harvesting techniques) and environmental characteristics

[7] Average abundance: Mean number of taxa counted at each sample station
[8] Relative abundance (%): The proportion of the total community represented by a given taxa.

(*e.g.* depth, current speeds and directions, existing benthic habitat, wave climate, riverine influences, phytoplankton abundance).

Spatial extent of effects from deposition

The depositional footprint of the PMF site was estimated using a predictive model, which estimated the distance and direction pseudofaeces and faeces travelled before reaching the seabed. This was determined using the general water flow patterns and current speeds determined at the site (see later), and an estimated particle sinking velocity for faeces and pseudofaeces. In the past, Cawthron has used a sinking rate for mussel farm depositional matter of 40 m/hr, as this was considered at the time to be conservative, and would therefore provide the worst-case scenario. However, recent experiments using a laboratory flumes have measured much faster participle sinking velocities for mussel biodeposits (Table 20), which correspond more closely with the spatial effects of deposition observed in the field (*e.g.* Hartstein in press; pers. obs.). Therefore a particle sinking rate of 80 m/hr was used to predict the depositional footprint for each farm, as this was considered to provide a conservative, yet realistic estimate of the depositional footprint. The depositional footprint was also calculated using the average and 80th percentile current speed at the site.

Table 20: Sinking rates of mussel biodeposits estimated in laboratory flume experiments.

Author	Estimated sinking rate	Comments
Giles & Pilditch (2003)	2.46-2.71 cm/s (89-98 m/hr)	* Sinking rates for mussels fed on seawater with added algae. Sinking rates for mussels fed on a natural diet or a diet containing silt were approximately four times faster than for mussels fed on seawater with added algae (*i.e.* greater than 8 cm/s or 288 m/hr).
Hartstein (*in press*); cited in Hartstein & Rowden (2004)	3.54 cm/s (127 m/hr)	Average faecal pellet falling velocity

Water current speeds measured at the Paul Marine Farm Ltd site by Hartstein (unpublished data) ranged between <0.1 and 11.2 cm/s (average=3 cm/s), with the strongest currents flowing in a northeast direction (Figure 44). Current speeds measured at the PMF site were similar to those measured other sites within the Catherine Cove area (Table 8, Section 4).

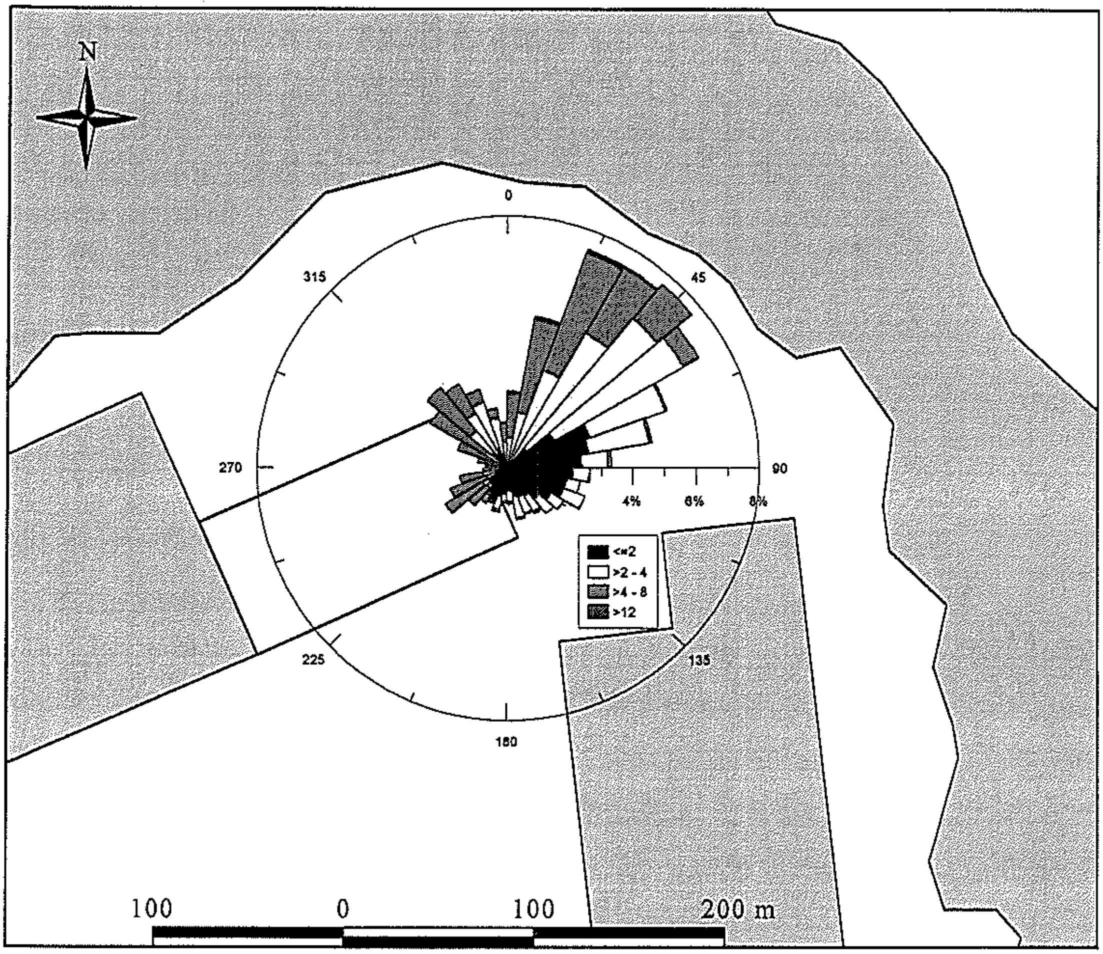


Figure 44: Current speed and direction as determined at the PMF site from, a FSI current meter (deployed from 15/01/2002 to 20/02/2002; Hartstein unpublished data). The plot shows the direction the water is moving to, not where the water is coming from.

The depositional footprint was predicted to extend to a maximum of 126 m from the farm boundaries (average=33 m) (Table 21). Figure 45 shows the predicted pattern of dispersion for faeces and pseudofaeces at the site, calculated using a mussel biodeposit sinking rate of 80 m/hr. Note that several caveats (or qualifiers) were used when generating the effects footprints, in order to ensure that the predicted sedimentation footprint would encompass the maximum extent of ecological depositional effects from the farms. The most important of these are:

- Current meter data collected from a depth of 20 m at the site is representative of the entire water column.
- Biodeposits were assumed to travel from the farm in the same direction until they reach the seabed. However, particles will generally travel in more than one direction (including toward the point of origin) as they sink through the water column.
- Mussel production was assumed to extend to the site perimeter (*i.e.* no allowance was made for anchor warps or buffer zones within the proposed area).

- The sedimentation pattern was based on particles originating at the water surface whereas, in reality, the majority of the mussels will be positioned lower down in the water column, thus particulates will likely settle quicker and closer to the farm.

Table 21: Theoretical extent of the depositional effect footprints for the PMF site.

Current speed	Distance from farm
Average	33 m
80^{th} percentile	53 m
Maximum	126 m

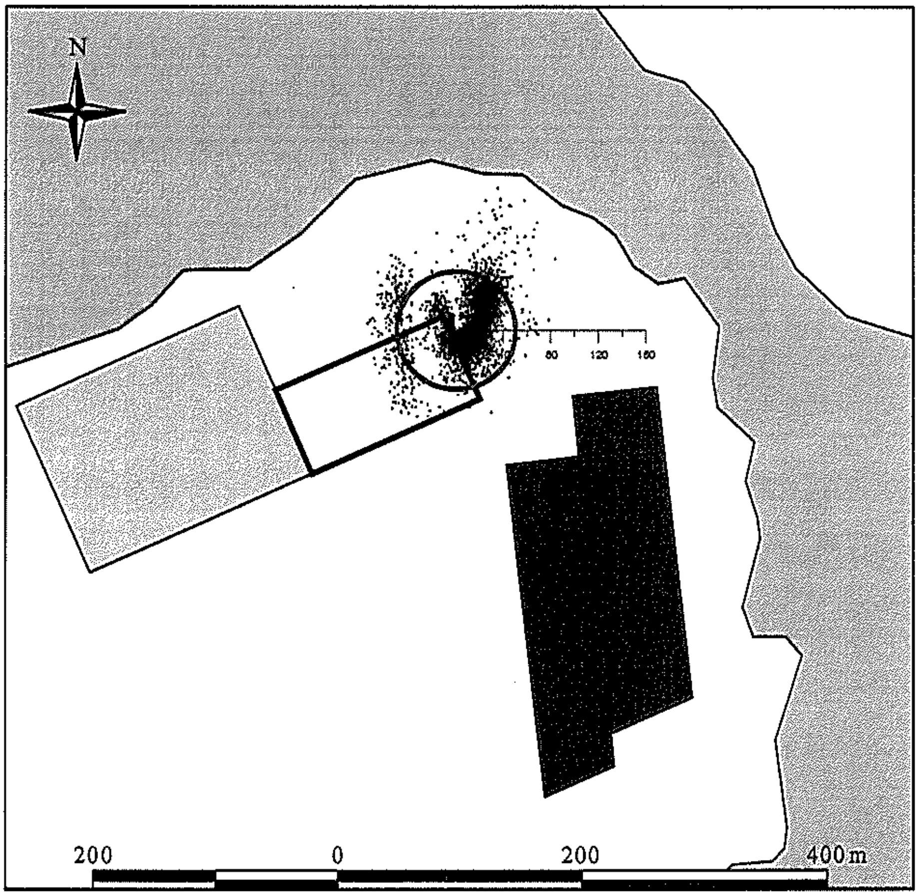


Figure 45: Theoretical effects footprint at the proposed PMF site (Red circle indicates 80^{th} percentile of particle deposition).

The theoretical distances the pseudofaeces and faeces will travel indicated by current speed is supported with what was observed in the field; *i.e.* that the impacts from the current (PMF) farm were localised and not evident 30 m from the farms edge.

6.3.2 Potential benthic effects at the proposed site due to organic enrichment

The available published and unpublished information indicates that benthic impacts occur because the suspended layer of bivalve filter feeders (and biofoulers) above the seabed alter the form and magnitude of the organic matter and other particles (*e.g.* shell, and dislodged plants and animals) reaching the seabed. Mussels filter particulate materials, primarily phytoplankton, but also zooplankton, organic detritus and inorganic sediment from the water. Material is transported via the food grooves on the gills to the labial palps of the shellfish where it is sorted into digestible material, which is ingested and the waste later expelled as faecal pellets. Inedible or excess material is loosely bound in mucous and expelled from the shell cavity as pseudofaeces. Faecal pellets and mucous bound pseudofaeces sink and can accumulate on the seabed below.

Heavy sedimentation of mussel biodeposits has been reported to increase organic enrichment and alter macrofaunal communities (Tenore *et al.* 1982, Mattsson and Lindén 1983, Kaspar *et al.* 1985, Christensen *et al.* 2003), by selecting for species more adaptable to low oxygen levels or to the instability of finer-textured, high organic sediments (Tenore *et al.* 1982). The magnitude of the impacts will depend on the rate of supply of particles (*i.e.* density and feeding rate of the mussels within the farm) and the sensitivity of the organisms beneath the farm to enrichment. The spatial extent of the impacts will further depend on the sedimentation footprint.

Sediments within and adjacent to the proposed PMF site are composed of a high proportion of mud-sized particles, and have an organic content of around 3.8-7.7%; suggesting that the sediments at the site are already moderately enriched (Section 6.2.2). The infaunal communities described at the site are healthy and diverse, but reflect the existing level of organic enrichment occurring at the site from the existing mussel farm. It is expected that the severity and spatial extent of organic enrichment effects beneath and adjacent to the PMF will continue at the present level, unless major changes in farm management practices occur (*e.g.* an increase in longline spacing). However, it is likely that cumulative impacts are occurring at the site, due to the continued presence of the mussel farm.

Bedrock/cobble habitats were identified inshore of the PMF site, and are within the predicted depositional footprint of the farm (Section 6.2.2). Rocky/cobble habitats and associated epibiota are commonly found within Catherine Cove and elsewhere along the D'Urville Island coastline, and throughout the Marlborough Sounds region (*e.g.* Forrest 1995). At present these habitat do not appear to be adversely impacted as a result of the presence of the PMF marine farm. However, due to the sensitivity of these rocky habitats to sedimentation (Airoldi 2003), and the high ecological values often associated with them, the inshore rocky habitats will be monitored as part of the Catherine Cove adaptive management plan (AMP) to ensure that they are not adversely impacted as a result of the proposed renewal (refer Part B Cawthron Report No. 881).

6.3.3 Potential effects of shell deposition

Perhaps the most visually conspicuous of the seabed impacts is the modification of the benthic habitat that occurs through the accumulation of live and dead mussel material on the seafloor, produced primarily during harvesting and farm maintenance (Davidson 1998, Davidson and Brown 1999). Visual observations suggest that shell deposition within a farm can be patchy, ranging from rows of clumps of live mussels and shell litter directly beneath long lines to widespread coverage across the farm site (Forrest and Barter 1999). Mussel clumps and shell litter beneath a mussel farm have been observed as acting as a substrate for the formation of reef-type communities (Davidson & Brown 1999, De Jong 1994). Kaspar *et al.* (1985) described reef-like communities under an existing farm that included large epibiota such as tunicates, sponges, sea cucumbers, calcareous polychaetes, and mobile predatory species such as starfish, crabs and fish. An increase in the numbers of predatory species will help to maintain a balance with respect to the large number of prey species. In other situations, mussel clumps and shell litter can remain relatively barren of reef-type communities (Watson 1996). Various species of fish (*e.g.* spotties) are known to be attracted to the food sources associated with mussels and biofoulers on the culture ropes, farm structures and the modified seabed habitat. However, the extent and impacts of this shift in population dynamics has not been assessed in New Zealand and there is some controversy over the extent that this may occur.

Based on observations at the PMF site, shell material is expected to continue to accumulate beneath the farm. Although significant reef-like communities have not developed due to the depth and low current velocities, the farm will continue to support an associated attached epifaunal community (*e.g.* 11-armed sea stars, tunicates, kina *etc*). Changes in farm management may mitigate the extent of impact from mussel shell debris. The AMP will include monitoring of predator aggregations that may occur due to the present marine farm.

6.3.4 *Changes to predator-prey interactions*

Increased predator densities have been shown to occur on oyster farms and beneath mussel farms due to an increase in the number/density of bivalves (a potential food source) on the sea floor (Forrest 1991, Cole & Grange 1996). The potential concern is that the increased food source will create a predator oasis, which in turn may increase the potential for recruitment of juvenile predators into the adult population. It is obvious predators such as *Coscinasterias muricata* aggregate beneath mussel farms; however the link to increased recruitment has not been established. Theoretically this potential increase of individuals into the adult population could also affect existing populations of benthic animals further away from the mussel farm, but this has not been investigated at existing marine farming sites within the Marlborough Sounds. Changes to predator-prey interactions will be addressed in the adaptive management plan (AMP) (Part B Cawthron Report No. 881).

6.3.5 *Effects to nutrient dynamics*

Phytoplankton production is usually nitrogen (N) and/or light limited in coastal marine environments and this is also the case for sites in the Marlborough Sounds (Gibbs & Vant 1997). Intensive mussel farming in a region can effect the distribution of N in the following ways:

1. Particulate organic nitrogen (PON) is captured from a large area via mussel filtration as the water passes into the bay and through the farm. PON that might otherwise have been flushed out of the bay would thus be concentrated and entrained in a small area with a larger proportion entering the seabed below the farm as mussel faeces and pseudofaeces rather than following a more diffuse sedimentation pattern.
2. A percentage of the particulate N consumed by the mussels is also released directly into the water in the soluble form of ammonium. This is, in effect, a gardening-like strategy that stimulates additional phytoplankton production.
3. The harvesting of mussels removes fixed N from the coastal environment, however the amount exported in this way is small in comparison to the amount that is recycled back into the environment by the mussels. To put this into perspective, MacKenzie and MacIntosh (1995) estimated that the N removed with entire mussel crop for Pelorus Sound (at the time) would be roughly equivalent to one half the annual N discharged from the Pelorus River. Considering, however, that the inflow of oceanic water from Cook Strait is the predominant

source of nutrients to the Sound, far outweighing freshwater inflows, N removal through mussel harvesting is not likely to result in a localised nutrient impoverishment.

Research carried out beneath and outside the influences of small mussel farms in the Marlborough Sounds (Kaspar *et al.* 1985; Christensen *et al.* 2003) indicates that farm-generated sedimentation can alter benthic nutrient recycling characteristics; *e.g.* microbial denitrification (the conversion of nitrate to the non-nutrient form of N_2 gas). The effects can be quite different depending on the rate of sedimentation beneath the farm. Where sedimentation rates are high (*e.g.* directly beneath the culture ropes with high stocking densities and/or low current velocities), a larger proportion of the nitrogen appears to be retained in the sediments or released back into the water column, thus compounding the localised enrichment effects. Where sedimentation rates are more diffuse, the process of denitrification can be enhanced, resulting in a greater loss of nutrient forms of nitrogen. Therefore it may be possible to moderate some of the localised enrichment effects through farm management (*e.g.* by maintaining larger spacing between long lines and/or lower stock densities). The PMF application for a marine farming permit is a renewal of an existing site, and the stocking densities and amount of growing rope will not be increased if the renewal is permitted, so any additional effects to nutrient dynamics are not expected to occur.

6.3.6 Effects on phytoplankton and zooplankton communities

There are a number of different ways mussel farms interact with, and affect, the water-column environment in which they are located. For example, farms remove suspended organic material from the water-column via feeding. The magnitude of this interaction will vary depending on factors such as site location, farm size, stocking rates, and ambient background levels of plankton. The nature of these interactions will also be variable. Mussel farms result in the removal of water column organisms during feeding. Mussels feed on suspended organic material including phytoplankton and zooplankton (suspended passive or slow moving microscopic plants and animals respectively), and detritus. Suspended organic material plays an important role in the marine food web; therefore this 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.

While decisions to grant consents for new mussel farm applications need to consider all interactions likely to result in a change to the environmental conditions of a site, some processes can be singled out as being more important than others. Phytoplankton is the main dietary component of cultured mussels in the Marlborough region and is also one of the fundamental building blocks in the marine food web. Hence, assessing the effects of a proposed mussel farm on the phytoplankton population provides a useful indicator of the general impacts likely to occur in the water-column environment in which a farm is situated. It also provides important information on the capacity of the environment to sustain the proposed aquaculture activity and to assess the productivity necessary to produce mussels in an economically sustainable manner.

The water-column environment in Catherine Cove contains large numbers and types of floating microscopic plants (phytoplankton) and animals (zooplankton), detritus (non-living organic debris), and suspended inorganic particles. This fine material is consumed by benthic filter feeders, small pelagic herbivorous and carnivorous fishes (sprats, pilchards *etc*), jellyfish and similar gelatinous organisms. In turn, these animals become prey for larger fish, seabirds, marine mammals etc. The presence of mussel farms in Catherine Cove will filter out some of this very small suspended dead and living material that supports larger animals higher up in the food web. Therefore, an opportunity cost of having the mussel farms is that some suspended matter will no longer be available for animals on the same trophic level and higher trophic levels.

Part B (Cawthron Report No. 881) of this report provides a detailed assessment of the predicted effects to phytoplankton and zooplankton communities from the proposed and existing marine farming activities in Catherine Cove. This includes the results of zooplankton and phytoplankton monitoring within the Cove and predictive modelling of phytoplankton and zooplankton depletion within the Cove.

6.3.7 Effects of establishing new structures

The structures used in bivalve aquaculture are generally based on the longline method, with a backbone either weighted or anchored to the sea bed, and a continuous longline on which the mussels grow is attached to the backbone. Inserting 3-dimensional structures into the marine environment has an immediate effect on local hydrography and provides a new stratum upon which other epibiota can settle and grow (Kaiser 2001). The currents in the immediate vicinity of a mussel farm have the potential to be altered. For example, Ogilvie (2000) observed that higher current velocities exist under the farm and lower velocities within and adjacent to the farm. This altered flow was attributed to the drag imposed on the water by the submerged marine farming structures. The decreased within-farm velocity could be significant as it indicates the phytoplankton supply to the mussels is likely to be lower than that which would be calculated using ambient velocities. The reduced current velocities would allow the farmed mussels more time to filter and re-filter the same water so that, overall, a larger proportion of the existing phytoplankton can be removed. Increased current velocities below the mussel lines could have some mitigating effects on benthic impacts but this has not been assessed. The PMF application for a marine farming permit is a renewal of an existing site, the stocking densities and amount of growing rope will not be increased and no new structures added, so it is unlikely that any added effects due structures will occur from the present day levels.

6.3.8 Biofouling

Biofouling (in the context of mussel farming) is the attachment of flora and fauna to mussel farm structures and to the suspended mussels themselves. Biofouling is an increasing problem for mussel farms within New Zealand and overseas. The two primary impacts are: reduced mussel productivity through competition for space and food, and biofouler fall-out to the seabed community. To date there have been few studies of biofouling in New Zealand. However, fouling by blue mussels and algae (*e.g. Undaria pinnatifida*) at the surface, and sea squirts (in particular *Ciona*) at depth, has the potential to create management problems in some locations in New Zealand.

While the applicants within the Cove are willing to adopt biosecure practices, it is still very likely that ascidians and macro-algae will attach to the structures and some may accumulate on the seabed below. The survival and longevity of those organisms that do result on the seabed is unknown, and would be subject to various environmental parameters. The accumulation of growths of macro-algae would not survive due to the limited light resources at depths of 40 m. Ascidians may survive for longer periods; however, their numbers may be reduced by periodic high sedimentation associated with storm events. Accumulation of biofouling organisms beneath farms is common throughout the Sounds and in Catherine Cove, and is not considered to be a high risk issue.

It is anticipated that some degree of biofouling will continue to occur at the PMF site, and will be similar to that historically occurring at the existing farm site. For example, in recent years (since 1999) *Ciona intestinalis* has been the most prominent biofouling species in Catherine Cove. However it seems as if in general ascidians are becoming more of a biofouler and it is in the farmers best interest to monitor the amount of biofouling occurring at the site. Therefore, it is proposed that biofouling species within the Cove will be monitored as part of the EMS proposed in the AMP (Part B Cawthron report No. 881).

6.3.9 Biosecurity risks

The role of marine farming activities in the transfer of marine pest species is well recognised (Carlton 1992; Sinner *et al.* 2000; Naylor *et al.* 2001). In particular, the spread of pest species can be caused or exacerbated by the transfer of equipment and stock. Any expansion of marine farming activities into both farmed and non-farmed regions requires careful consideration with regard to the transfer of marine pest species. Predicting the potential risks of a proposed farm site becomes increasingly complex if the expansion is into a region with significant existing marine farming activities.

The introduction of new stock into a different region could potentially (positively or negatively) effect the natural populations. Introduced species can compete with native species for the same resources, they could potentially carry pests, predators and diseases to which native species is more vulnerable Kaiser (2001). The translocation of aquaculture species can have genetic effects by introducing different genetic material to populations. This is mainly an issue for species that have limited out-breeding, limited dispersal and localised populations (Cole 2002). Genetic variation is the foundation of biological diversity (Kaiser 2001). To alter the genetic variation, could have implications on the sustainability and evolutionary potential of the wild populations of bivalves in the region. The Greenshell™ mussel industry relies heavily on Kaitaia spat, which may have implications for the transfer of genetic material around New Zealand. The implications of this genetic transfer are increased vulnerability to environmental changes due to the loss of genetic differences between populations and decreased production and fitness of wild populations due to out-breeding depression.

At present, there are eight operating mussel farms in Catherine Cove, occupying approximately 32 ha of space. In addition to this application by PMF (1.25 ha), there is also an application for a 5.62 ha extension to an existing marine farm (refer to Sections 5) and a 12.35 ha new site (Section 4). If all marine farm site applications in Catherine Cove are granted, this will represent a 56% increase in area of marine farming in the Cove. This raises some interesting questions with respect to biosecurity, such as whether the expansion will:

- Appreciably increase the available surface area of structures for pest organisms to attach?
- Require more frequent visits by servicing vessels, thus increasing the opportunity for pest transfer?

- Require additional spat to be sourced from areas not already used for spat collection?

It is recognised by the marine farmers in Catherine Cove that it is in their best interests to adopt 'biosecure' practices to ensure that their activities do not transfer high risk pest species to or from sub-regions of the Sounds where: (i) they don't currently occur, and (ii) they are unlikely to spread by natural dispersal processes or other vectors like shipping. It is proposed that a management programme designed to minimise the artificial transfer of unwanted marine organisms (via their industry practices) is incorporated into the adaptive management plan of the Cove (Part B Cawthron Report No.881). The management programme will include a monitoring component, which will involve annual qualitative surveys of the shoreline and culture ropes in the Cove. Additionally, given the cooperative nature of the marine farmers within the Cove, this provides an excellent opportunity for the whole Cove to be managed in a biosecure manner, which is likely to be more effective than if the efforts were not adopted by all farmers.

6.3.10 Effects on associated and dependent species

The effects of marine farms on associated and dependent species are not well documented. The associated effects with these species include changes to the behaviour of the associated and dependent species, changes to access to feeding and breeding grounds and changes to available food supply due to possible effects on fisheries resources. This will be further addressed in the bay wide assessment (Part B Cawthron Report No. 881).

6.3.11 Options to avoid, remedy or mitigate any adverse impacts

The existing and proposed marine farms within Catherine Cove are owned and managed by members of the Ngati Koata iwi. Marine farmers in Catherine Cove are committed to ensuring the long-term sustainability of fisheries resources within the Cove, and have commissioned Cawthron to develop an adaptive management plan for the Cove (provided in Part B Cawthron Report No. 881). This approach is consistent with the draft guidelines on Fisheries Resource Impact Assessment (FRIA, 2002). The inshore line of the present marine farm is overlying a cobble habitat. The applicant is proposing to mitigate the effects to the cobble habitat by moving all the backbones further offshore. The proposed AMP will also include monitoring of the cobble habitat to ensure the marine farm is not adversely affecting the communities associated with the cobble habitat.

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