

# Aquatic Animal Pest and Disease Readiness Planning and Intelligence

Phase I – Data Acquisition  
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# Executive Summary

## Background

The purpose of this study is to collect data on the location of farmed and enhanced aquatic species, their movements and the associated environmental conditions that may contribute to the spread of pests or diseases of aquatic animals. This information will feed into a baseline of aquaculture and enhanced fisheries species information that stakeholders and MAF Biosecurity New Zealand (MAFBNZ) hope to continue to improve and update in the future, and use in biosecurity emergencies.

Information on the location of aquaculture facilities was collated primarily from resource consents issued by regional councils and unitary authorities, the Ministry of Fisheries' (MFish) Fish Farm Register, and directly from organisations such as Fish and Game New Zealand. Information on the movement of stock and equipment among facilities within New Zealand was obtained from MFish's Fish Transfer Authorisation dataset, Fish and Game New Zealand regional offices, and telephone interviews with selected aquaculture industry groups, companies and individual farmers. Sources of hydrodynamic information were identified in consultation with NIWA specialists.

## Information collated

### *Location dataset*

The location dataset includes approximately 4,000 lines of data (each line representing a farm-species combination), of which one is estuarine, 59 freshwater, 105 land-based, and the remainder marine, indicating the extreme dominance of aquaculture in New Zealand by marine farming.

Information on membership of industry organisations, the role of a facility within the structure of a company, and the role of the contact person was often lacking from the information obtained or not applicable. Contacting each consent holder to obtain these missing data was beyond the resources of the present study.

There were a number of major gaps in the dataset, the most notable being the complete lack of information on stocking densities or biomass held on farms. To have obtained this information from individual organisations or farms (assuming that they would have been willing to provide it) would be a major task and of questionable value, given the variability of stocking densities over time.

### *Movement dataset*

This dataset contains approximately 600 records of movements of aquaculture stock, and provides a representative overview of current movements occurring among aquaculture facilities. Those interviewed to obtain information included individual farmers, representatives of large aquaculture companies (Aotearoa Fisheries, Marlborough Mussel Company, New Zealand King Salmon, Sanfords) and Fish and Game Council. Information was also extracted from MFish's database of transfers (including movements of paua).

Predominant movements were of mussel and oyster spat by land or water, and of salmon ova or juveniles for stock enhancement or farming. Distances moved range from transfer of mussel spat from Kaitia (Ninety Mile Beach) to farms in the Marlborough Sounds and the Coromandel, to local redistribution.

Notable gaps in the dataset are those relating to disease, which may reflect low incidence of disease with aquaculture facilities in New Zealand but may also reflect reluctance to reveal potentially sensitive and/or damaging information.

### *Species farmed*

In addition to Greenshell mussels, Pacific oysters and king salmon, species listed on existing consents include a wide range of algae (including various kelps), sponges, molluscs (including paua, cockles, flat oysters and scallops), crustaceans (including crayfish and freshwater koura), echinoderms (kina) and fish (including bluefin tuna, kingfish, seahorses and snapper). Only a subset of these species, however, is actively farmed at present.

## **Problems with data**

The extent of inconsistencies in content among supposedly overlapping datasets was enormous, and every effort to cross-check data from one source with those from another invariably led to the discovery of new facilities not included in previously-consulted sources. There was also huge variation in the formats of datasets in terms of the type and organisation of information provided. Inconsistencies and errors in field names, including the names of farms or companies, were widespread and, if not corrected, will hamper searching and filtering of the data.

Commonly-occurring problems with the datasets were:

- Missing fields/ inconsistencies in the fields provided
- Duplications of entries
- Changes in use (species) and species consented but not currently farmed
- Farms no longer operating
- Inconsistencies in coordinate systems used or lack of coordinates
- Inconsistencies among different sources of the same information
- Inconsistencies in format of licence numbers, consent numbers, names of consent holders, address format, place names

## **Recommendations and data maintenance**

1. Maintenance of the location dataset will require the following:
  - Adding information on new farms and other facilities
  - Adding information on changes in use, including closure and changes in species farmed or processed
  - Adding information on changes in area of farms or other facilities
  - Updating information on ownership and contact details
2. MFish's Marine Farm Register provides some of the information required to update the location dataset, and linking the location dataset to the MFish register is a logical first step in maintaining the former. However, farmers are apparently not always diligent in filing applications for registration or variations to an existing registration. Further, the register does not include location coordinates for the facilities or information on numbers or weight of stock held or harvested. Consequently, information from the register will need to be supplemented (and cross-checked) from other sources.

3. Equivalent information for freshwater or land-based facilities may be available from MFish's Freshwater Fish Farm Register. Again, coordinates of locations are not always recorded and information would need to be supplemented from other sources, such as resource consents.
4. The best approach to maintenance of the dataset of information on the location of aquaculture facilities is, therefore, to develop links between MAFBNZ and MFish's Marine and Freshwater Fish Farm Registers to allow access to information on new or altered consents and to annual updates, and to obtain regular data summaries of new consents from regional councils and unitary authorities. Resource consents may not capture information on the species actually farmed (as opposed to potential farmed species for each site) but this information should be available from the Fish Farm Registers. Conversely, the latter may not include detailed farm locations but these will usually be recorded on consents.
5. Regular access to MFish's Freshwater Fish Transfer Authorisation database will allow updating of the movement database for freshwater and land-based farms. Updates on patterns of movement for marine farms is not available from any single source and is probably best achieved by regularly repeating the questionnaire-based survey used in the present study. Information should be sort from industry organisations, who have a broad overview of movements within their industry as a whole, supplemented and verified by more detailed surveys of selected companies within each sector of the industry.

# 1. Introduction

## 1.1. BACKGROUND

Protection of New Zealand's natural resources and primary industries from the impacts of unwanted organisms requires a high degree of preparedness and planning. The need to be prepared invokes all aspects of the New Zealand's biosecurity system from surveillance, prevention of incursion, to incursion responses and pest management. Pests and diseases can spread rapidly, so the ability to detect early and act swiftly to eradicate or contain them is important. An essential prerequisite to such action is prior knowledge of the location of likely hosts, suitable habitats and vectors of spread (Inglis et al. 2006; Floerl et al. 2008).

Aquaculture and fisheries enhancement are two of New Zealand's most important aquatic industries. Aquaculture in particular is growing rapidly. The industry has set itself ambitious growth targets (NZAC 2006), and a Technical Advisory Group recently convened by the government has made a series of recommendations to help advance aquaculture development in New Zealand (Aquaculture Technical Advisory Group 2009).

While keen to expand, the industry is fully aware of the need for growth to be demonstrably sustainable and secure from biosecurity threats. Recent incursions of pests such as *Styela clava* (Gust et al. 2006), *Didemnum vexillum* sp. (Denny 2008), *Sabella spallanzanii* (Inglis et al. 2008), and *Eudistoma elongatum* (Morrisey et al. 2009) have left the New Zealand aquaculture industry in no doubt about the threats that unwanted organisms pose to their industries. At the same time, aquaculture and enhancement industries are potential exacerbators of the spread of pests and diseases as a result of stock and equipment movements. Thus, there is a need for data on the location of farmed and enhanced aquatic species, their movements and the associated environmental conditions that may contribute to the spread of marine pests or diseases; (i) MAF Biosecurity New Zealand (hereafter MAFBNZ) needs to be able to target its surveillance efforts, (ii) plan for and manage pest and disease outbreaks in farmed and enhanced aquatic species, and (iii) the industry wants assurance that such outbreaks will be managed effectively with minimum disruption to their operations and production.

Phase I of the overarching MAFBNZ Aquaculture Readiness Data project is directed at producing readily available data, or access to data in a suitable format to underpin effective surveillance, incursion investigation and response, and biosecurity readiness work for cultured and enhanced aquatic species. The data collected in Phase I will feed into a baseline of aquaculture and enhanced fisheries species information that stakeholders and MAFBNZ hope to continue to improve and update in the future, and use in biosecurity emergencies.

The data collected in Phase I will also be used to create 'defined areas' in Phase II (RFP11719) of the MAFBNZ *Aquaculture Readiness Data* project. Creating 'defined areas' based upon the concept of the epidemiological unit will underpin biosecurity activities in response and readiness work, which stakeholders both agree with and understand the benefits of having.

The information contained in this report is current as of the end of June 2010.



## 1.2. SPECIES FARMED IN NEW ZEALAND

The species of marine and freshwater organisms that may be farmed in New Zealand (Appendix 2: Table 1) were gazetted in 2006 under the Freshwater Fish Farming Regulations 1983<sup>1</sup>.

At present, very few of these species are commercially farmed and production is overwhelmingly dominated by (in order of production) Greenshell™ mussels (33,296 tonnes exported in 2008: information from Aquaculture New Zealand), king (or quinnat) salmon (3,479 tonnes) and Pacific oysters (1,873 tonnes). Blue mussels, Bluff oysters and paua (abalone) are also farmed. Species still in the research or pre-commercial stages include eels, European perch, sea cucumbers, kina, rock lobsters and groper/hapuka (source of information: Ministry of Fisheries<sup>2</sup>).

No marine algae are currently farmed in New Zealand (Wendy Nelson, NIWA and Jill Bradley, Seaweed Association of New Zealand, pers. comm. to Mike Page).

The regional coastal plans of several regional councils and unitary authorities currently restrict the range of species that may be farmed in their coastal marine area. Waikato Regional Council and Tasman District Council, for example, only allow shellfish farming and prohibit other types of aquaculture (even experimental). These restrictions for the Waikato Region and Tasman District are, however, under review.

Note that aquarium species, garden pond plants and programmes for population enhancement of native freshwater fish (including eels) were excluded from the present study at the instruction of the MAFBNZ liaison.

## 1.3. AQUACULTURE AREAS

The principal areas for marine farming (and, therefore, for aquaculture generally) in New Zealand are: Northland, Auckland, the Coromandel, Tasman and Golden Bays, the Marlborough Sounds, Canterbury and Stewart Island (Figure 1, Appendix 2: Table 2).

Minor and developmental marine species also tend to be cultured in the main areas listed above because of the presence of necessary infrastructure. Freshwater and land-based aquaculture facilities are scattered around New Zealand.

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<sup>1</sup> see <http://fs.fish.govt.nz/Page.aspx?pk=24&tk=450>

<sup>2</sup> see <http://fs.fish.govt.nz/Page.aspx?pk=24&tk=349>

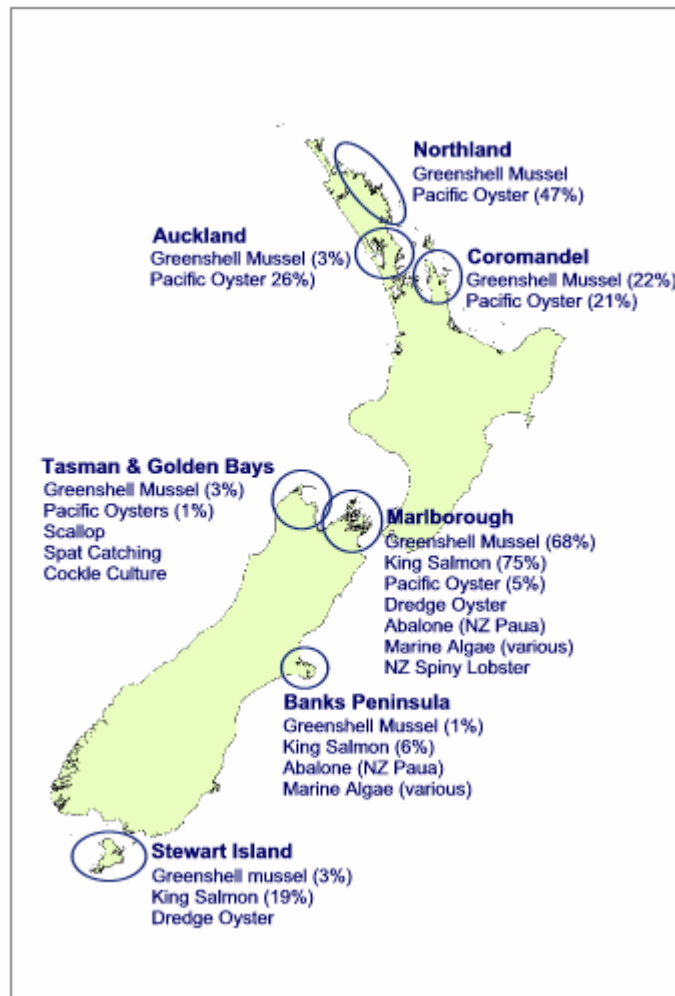


Figure 1: Principal aquaculture regions in New Zealand, showing the species farmed and (for major species) the contribution to total national production (by export value).

The New Zealand Government's aquaculture website ([www.aquaculture.govt.nz](http://www.aquaculture.govt.nz), accessed 22 June 2010) contains summaries of the current status of aquaculture in each region of the country, and developments currently in progress. These are described below.

**Northland:** Currently 704.9 ha of marine farms, mostly oysters with some mussels, and an aquaculture research facility (operated by NIWA) and land-based paua farm at Bream Bay. The regional council is in the process of proposing a plan change to provide for aquaculture growth in the region.

**Auckland:** Currently 326 ha of marine farms, mostly oysters and some mussel farms. There has been a rapid increase in applications for aquaculture development since 2000, especially in the Firth of Thames. Hearings on new Aquaculture Management Areas (AMAs) are on hold since 2006, pending consultation on proposed aquaculture policy framework and aquaculture-exclusion areas.

**Waikato:** At present there are 1003 ha of marine farms, mostly mussels and some oysters in the Firth of Thames and Coromandel areas, together with land-based paua farms. An additional 520-ha AMA in the Firth of Thames (Wilson Bay Area B) will be consented in 2010. At present, the regional coastal plan prohibits most aquaculture outside existing locations and the Wilson Bay zone, but this may be lifted as a result of current aquaculture law reform.

**Bay of Plenty:** Currently three oyster farms, in Ohiwa Harbour and a permit for a mussel farm at Te Kaha that has not yet been developed. Total area of marine farms is 9.6 ha but a 3,800-ha offshore mussel farm (off Opotiki) has recently been approved and an application for a 4,009-ha mussel farm off Otamaraku is being processed. There is also a small, land-based paua farm at Te Kaha.

**Gisborne:** There are no AMAs or coastal permits for aquaculture in the district at present, but there is a land-based paua farm.

**Hawkes Bay:** There are currently no operational marine farms in Hawkes Bay but a consent has been granted for a 2,469-ha, offshore farm at Waipatiki Beach for mussels (other species are also being trialled). This, and a 4-ha area off Mahia Peninsula, have been identified as AMAs.

**Taranaki:** Demand for aquaculture space is currently limited and the only facility is Fish and Game New Zealand's salmon hatchery at Hawera.

**Manawatu-Wanganui:** There are currently no marine farms in this region.

**Wellington:** There has been little aquaculture development in the region to date, with only 4.3 ha of small marine farms used for trials of a range of species and a small number of land-based farms.

**Marlborough:** Total current area of marine farms is 3,056.4 ha, mostly mussels with salmon and trials of new species. There are also a few consents for land-based farms for a range of species, including shellfish. On 29 June 2010, MFish approved a 770-ha AMA for Greenshell mussels off the southern end of Durville Island, northwestern Tasman Bay.

**Nelson:** There are currently no marine farms but there are several land-based consents for salmon, oyster, and paua facilities, including the Cawthron research facility at Glenhaven. A new research facility is currently under development near Glenhaven and, like the Cawthron facility, will draw water from the adjacent sea.

**Tasman:** At present there are a total of 6,086 ha of marine farms in the district, for mussel farming and mussel and scallop spat catching. Of this, 2,637 ha are in Golden Bay and 896 ha in Tasman Bay, of which 96 ha are zoned for mussel farming only, 52 ha for mussel spat catching only, and 598 ha for both mussel farming and spat catching. The remaining area is under application for spat catching. A further 2,000 ha has been approved or potentially approved for development.

**West Coast:** Currently there is only one mussel farm of 45.6 ha in Jacksons Bay, and a number of consents for freshwater salmon farms.

**Canterbury:** Currently 179.4 ha of marine farms, mainly mussels but also salmon and paua, around Banks Peninsula. Further consents have been granted but not yet developed, including a 2,695-ha mussel farm in Pegasus Bay.

**Otago:** To date there has been very little aquaculture development in Otago and planning for aquaculture management is on hold pending review of the Regional Plan: Coast. There are a small number of freshwater or land-based farms for salmon and koura.

**Southland:** There are currently 285.9 ha of marine mussel and salmon farms in Big Glory Bay, Stewart Island, and marine and land-based culture of a range of species in Bluff Harbour.

## 2. Data acquisition process

### 2.1. BACKGROUND

The objective of Phase I of the *Aquaculture Readiness Data* project is to obtain and collate detailed information on New Zealand's aquatic animal production, enhancement and processing facilities to enable development of biosecurity management plans and surveillance programmes. Immediate access to this information is also necessary to make timely and appropriate decisions in investigation and response situations.

The required information will include accurate farm location data, general details of the spatial and temporal aspects of stock and equipment transfers between locations (including farms, processing facilities and grow-out areas) and any applicable information on local hydrography (including tidal flows, currents etc). This information will also be used to support the development of epidemiologic units/distinct areas in Phase Two of the project.

A three-pronged approach was used to acquire the data, described in detail in sections 2.2-2.4. In the first stage, we interrogated existing datasets and recent reviews of aquaculture in New Zealand to identify locations of, and contact details for, aquaculture operations. These datasets were identified during the preparation of the proposal for the study and during the preliminary stage of the study itself, together with assessments of the accessibility, costs and limitations of the data, where possible. Once acquired, the data were subject to quality assessment and control and incorporated into a geodatabase.

In the second stage, we sourced information on movements of aquaculture species and equipment that could harbour live organisms, primarily via telephone interviews using the contact details obtained in Stage 1 and based on a questionnaire developed as part of the study in conjunction with MAF Project Liaison.

Finally, in Stage 3 we identified sources of, and contacts for, data and models of the hydrodynamics in aquaculture areas.

### 2.2. COLLATING INFORMATION ON THE LOCATION OF AQUACULTURE FACILITIES

Sources of information on the location of aquaculture facilities (marine, estuarine, freshwater and land-based facilities for spat catching, ongrowing, holding and processing) were identified during the preparation of the proposal (see below) and recontacted at the start of the project to obtain relevant information. As expected, potential new sources of information emerged during the course of the project and were subsequently contacted. Information on movements of organisms and equipment among aquaculture facilities was obtained by telephone interviews of selected organisations and individuals, as described below.

While we have made every effort to extract the most up-to-date information from the various sources consulted (see below) it is important to recognise that the dataset cannot provide an up-to-the-minute account of ownership and contact details, species farmed, etc. because this information changes constantly. Consequently, the considerable effort required to update all the relevant fields for every entry would become obsolete as soon as it was completed. Rather, the dataset is intended to provide as comprehensive a list of facilities as possible, based largely on extant resource consents from regional councils and unitary authorities, supplemented by other sources. We have, therefore, incorporated information as it was

presented in the various sources consulted. In the event of a disease or pest outbreak, this list can be consulted to identify potentially affected facilities and these contacted using the information provided or, where this is found to be out of date, current information obtained.

### 2.2.1 Dataset structure

The fields included in the dataset (Appendix 2: Table 3) include the type of facility and its location, consent or licence number, species held, the organisation to which the facility belongs and their contact details. Every field was completed where possible, but the information available was seldom available to allow this (see section 3.4 *Problems with the data obtained*, below).

### 2.2.2 Sources of information on location of facilities

Information on locations of facilities was obtained from the following sources, listed in order of importance for the present study. Further information on each source is given in Appendix 2: Table 4, including nature of data available, completeness and any quality-control issues.

- i. The primary source of information on the location of aquaculture facilities were resource consents held by Regional Councils and Unitary Authorities that have aquaculture facilities within their jurisdictions. Some councils (e.g. Marlborough District Council) maintain comprehensive GIS databases of marine farms under their jurisdiction. Other councils provided data in a range of formats, including Microsoft Excel files and portable document format (pdf) files (data in this format required entering into the dataset by hand). Resource consent data are generally in the public domain and contain information on location of the consented activity, contact details for the consent holder, and the species that may be farmed. However, existence of a resource consent to occupy coastal water space does not always mean that an aquaculture operation has been established, or still remains at the consented site. Further, applicants for consents often apply to farm a range of potential species on the basis that it is simpler to obtain consent at the outset rather than having to modify an existing consent later if the opportunity arises to farm a new species. Consequently, consents may be granted for a range of species even though most are unlikely to be farmed on the site in the foreseeable future. Information held by councils may not have been updated since the consent was granted (marine-farming consents are often valid for 35 years) and may be out of date. Information was obtained from the following councils:

- Auckland Regional Council
- Bay of Plenty Regional Council
- Canterbury Regional Council
- Hawkes Bay Regional Council
- Northland Regional Council
- Otago Regional Council
- Southland Regional Council
- Taranaki Regional Council
- Waikato Regional Council
- Wellington Regional Council
- West Coast Regional Council
- Gisborne District Council
- Marlborough District Council
- Tasman District Council

ii. The Ministry of Fisheries (MFish) Fish Farm Register, on which all marine farmers are required to register under the Fisheries Act 1996, and to update whenever there are changes to their consents, etc. The register records the name and contact details of the consent holder, start and expiry dates of the consent, region where the farm is located (but not coordinates of the farm), regional council resource consent number or marine farming permit or licence number, farm area, and the species for which the farm is registered, but does not record stocking densities. The register for marine fish farms is maintained by FishServe<sup>3</sup> and an electronic copy can be obtained for a fee. The Register for freshwater fish farms is held by the Ministry of Fisheries and was made available on request. The data used to populate the Fish Farm Registers are collected by MFish as part of the process of issuing permits to culture aquatic species at consented sites. After a regional council has issued a consent or a consent variation, an application for registration with the Fish Farm Register, or a variation of a fish farmer's registration, must be completed by the person carrying out the activity of fish farming and returned to FishServe. An application must also be completed when the following changes are made to a registration:

- Changes in the number of sites farmed, e.g. if farming commences on a site not currently noted on the register
- Changes in the number of sites farmed, e.g. if farming ceases on a site currently noted on the register
- Changes in the species authorised to be farmed on the site, e.g. change in the species listed on the resource consent
- Changes in the area farmed on a site, e.g. for those persons who farm part of the area covered by the resource consent
- A consent is renewed.

FishServe also sends out an annual update form to each registered fish farmer that must be completed and returned as soon as possible to be used in updating their details. While the data in the register are reliable when the permits are first issued, farmers are not necessarily diligent about updating their records (even though legally required to do so) and consequently data are not always up-to-date and accurate.

iii. Commercial land-based fish farms are licensed by the MFish under provisions of the Freshwater Fish Farming Regulations 1983. This includes land-based marine farms operating with pumped seawater and businesses set up as salmon fishing ponds. MFish maintain a register of land-based fish farms. These datasets are not considered complete and are dynamic, as new enterprises start up. Location details may be incomplete.

iv. Sports fish hatcheries (raising trout and salmon) are excluded from the freshwater fish farming regulations<sup>4</sup>. Fish and Game New Zealand operate hatcheries for game fish throughout New Zealand. There are some organisations outside of Fish and Game New Zealand that operate hatcheries in the South Island for sports fisheries. These are registered as charitable trusts, operating under regional Fish and Game New Zealand authority.

v. Mussel, oyster and salmon farmers pay a levy to Aquaculture New Zealand (AquaNZ), which is based on their production. AquaNZ maintains an accurate dataset of monthly greenweight produced for the three species by farm and a dataset of contact details for members. AquaNZ initially indicated that these data would be made available for the

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<sup>3</sup> See <http://www.fishserve.co.nz>

<sup>4</sup> Freshwater Fish Farming Regulations 1983, Section 2, Interpretation: "Fish farm" ....does not include – (a) any hatchery established and operated by an acclimatisation society or by the Ministry of Agriculture and Fisheries or by the Department of Internal Affairs....."

project, provided that no commercially sensitive information was revealed (telephone conversation between Mike Mandeno, AquaNZ and Barbara Hayden, NIWA). However, the Directors of AquaNZ subsequently decided that they were not willing for any production or contact information to be made available (email from Rebecca Clarkson, Business Manager Aquaculture New Zealand to Mike Page, NIWA, 15 June 2010).

- vi. Aquarium species, garden pond plants and programmes for population enhancement of native freshwater fish, including eels, were excluded from the present study at the instruction of the MAFBNZ liaison.

## 2.3. COLLATING INFORMATION ON ANTHROPOGENIC MOVEMENTS OF STOCK AND EQUIPMENT

### 2.3.1 Background

Responsibilities for freshwater aquaculture, including movements of stock, is divided in accordance with the different legislation that applies to commercial fish farms and sports fish hatcheries. Commercial, land-based fish farms are licensed by the MFish under provisions of the Freshwater Fish Farming Regulations 1983. This includes land-based marine farms operating with pumped seawater and businesses set up as salmon-fishing ponds. MFish maintains a register of land-based fish farms, and a separate dataset of freshwater fish transfer authorisations. This has good information relating to farms licensed under the Freshwater Fish Farming Regulations, but the application of regulations for the authorisation of the transfer of sports fish from hatcheries are complex and data are incomplete.

As previously discussed, sports fish hatcheries (raising trout and salmon) are excluded from the Freshwater Fish Farming Regulations. Fish movements from sports fish hatcheries are regulated by provisions of Section 26ZM(2) of the Conservation Act 1987 (see Appendix 3).

Where the transfer involves a new species into a new area then the Department of Conservation (DoC) is the lead agency and requires an environmental impact assessment and they consult with MFish and Fish and Game New Zealand. For transfers to areas where the species already exists, MFish is the lead agency and consults with DoC. Transfers by Fish and Game New Zealand from hatcheries for the purpose of stocking rivers with sports fish do not require MFish or DoC fish transfer authorisations if the transfer is within the same island and the species already exists at the site (Conservation Act Section ZM26 part 6). For some Fish and Game New Zealand transfers in the South Island, tests are conducted for the introduced alga *Didymosphenia germinata* (“didymo”) prior to transfer and MFish approval is sought. MFish is not consulted regarding North Island sports fish hatcheries. MFish does include in their fish transfer database some transfers authorised under section 26ZM of the Conservation Act, as that section requires prior approval from the Minister of Fisheries. However, for species that are not salmonids, once a fish farmer has approval from DoC for the first release onto the fish farm, further releases/transfers between fish farms are exempt from MFish approval, so those transfers can only be identified through fish-farm records.

There are some organisations other than Fish and Game New Zealand that operate hatcheries in the South Island for sports fisheries. These are registered as charitable trusts, operating under regional Fish and Game New Zealand authority. Some transfers are made by seeking MFish authorisations but the exemption under section ZM26 applies. There is no specific database of these transfers but the information is generally contained within operational records of each facility.



Movements of marine organisms are less subject to statutory controls or requirements for record keeping than those of freshwater organisms, presumably because of the inherent connectedness of marine areas. Restrictions on sources of stock or other activities may be imposed as conditions of resource consents for marine farms on a farm-by-farm or regional basis. For example, conditions attached to the consent for spat-catching lines in Jacksons Bay on the west coast of the South Island forbid the import of spat, stock or used equipment into the site from other locations, to minimise the risk of introduction of the non-indigenous, invasive alga *Undaria pinnatifida*. Individual farms and companies will generally record information on transfers of spat, stock and other material for their own purposes, including disease control.

### 2.3.2 Dataset structure

Information on movements of stock and equipment were obtained primarily through telephone interviews with a selected subset of aquaculturists. Initial discussions with representatives of industry organisations were used to gain an overview of the major pathways of movement and to seek advice on appropriate individual farmers to contact in order to gain a representative understanding of current patterns and pathways of transfer.

These individuals were then interviewed by telephone and asked a set of standardised questions contained in a prepared questionnaire<sup>5</sup>. The questionnaire contained questions relating to patterns and frequency of movement and possible biosecurity risks or precautions associated with movements (see Appendix 2: Table 5 for a full list of data fields). The objective of the questionnaire was to obtain an overall view of the types of movements of stock and equipment among aquaculture facilities and areas in New Zealand, including origins, destination and types of material moved, rather than a detailed catalogue of individual movements at any particular time.

Patterns of movement change in response to a wide range of factors, including growing and harvesting conditions, and market forces, and a broad overview of past patterns of movement will allow MAFBNZ to identify appropriate stakeholders to contact for information on recent movements in response to a pest or disease outbreak. While we have made every effort to extract the most up-to-date information from the various sources consulted (see below) it is important to recognise that the dataset cannot provide an up-to-the-minute account of movements of aquaculture stock and equipment because this information changes constantly. Consequently, the considerable effort required to update all the relevant fields for every entry would become obsolete as soon as it was completed. Rather, the dataset is intended to provide an overview of transfer pathways that can be used to focus enquiries in the event of an outbreak of a disease or pest. In the event of an outbreak, this description can be consulted to identify potential pathways of transfer among facilities and these contacted using the information provided or, where this is found to be out of date, current information obtained.

### 2.3.3 Sources of information on movements

In addition to the interviews, information on movements was obtained from the following sources (and see Appendix 2: Table 6):

- i. The Freshwater Fish Transfer Authorisation dataset owned by MFish.

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<sup>5</sup> The questionnaire has been provided to the MAFBNZ project liaison.

- ii. Fish and Game New Zealand regional offices. No specific datasets exist of the locations of the hatcheries or of releases from them, but information was obtained from regional offices by telephone. Some transfers are captured by the MFish Fish Transfer dataset.

## 2.4. HYDRODYNAMIC INFORMATION

Given the funding available for Phase II of this study, running detailed models for each facility (or even geographical areas such as bays) will not be feasible. Therefore we will need to use simple, easily extracted parameters to characterise hydrographical areas, such as tidal excursions for coastal facilities or river flow rates. Derivation of these layers will draw on existing hydrological models (pest dispersion models, contaminant dispersion models, general hydrodynamic models) for relevant coastal and river areas, as identified in Phase I.

Consequently, our review of relevant hydrodynamic information has focussed on sources where the information required (such as time-averaged or maximum current flows) can be extracted from existing documentation.

A considerable amount of information about the hydrodynamics of New Zealand's coastal water exists, and much of this information is held within NIWA databases. Hydrodynamic models have been developed to describe flow patterns at a variety of scales and empirical data collected to validate the models, and these may be used to develop models of connectivity (e.g. Chiswell & Rickard 2008). We have summarised the publicly-available information that can be obtained from models and other sources (Appendix 2: Table 7).

NIWA also maintains a comprehensive database of freshwater hydrological data, including flow from rivers and lakes throughout New Zealand. For example, NIWA has developed a New Zealand River Environment Classification<sup>6</sup> (REC) system on behalf of the Ministry for the Environment (MfE). The REC groups rivers and parts of river systems at a range of spatial scales based on environmental attributes of the catchment as well as attributes of the valley that a river channel occupies. The REC is an ecosystem-based spatial framework for river management purposes and provides a context for inventories of river resources, and a spatial framework for effects assessment, policy development, developing monitoring programmes and interpretation of monitoring data and state-of-environment reporting. The REC has been used to classify all the rivers of New Zealand at a 1:50,000 mapping scale, with the area classified comprising 267,000 km<sup>2</sup> and 426,000 km of river network. Characteristics such as flow regime, water quality, and biological communities of rivers are strongly determined by physical attributes. REC classes are, therefore, a useful way of subdividing rivers into units for management. In conjunction with regional councils, NIWA has also completed various case studies using the REC as a 'spatial framework' for broad scale environmental assessment. Kilroy et al. (2008) provide a recent example of NIWA utilising its extensive freshwater databases and models for assessing freshwater environmental connectivity relative to the potential spread of *Didymosphenia geminata*.

NIWA has also developed the Marine Environment Classification (MEC), a GIS-based environmental classification of the marine environment of the New Zealand region, which is an ecosystem-based spatial framework designed for marine management purposes. Developed by NIWA with support from the Ministry for the Environment (MfE), DoC and MFish, and with contributions from several other stakeholders, the MEC provides a spatial framework for inventories of marine resources, environmental effects assessments, policy development and design of protected area networks (see: <http://www.niwa.co.nz/our-services/databases/mec>). We have not sourced any data from LINZ, as per Schedule 2, Appendix 2 in the RFP.

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<sup>6</sup> See <http://www.niwa.co.nz/news-and-publications/publications/all/wru/2004-06/classification>

## 2.5. QUALITY CONTROL OF THE DATA OBTAINED

The main form of quality control for completeness of the location dataset was cross-checking among different sources of data, using the resource consent lists from relevant councils as the starting point. Secondary sources of data included the marine and freshwater farm databases from MFish, the Marine Farming Association's list of members (in hard copy) and farm locations (as an Excel spreadsheet) and, where available, the membership lists of industry organisations. In addition to checking for completeness, these sources allowed verification of contact details.

Missing location coordinates were obtained, when possible, by locating the facility on a map using the topographical mapping software MapToaster and/or Google Earth, and noting the coordinates (in New Zealand Map Grid and latitude/longitude, respectively). Consent information for freshwater facilities rarely included coordinates.

Comparisons among different sources of data invariably led to the finding that overlap in the facilities listed was incomplete (or, in the worst case, that there was no overlap at all). The resources available for the project did not allow exhaustive verification of the information included in the two datasets. Updating and correcting of the datasets is, therefore, an ongoing process.

### 3. Data collected

#### 3.1. INFORMATION ON THE LOCATION OF AQUACULTURE FACILITIES

This dataset<sup>7</sup> included approximately 4,000 lines of data (each line representing a farm-species combination), of which one is estuarine, 59 freshwater, 105 land-based, and the remainder marine, indicating the extreme dominance of aquaculture in New Zealand by marine farming.

Most fields in the dataset could be completed for at least some facilities. Information on membership of industry organisations and on type of subunit within a company was often lacking or not applicable. In many cases, the role of the contact person was not specified in the original data. Contacting each consent holder to obtain these missing data was far beyond the resources of the present study.

There were a number of major gaps in the dataset, the most notable being the complete lack of information on stocking densities or biomass held on farms. This was the result of the decision by Aquaculture New Zealand not to release their dataset to the study. To have obtained this information from individual organisations or farms (assuming that they would have been willing to provide it, which is unlikely given the commercial sensitivity of the information) would be an enormous task. It may also be of questionable value, given the variability of stocking densities over time.

#### 3.2. INFORMATION ON THE MOVEMENT OF AQUACULTURE STOCK AND EQUIPMENT

This dataset<sup>8</sup> contains approximately 600 records of movements of aquaculture stock, and provides a representative overview of current movements occurring among aquaculture facilities. Those interviewed to obtain information include individual farmers, representatives of large aquaculture companies (Aotearoa Fisheries, Marlborough Mussel Company, New Zealand King Salmon, Sanfords) and Fish and Game New Zealand. Information was also extracted from MFish's database of transfers (including movements of paua).

Predominant movements were of mussel and oyster spat by land or water, and of salmon ova or juveniles for stock enhancement or farming. Distances moved range from distribution of mussel spat from Kaitaia (Ninety Mile Beach) to farms in the Marlborough Sounds and the Coromandel, to local redistribution.

Because the interviews were based on a questionnaire incorporating the data fields shown in Appendix 2: Table 5, most fields were completed. Notable gaps in the dataset are those relating to disease, which may reflect low incidence of disease with aquaculture facilities in New Zealand but may also reflect reluctance to reveal potentially sensitive and/or damaging information. Nevertheless, there were records of shell abnormalities in oysters due to mudworms, spat mortality due to viral infection and white spot disease in salmon. Biosecurity issues identified included fouling by the introduced kelp *Undaria pinnatifida* and the introduced ascidians *Aplidium phortax*, *Ciona intestinalis*, *Didemnum vexillum*, *Diplosoma listerianum*, *Eudistoma elongatum* and *Styela clava*.

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<sup>7</sup> The dataset has been supplied to MAFBNZ in the form of ArcGIS files.

<sup>8</sup> The dataset has been supplied to MAFBNZ in the form of ArcGIS files.

### 3.3. SPECIES FARMED

In addition to the main three species (Greenshell mussels, *Perna canaliculus*, Pacific oysters, *Crassostrea gigas*, and king salmon, *Oncorhynchus tshawytscha*), species listed on existing consents include:

**Algae:** bull kelp (*Durvillea antarctica*), giant kelp (*Macrocystis pyrifera*), kelp (*Ecklonia radiata*), sea lettuce (*Ulva* spp.), wakame (*Undaria pinnatifida*), *Xiphophora gladiata*, unspecified algal species

**Sponges:** unspecified species

**Molluscs:** abalone (*Haliotis* spp., including paua, *H. iris*), blue mussels (*Mytilus edulis* and *M. galloprovincialis*<sup>9</sup>), cockles (*Austrovenus stutchburyi*), flat oysters (*Ostrea* (*Tiostrea*) *chilensis*), horse mussels (*Atrina zelandica*), hohehohe (geoduck, *Panopea zelandica*), scallops (*Pecten novaezelandiae*), surf clams (*Paphies* spp.), Sydney rock oysters (*Saccostrea commercialis*), trough shells (*Mactra* spp. and *Spisula* spp.), venus shells (*Ruditapes largillierti*)

**Crustaceans:** brine shrimp (*Artemia salina*), crayfish (*Jasus edwardsii* and *J. verreauxi*), freshwater prawns (*Macrobrachium rosenbergii*), koura (*Paranephrops zealandicus*)

**Echinoderms:** kina (*Evechinus chloroticus*)

**Fish:** bluefin tuna (*Thunnus thynnus*), eels (*Anguilla* spp.), grass carp (*Ctenopharyngodon idella*), king fish (*Seriola lalandi*), mullet (*Mugil cephalus*), other salmon species (*Salmo* spp.), pilchards (*Sardinops neopilchardus*), seahorses (*Hippocampus abdominalis*), snapper (*Pagrus auratus*), sockeye salmon (*Oncorhynchus nerka*)

As noted previously, however, only a subset of these species is actively farmed at present. Others may be listed on consents because they have been farmed in the past or because they may be farmed in the future. Obtaining a list of currently-farmed species would require a significant amount of effort to contact all the consent holders, and would be largely futile because of the rapidity with which the situation is likely to change.

The Marine Fish Farm database (from FishServe) contains several species not recorded on resource consents. These include: the red alga *Gracilaria* sp., the kelp *Lessonia* sp., the sponge *Lissodendoryx* sp., cat's eye (*Turbo smaragdus*), circular saw shell (*Astraea heliotropium*), frilled venus shell (*Bassinia yatei*), ringed dosinia (*Dosinia anus*), sea cucumber (*Australostichopus* (*Stichopus*) *mollis*), anchovy (*Engraulis australis*), butterfish (*Odax pullus*), hapuku (*Polyprion oxygeneios*), and John dory (*Zeus faber*).

### 3.4. PROBLEMS WITH THE DATA OBTAINED

The extent of inconsistencies in content among supposedly overlapping datasets was enormous, and every effort to cross-check data from one source with those from another invariably led to the discovery of new facilities not included in previously-consulted sources. There was also huge variation in the formats of datasets in terms of the type of information provided and whether data were in single worksheets within a spreadsheet or separated into several worksheets (and, therefore, required joining together for inclusion in our datasets).

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<sup>9</sup> *Mytilus edulis* and *M. galloprovincialis* in New Zealand and now considered to be one species, *M. galloprovincialis*.

Inconsistencies and errors in field names, including the names of farms or companies, were widespread and hampered efforts to search for specific terms during cross checking.

Commonly-occurring problems with the two datasets were:

- Missing fields/ inconsistencies in the fields provided
- Duplications of entries
- Changes in use (species) and species consented but not currently farmed
- Farms no longer operating
- Inconsistencies in coordinate systems used or lack of coordinates
- Inconsistencies among different sources of the same information
- Inconsistencies in format of licence numbers, consent numbers, names of consent holders, address format, place names

## 4. Recommendations for data maintenance

Maintenance of the location dataset will require the following:

- Adding information on new farms and other facilities
- Adding information on changes in use, including closure and changes in species farmed or processed
- Adding information on changes in area of farms or other facilities
- Updating information on ownership and contact details

Marine farmers are legally required (under the Fisheries Act 1996) to provide or update this information in the Marine Farm Register whenever a new consent is issued or an existing consent is modified. Annual requests for updates are also sent out by MFish (see *Sources of information on location of facilities*) and must be completed and returned as soon as possible. These registrations provide some of the information required to update the location dataset, and linking the location dataset to the MFish register is a logical first step in maintaining the former. However, farmers are apparently not always diligent in filing applications for registration or variations to an existing registration. Further, the register does not include location coordinates for the facilities or information on numbers of weight of stock held or harvested. Consequently, information from the register will need to be supplemented (and cross-checked) from other sources.

Equivalent information for freshwater or land-based facilities may be available from MFish's Freshwater Fish Farm Register. Again, coordinates of locations are not always recorded and information would need to be supplemented from other sources, such as resource consents.

The best approach to maintenance of the dataset of information on the location of aquaculture facilities is, therefore, to develop links between MAFBNZ and MFish's Marine and Freshwater Fish Farm Registers to allow access to information on new or altered consents and to annual updates, and to obtain regular data summaries of new consents from regional councils and unitary authorities. Resource consents may not capture information on the species actually farmed (as opposed to potential farmed species for each site) but this information should be available from the Fish Farm Registers. Conversely, the latter may not include detailed farm locations but these will usually be recorded on consents.

Regular access to MFish's Freshwater Fish Transfer Authorisation database will allow updating of the movement database for freshwater and land-based farms. Updates on patterns of movement for marine farms is not available from any single source and is probably best achieved by regularly repeating the questionnaire-based survey used in the present study. Information should be sort from industry organisations, who have a broad overview of movements within their industry as a whole, supplemented and verified by more detailed surveys of selected companies within each sector of the industry.

## 5. Acknowledgements

We are very grateful to the many staff of regional councils, unitary authorities, aquaculture industry organisations, the Ministry of Fisheries and regional offices of the Department of Conservation and Fish and Game New Zealand who provided information for this study. We particularly thank those individuals who agreed to be interviewed during the collection of information on movements of stock and materials. Thanks also to Lisa Peacock (NIWA) for help with compiling the geodatabase and Anna Bradley and Jenny McLean (NIWA) for entering data obtained in hard copy.



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## 7. Appendices

### Appendix 1: Glossary

<b>Term</b>	<b>Definition</b>
Aquaculture management area	A coastal marine area described as an aquaculture management area under the Resource Management Amendment Act (No. 2) 2004
Biosecurity	A set of preventive measures designed to reduce the risk of transmission of infectious diseases, pests, invasive alien species or living modified organisms.
Catchment	A natural land drainage area.
Circulation type	Characteristics of a location in terms of water containment and flow.
Epidemiological unit	A group of animals or plants that share approximately the same likelihood of exposure to a pathogen. This may be because they share a common environment (e.g. animals in a pond), or because of common management practices. It may apply to the stock on a particular farm or stock sharing a communal animal handling facility. The epidemiological relationship may differ from disease to disease, or even strain to strain of the pathogen.
Farm	A facility for the rearing and growing of stock organisms for commercial use. Note that under the Fish Farming Regulations 1983, “fish farm” does not include any hatchery established and operated by an acclimatisation society (now Fish and Game New Zealand), MAF or the Department of Internal Affairs (now the Department of Conservation).
Geodatabase	A database designed to store, query, and manipulate geographic information and spatial data. May be incorporated into a geographic information system (GIS).
Grow-out area	An area or water body where juveniles are grown to market size.
Grow-out facility	A specific type of farm where juveniles are grown to market size.
Hatchery	A facility for rearing stock from hatching.
Host	An organisms that carries a parasite, disease or pathogen.

Hydrodynamics	The study of liquids in motion, including tidal and wind-driven currents in the sea and river flow.
Hydrography	The measurement and description of a body of water.
Incursion Pond	A stock holding facility.
Preparedness	Developing operational systems and capabilities before an emergency happens. This includes self-help and response programmes for the public, as well as specific programmes for emergency services.
Processing facility	A facility for processing stock organisms for commercial sale.
Spat catching	Collection of juvenile bivalves ('spat') as they settle out of the water column and metamorphose from their planktonic larval form to their adult form.
Stock organism	A valuable aquatic animal or plant reared for commercial purposes.
Surveillance	The systematic ongoing collection, collation, and analysis of information related to animal health and the timely dissemination of information to those who need to know so that action can be taken.
Transfers	The intentional movement of animals, gametes, or animal product from one location to another.

## Appendix 2: Tables

Table 1 List of species that may be farmed in New Zealand.

Common name (species)	Common name (species)	Common name (species)	Common name (species)
(1.1) Abalone or paua, being:	(iv) Sand flounder ( <i>Rhombosolea plebeia</i> )	(1.28) Parore ( <i>Girella tricuspidata</i> )	(ix) Red flabby sponge ( <i>Crella encrustans</i> )
(i) Ordinary paua ( <i>Haliotis iris</i> )	(v) Turbot ( <i>Colistium nudipinnus</i> )	(1.29) Perch ( <i>Perca fluviatilis</i> )	(1.42) Striped trumpeter ( <i>Latris lineate</i> )
(ii) Virgin paua ( <i>Haliotis virginea</i> )	(vi) Yellowbelly flounder ( <i>Rhombosolea leporina</i> )	(1.30) Pipi ( <i>Paphies australis</i> )	(1.43) Surf clam, being:
(iii) Yellow-foot paua ( <i>Haliotis australis</i> )	(1.15) Freshwater crayfish or koura, being:	(1.31) Red gurnard ( <i>Chelidonichthys kumu</i> )	(i) Deep water tuatua ( <i>Paphies donacina</i> )
(1.2) Anemone, being:	(i) <i>Paranephrops planifrons</i>	(1.32) Rock shrimp ( <i>Palaemon affinis</i> )	(ii) Fine dosinia ( <i>Dosinia subrosea</i> )
(i) Common anemone ( <i>Actinotheroe albocincta</i> )	(ii) <i>Paranephrops zealandicus</i>	(1.33) Salmon, being:	(iii) Frilly venus shell ( <i>Bassina yatei</i> )
(ii) Dahlia anemone ( <i>Isocradactis magna</i> )	(1.16) Grey mullet ( <i>Mugil cephalus</i> )	(i) Atlantic salmon ( <i>Salmo salar</i> )	(iv) Large trough shell ( <i>Macra murchisoni</i> )
(1.3) Bass ( <i>Polypriion moeone</i> )	(1.17) Hapuku ( <i>Polypriion oxygeneios</i> )	(ii) Chinook or quinnat salmon ( <i>Oncorhynchus tshawytscha</i> )	(v) Ringed dosinia ( <i>Dosinia anus</i> )
(1.4) Blue cod ( <i>Parapercis colias</i> )	(1.18) John dory ( <i>Zeus faber</i> )	(iii) Sockeye salmon ( <i>Oncorhynchus nerka</i> )	(vi) Silky dosinia ( <i>Dosinia lambata</i> )
(1.5) Brine shrimp ( <i>Artemia salina</i> )	(1.19) Kahawai ( <i>Arripis trutta</i> )	(1.34) Scallops ( <i>Pecten novaezelandiae</i> )	(vii) Small trough shell ( <i>Macra discors</i> )
(1.6) Butterfish ( <i>Odax pullus</i> )	(1.20) King clam or geoduck ( <i>Panopea zelandica</i> )	(1.35) Scampi ( <i>Metanephrops challenger</i> )	(viii) Triangle trough shell ( <i>Spisula aequilateralis</i> )
(1.7) Carp, being:	(1.21) Koheru ( <i>Decapterus koheru</i> )	(1.36) Sea cucumber ( <i>Stichopus mollis</i> )	(ix) Tuatua ( <i>Paphies subtriangulata</i> )
(i) Grass carp ( <i>Ctenopharyngodon idella</i> )	(1.22) Leatherjacket ( <i>Parika scaber</i> )	(1.37) Seahorse, being:	(1.44) Tarakihi ( <i>Nemadactylus macropterus</i> )
(ii) Silver carp ( <i>Hypophthalmichthys molitrix</i> )	(1.23) Lobster, being:	(i) Seahorse ( <i>Hippocampus abdominalis</i> )	(1.45) Toheroa ( <i>Paphies ventricosa</i> )
(1.8) Cat's eye ( <i>Turbo smaragdus</i> )	(i) Packhorse or green lobster ( <i>Jasus verreauxi</i> )	(ii) Spotted seahorse ( <i>Hippocampus kuda</i> )	(1.46) Trevally ( <i>Pseudocaranx dentex</i> )
(1.9) Crab, being:	(ii) Spiny or red rock lobster ( <i>Jasus edwardsii</i> )	(1.38) Sea urchin ( <i>Evechinus chloroticus</i> )	(1.47) Tropical freshwater prawn ( <i>Macrobrachium rosenbergii</i> )
(i) Cancer crab ( <i>Cancer novaezelandiae</i> )	(1.24) Mussel, being:	(1.39) Seaweed, being:	(1.48) Tuna, being:
(ii) Giant spider crab ( <i>Jacuinotia edwardsii</i> )	(i) Blue mussel ( <i>Mytilus galloprovincialis</i> )	(i) Agar weed ( <i>Pterocladia lucida</i> )	(i) Bigeye tuna ( <i>Thunnus obesus</i> )
(iii) King crab ( <i>Lithodes murrayi</i> )	(ii) Freshwater mussel ( <i>Hyridella menziesii</i> and <i>Cucumerunio websteri</i> )	(ii) Gigartina ( <i>Gigartina atropurpurea</i> and <i>Gigartina circumcincta</i> )	(ii) Southern bluefin tuna ( <i>Thunnus maccoyii</i> )
(iv) Paddle crab ( <i>Ovalipes catharus</i> )	(iii) Green lipped mussel ( <i>Perna canaliculus</i> )	(iii) Gracilaria ( <i>Gracilaria chilensis</i> )	(1.49) Venus clam ( <i>Ruditapes largillierti</i> )
(v) Red crab ( <i>Chaeceon bicolour</i> )	(iv) Horse mussel ( <i>Atrina zelandica</i> )	(iv) Small agar weed ( <i>Pterocladia capillacea</i> )	(1.50) Watercress, being:
(1.10) Coarse dosina ( <i>Dosina zelandica</i> )	(1.25) Octopus, being:	(1.40) Snapper ( <i>Pagrus auratus</i> )	(i) <i>Nasturtium microphyllum</i>
(1.11) Cockle ( <i>Austrovenus stutchburyi</i> )	(i) <i>Octopus huttoni</i>	(1.41) Sponge, being:	(ii) <i>Nasturtium officinale</i>
(1.12) Cooks turban ( <i>Cookia sulcata</i> )	(ii) <i>Pinnocotopus cordiformis</i>	(i) Bath sponge ( <i>Spongia manipulatus</i> )	(1.51) Whitebait, being:

(1.13) Eel, being:	(1.26) Mysid shrimp, being:	(ii) Finger sponge ( <i>Callyspongia ramosa</i> )	(i) Banded kokopu ( <i>Galaxias fasciatus</i> )
(i) Longfin eel ( <i>Anguilla dieffenbachii</i> )	(i) <i>Mysidopsis</i> sp.	(iii) Grey sponge ( <i>Ircinia</i> sp.)	(ii) Giant kokopu ( <i>Galaxias argenteus</i> )
(ii) Shortfin eel ( <i>Anguilla australis</i> )	(ii) <i>Tenagomysis nova-zealandiae</i>	(iv) <i>Latrunclia</i> sp.	(iii) Inanga ( <i>Galaxias maculatus</i> )
(1.14) Flounder, being:	(iii) <i>Tenagomysis similes</i>	(v) <i>Lissodendoryx</i> sp.	(iv) Koaro ( <i>Galaxias brevipinnis</i> )
(i) Black flounder ( <i>Rhombosolea retiaria</i> )	(1.27) Oyster, being:	(vi) <i>Mycale</i> sp.	(v) Shortjaw kokopu ( <i>Galaxias postvectis</i> )
(ii) Brill ( <i>Colistium guntheri</i> )	(i) Dredge oyster ( <i>Tiostrea chilensis</i> )	(vii) Pink conular sponge ( <i>Chondropsis kirkii</i> )	(1.52) Yellowtail kingfish ( <i>Seriola lalandi</i> )
(iii) Greenback flounder ( <i>Rhombosolea tapirina</i> )	(ii) Pacific oyster ( <i>Crassostrea gigas</i> )	(viii) <i>Raspailia agminata</i>	

**Table 2 Major marine farming regions, major species cultivated and percentage of total production for the three dominant species in 2008.**

Region	Greenshell mussels	King salmon	Pacific oysters	Dredge oysters	Paua	Other
Northland			47%			
Auckland	3%		26%			
Coromandel	22%		21%			
Tasman and Golden Bays	3%		1%			Scallop, cockles, spat catching
Marlborough	68%	75%	5%	Yes	Yes	
Canterbury	1%	6%			Yes	
Stewart Island	3%	19%		Yes		

Source: [www.aquaculture.org.nz](http://www.aquaculture.org.nz)



Table 3 List of fields in dataset of location information on aquaculture facilities.

Field name	Identifier	Region	Place	Coordinate system	Coordinate easting	Coordinate northing	Place type
Example	1, 2, etc.	Northland, Auckland, Waikato, etc.	Hokianga Harbour, etc.	NZGD2000	Easting	Northing	Marine, freshwater, land-based
Comments	Unique identifier given to each facility by NIWA to aid sorting and cross-referencing	Regions as defined at <a href="http://www.localcouncils.govt.nz/lcip.nsf">www.localcouncils.govt.nz/lcip.nsf</a>	List of place names derived from NIWA's Masterplace database of standard names	Electronic datasets of consents for land-based facilities invariably lacked coordinates – this information may be contained in hard copies of consents			
Field name	Circulation type	Authorization Number	Lease (MAF)	Permit (MAF)	Consent (RMA)	Corresponding consent number (MF only)	Licence (MAF)
Example	Open system (e.g. mussel lines, river), semi-open (e.g. sea cages), semi-closed (e.g. outdoor ponds), closed (recirculating system)		Lease 2 Lot 1	MF Permit 123 MPE456 MF549	U123456		
Comments			Many farms have several permit and/or licence codes, reflecting historic licensing regimes, in addition to resource consent number.			Consent numbers allocated by Waikato Regional Council to MFish permits that became resource consents under law change in 2005. Applies only to farms in Wilsons Bay, Firth of Thames.	

Field name	Area of farm, etc.	Organism type	Maximum number/biomass	Organisation name	Organisation membership	Organisation type	Organisation unit (subdivision of organisation)
Example	Hectares	Scientific names of all species held or permitted to be held at that site		NIWA, Cawthron, Sanfords, NZMIC, etc.	MFA, Aquaculture New Zealand, NZMIC, etc.	Central government, local government, representative organisation (MFA, NZMIC, etc.), commercial, research	NIWA Bream Bay, Sanfords Kaeo
Comments		Consents commonly name several species, not all of which are farmed at present or in foreseeable future, and species farmed at a given location often change over time. All listed species included.	This information was not made available to the present study	May change over time with changing ownership	May change over time. Information often unavailable.		
Field name	Organisation unit type	Contact person	Role in organisation unit	Postal address	Telephone number	Email address	
Example	Farm, processing plant, hatchery, pond, grow-out facility						
Comments	Not always specified	May change over time	May change over time. Information often unavailable	May change over time with changing ownership	May change over time.	May change over time.	



Table 4 List of datasets containing information on locations of aquaculture facilities, ranked in order of utility for the present study (regional and district councils are ranked alphabetically).

Data source	Owner	Legislation	Content	Address of facility?	Accessibility	Limitations and comments
Auckland Regional Council aquaculture consents	Auckland Regional Council	Resource Management Act 1991	GIS shape files; Microsoft Excel file with consent and lease number, consent holder, contact details, descriptive farm location, species, consent area	Yes	Publicly available	Excel file did not include coordinates or street address – obtained from shape files
Bay of Plenty Regional Council aquaculture consents	Bay of Plenty Regional Council	Resource Management Act 1991	Pdf files for individual consents; Microsoft Excel file with consent number, consent holder, activity, farm location, shape files, consent status, contact details, consent start and end dates, farm location coordinates	Yes	Publicly available	Farm coordinates missing from Excel file in some cases.
Canterbury Regional Council aquaculture consents	Canterbury Regional Council	Resource Management Act 1991	GIS shape files and Microsoft Excel file with consent number, consent holder, activity, descriptive farm location, farm type, species, farm area, start and expiry date of consent, license number, location coordinates	Yes	Publicly available	Consent information for freshwater and land-based activities do not include coordinates – coordinates derived from descriptive farm location
Hawkes Bay Regional Council aquaculture consents	Hawkes Bay Regional Council	Resource Management Act 1991	Pdf file with location coordinates and other consent information	Yes	Publicly available	Only one facility listed. Information entered by hand.
Northland Regional Council aquaculture consents	Northland Regional Council	Resource Management Act 1991	GIS shape files; Microsoft Excel file with consent number, lease number, descriptive farm location, farm areas, consent holder, contact details, maps	Yes	Publicly available	Excel file did not include coordinates or street address – obtained from shape files

Otago Regional Council aquaculture consents	Otago Regional Council	Resource Management Act 1991	Microsoft Excel file with consent number, activity, species, map reference, consent holder contact details, activity	Yes	Publicly available	Consent information for freshwater and land-based activities do not include coordinates – coordinates derived from descriptive farm location
Southland Regional Council aquaculture consents	Southland Regional Council	Resource Management Act 1991	Microsoft Excel file with consent number, consent holder, licence number, descriptive farm location, species, contact details. Location coordinates in pdf files only.	Yes	Publicly available	
Taranaki Regional Council aquaculture consents	Taranaki Regional Council	Resource Management Act 1991	Descriptive farm location	n/a	Publicly available	Only one hatchery, at Hawera. Information obtained from TRC by telephone.
Waikato Regional Council aquaculture consents	Waikato Regional Council	Resource Management Act 1991	GIS shape files and Microsoft Excel file with consent number, descriptive farm location, species, farm area, name of consent holder, contact details	Yes	Publicly available	Locations for freshwater and land-based activities include coordinates and street address
Wellington Regional Council aquaculture consents	Wellington Regional Council	Resource Management Act 1991	Word files with consent number, consent holder, descriptive farm location, activity	No – contact monitoring officers for information	Publicly available	Locations for freshwater and land-based activities requested individually
West Coast Regional Council aquaculture consents	West Coast Regional Council	Resource Management Act 1991	Microsoft Excel file with consent number, consent holder, contact details, activity, location coordinates, expiry date of consent, name of river, descriptive location, type of consent	Yes	Publicly available	Locations for freshwater and land-based activities include coordinates

Gisborne District Council aquaculture consents	Gisborne District Council	Resource Management Act 1991	Species, name of consent holder, contact details	Yes	Publicly available	Information on single facility direct from council staff and contact details from FishServe. Coordinates derived from descriptive farm location
Marlborough District Council aquaculture consents	Marlborough District Council	Resource Management Act 1991	Microsoft Excel and GIS files; consent number, farm location, shape files, contact details, activity	Yes	Publicly available	Consent information for freshwater and land-based activities do not include coordinates – coordinates derived from descriptive farm location
Tasman District Council aquaculture consents	Tasman District Council	Resource Management Act 1991	Microsoft Excel file with location coordinates; separate Excel file with consent number, consent holder, contact details, descriptive farm location, owner's name, consent status, farm location coordinates; pdf files of maps of AMAs	Yes	Publicly available	
Fish & Game hatcheries and sports fish hatcheries	Individual Fish & Game regions and trusts	Regulated under the Conservation Act 1987	No specific databases exist of the locations of these hatcheries		n/a	Information obtained from staff at each office by telephone
Freshwater Fish Farm Register	Ministry of Fisheries	Freshwater Fish Farming Regulations 1983	Microsoft Access database includes licence number, farm name, owner, contact address, whether active (current licence fees paid). Includes land-based farms that use pumped seawater	Some – contact address may be head office	In contrast to the marine farm register, this is not a public database	Data incomplete for species and location coordinates for farms.
Department of Conservation hatcheries	Department of Conservation	Conservation Act 1987	DOC operates only the Turangi trout hatchery.			Fish used to stock a fishing pond on site and excess are transferred to other locations by Fish & Game Eastern Region

Abalone Farmers' Federation membership list	New Zealand Abalone Farmers' Association Inc.		Microsoft Excel file of members' names, locations and contact details	Yes		Information derived from MFish transfer database and resource consents. Contact list used to cross-check names and contact details.
Salmon farmers membership list	New Zealand Salmon Farmers Association Inc		Microsoft Excel spreadsheet of members	Some	Available to members of NZSFA (including NIWA)	Used to cross-check resource consent information
Oyster Industry Association membership list	New Zealand Industry Association Inc.		No electronic dataset exists	n/a	n/a	
Marine Farm Location Guide	Marine Farming Association		Printed copy of GIS-based maps of marine farms in the top of the South Island plus Microsoft Excel file of consent numbers, owners' names, descriptive farm location, farm area. Regularly updated by MFA by email to purchasers	Yes in GIS version	Hard copy can be purchased from MFA	Used for verifying farm locations, whether currently operating, and ownership.
Marine Fish Farm Register	Ministry of Fisheries	Fisheries Act 1996	Microsoft Excel database includes owner, contact address, licence/consent start and finish dates, licence and/or resource consent numbers, descriptive location of farm, licence area, species farmed	Not necessarily – contact address may be head office	Available for purchase	Does not contain location coordinates. Used to cross-check resource consent information.
Aquaculture New Zealand membership database	Aquaculture New Zealand Ltd		Aquaculture NZ maintain two databases. One is a fish farm register which is derived from MFish. The other is a list of contact addresses for members. This includes both marine farms and freshwater farms		Access to farm register via MFish	

Table 5 List of fields in dataset of information on aquaculture stock and equipment movements.

Category	Movements	Movements	Movements	Movements	Movements	Movements	Movements	Movements	Movements	Movements	Movements
Field name	Identifier	Name of interviewee	Name of organisation	Consent or permit no.	Type of movement	Purpose of movement	Origin	Destination	Materials moved	Timing of movement	Amounts moved
Example	1, 2, etc.				Human-land, water, air Natural-tidal, wind, river flow				Stock Spat/larvae Vessels Equipment Water	Daily Weekly Monthly Several times/year	Kg Single 14-m vessel Litre
Comments	NIWA identifier										
Category	Disease data	Disease data	Disease data	Disease data	Disease data	Disease data	Disease data	Disease data			
Field name	Mortality episodes	Deformities	Wasting or poor condition	Nervous signs	Skin/ fin/ shell abnormalities	Decreased feeding or growth	Recurring diseases	Respiratory signs			
Example											
Comments											
Category	Disease/ biosecurity precautions		Disease/ biosecurity precautions		Disease/ biosecurity precautions		Disease/ biosecurity precautions				
Field name	Past occurrence of disease at place		How is water from tanks, transfer water, etc. treated and disposed of?		How are dead or diseased stock disposed of?		Any other disease or biosecurity precautions?				
Example			To water body To sewer Soakage to land Treated		Landfill Incineration To environment						
Comments	Any information that emerges during interviews, based on list of relevant diseases supplied by MAFBNZ										

**Table 6 List of sources of information on movements of aquaculture stock and equipment (in addition to interviews conducted during the present study), ranked in order of relevance for the present study.**

Data source	Owner	Legislation	Content	Address of facility?	Accessibility	Limitations
Freshwater Fish Transfer Authorisation	Ministry of Fisheries	Freshwater Fish Farming Regulations 1983	Microsoft Access database includes records of fish transfer applications including origin, destination, approximate date of transfer, species, size and number. Species recorded are: salmon, trout, eels, koura, whitebait, silver carp and grass carp Paua transfers (reseeding proposals) require formal approval. Paua farms are required to send in returns of paua transfers off and on the farm, but it is unclear what the legal position is with these, given they contain commercial information. Dataset of paua transfers includes town, location coordinates for some farms, contact person, owner's name, species and contact address	Some – address may be head office	This is not a public database and there is no process in place to make this information available (in contrast to the marine database). Any request for information in this database would need to be directed to MFish as per the fish farm register.	Data are updated manually and are incomplete and often not current. Includes transfers of freshwater organisms by research organisations
Fish & Game hatcheries and sports fish hatcheries	Individual Fish & Game regions and trusts	Regulated under the Conservation Act 1987	No specific databases exist for the locations of these hatcheries or of the transfers or releases from them. Some of those transfers are captured by the MFish fish transfer database.	n/a	Verbal information provided very willingly	Information on transfers obtained directly from Fish & Game regional offices by telephone.
Department of Conservation hatcheries	Department of Conservation	Conservation Act 1987	DOC operates only the Turangi trout hatchery. Records of fish transfers are contained within hatchery operational records. Recent transfers have been to Wellington and Stratford for sports fishing ponds.	n/a	n/a	Information obtained from Fish & Game Eastern Region by telephone. Fish used to stock a fishing pond on site and excess are transferred to other locations by Fish & Game Eastern Region.

**Table 7 Sources of hydrodynamic information for aquaculture regions in New Zealand.**

Dataset	Environment	Data Type	Owner	Location	Contact	E mail	Contact Phone
FRIA	Marine	current meter, drogues	NIWA commercial clients	Marlborough Sounds, Golden Bay	Mark Hadfield	m.hadfield@niwa.co.nz	04 386 0363
FRIA	Marine	current meter, drogues	Cawthron commercial clients	Marlborough Sounds	Ben Knight	Ben.Knight@cawthron.org.nz	03 548 2319
Marine farm impacts	Marine	current meter	NIWA	Big Glory Bay, Stewart Island	Don Morrissey	d.morrissey@niwa.co.nz	03 545 7744
Marine farm impacts	Marine	current meter	NIWA	Big Glory Bay, Stewart Island	Don Morrissey	d.morrissey@niwa.co.nz	03 548 1715
Hauraki Gulf	Marine	published	NIWA	NE NZ, Hauraki Gulf	John Zeldis	j.zeldis@niwa.cri.nz	03 348 8987
Northland	Marine	model	NRC	Whangarei Harbour	Ricky Eyre	rickyE@nrc.govt.nz	09 438 4639
Northland	Marine	model	NRC	Kaipara	Ricky Eyre	rickyE@nrc.govt.nz	09 438 4639
Northland	Marine	model	NRC	Bay of Islands	Ricky Eyre	rickyE@nrc.govt.nz	09 438 4639
Whanganui Outfall	Marine	model	NIWA	Whanganui	Rob Bell	r.bell@niwa.co.nz	07 856 7026
Papamoa Outfall	Marine	model	NIWA	Tauranga/ Mt Manganui	Rob Bell	r.bell@niwa.co.nz	07 856 7026
Wellington Outfall	Marine	model	NIWA	Wellington	Rob Bell	r.bell@niwa.co.nz	07 856 7026
North Shore outfall	Marine	model	NIWA	Auckland / Hauraki Gulf	Rob Bell	r.bell@niwa.co.nz	07 856 7026
Manukau Outfall	Marine	model	NIWA	Manukau/Mangare	Rob Bell	r.bell@niwa.co.nz	07 856 7026
Whangarei Outfall	Marine	model	NIWA	Whangarei Harbour	Rob Bell	r.bell@niwa.co.nz	07 856 7026
Christchurch Outfall	Marine	model	Unisearch, University of NSW	Christchurch	Rob Bell	r.bell@niwa.co.nz	07 856 7026
Outfall	Marine	dye tracer	NIWA	Browns Bay	Max Gibbs	m.gibbs@niwa.co.nz	07 856 7026
Outfall	Marine	dye tracer	NIWA	Nelson	Max Gibbs	m.gibbs@niwa.co.nz	07 856 7026
Outfall	Marine	dye tracer	NIWA	Rabbit Island, Tasman Bay	Max Gibbs	m.gibbs@niwa.co.nz	07 856 7026
Outfall	Marine	dye tracer	NIWA	Picton	Max Gibbs	m.gibbs@niwa.co.nz	07 856 7026
Outfall	Marine	dye tracer	NIWA	Raglan	Max Gibbs	m.gibbs@niwa.co.nz	07 856 7026
Oyster Beds	Estuarine	indicative modelling	NIWA	Mahurangi	Max Gibbs	m.gibbs@niwa.co.nz	07 856 7026
Pelorus Mussels	Marine	current meter	NIWA	Pelorus Sound	Max Gibbs	m.gibbs@niwa.co.nz	07 856 7026
Wilsons Bay	Marine	model	NIWA	Hauraki Gulf Wilsons Bay	Max Gibbs	m.gibbs@niwa.co.nz	07 856 7026

Mussels							
National Hydrometric Database	Freshwater Rivers	River flow gauging	NIWA	NZ-wide	Kathy Walter	k.walter@niwa.co.nz	03 348 8987
MetOcean Solutions	Marine	model	MetOcean Solutions	Various	Peter McComb	enquiries@metocean.co.nz	06 758 5035
LINZ Navigational Charts	Marine	published	LINZ			<a href="http://www.linz.govt.nz/hydro/charts/nz202_chart_catalogue/index.aspx">http://www.linz.govt.nz/hydro/charts/nz202_chart_catalogue/index.aspx</a>	
NIWA Estuarine Environmental Classification database	Estuarine	published	NIWA		Terry Hume	t.hume@niwa.co.nz	07 856 7026



## Appendix 3: Section 26ZM(2) of the Conservation Act 1987

1. No person shall transfer live aquatic life or release live aquatic life into any freshwater, except in accordance with this section.
  2. The prior approval of the Minister of Fisheries shall be required for the following:
    - a. (a) The movement of live aquatic life between sites where the species already exists:
    - b. (b) The movement of live aquatic life between the islands of New Zealand.
  3. The prior approval of the Minister of Conservation shall be required for the following:
    - a. (a) The transfer of live aquatic life to or the release of live aquatic life in a new location where the species does not already exist (including the transfer of a new species to or the release of a new species in an existing or a new fish farm):
    - b. (b) The transfer of a species of live aquatic life to any land or water managed or administered under this Act or any other Act specified in Schedule 1 to this Act.
  4. The following provisions shall apply where the approval of the Minister of Conservation is required under subsection (3) of this section:
    - a. (a) The applicant shall advertise, on at least 2 consecutive Saturdays in at least one newspaper circulating in the area concerned, the intention to transfer or release live aquatic life:
    - b. (b) Every advertisement under paragraph (a) of this subsection shall state that submissions or objections in respect of its subject-matter should be sent to the Director-General within 20 working days after the date specified in the advertisement for that purpose (being a date that is not earlier than the date on which the advertisement is first published):
    - c. (c) The Director-General may require an applicant to provide an environmental impact assessment report before granting approval.
  5. Every person commits an offence and is liable to a fine not exceeding \$5,000 who contravenes or fails to comply with subsection (1) of this section.
- (5A) Nothing in this section applies to the transfer of any live aquatic life to an existing fish farm where the species is already present.
6. Except where the Director-General or the Director-General of Agriculture and Fisheries requires it to comply with this section, nothing in this section shall apply to the transfer by a Fish and Game New Zealand of sports fish to another location within the same island in New Zealand where the species is already present.
  7. (7) Except as provided in subsections (5A) and (6) of this section, this section applies to all persons.

Part 5B, comprising sections 26ZG to 26ZR, was inserted, as from 10 April 1990, by section 17 Conservation Law Reform Act 1990 (1990 No 31).

Subsection (4)(b) was amended, as from 17 May 2005, by section 3 Conservation Amendment Act 2005 (2005 No 47) by adding the words “within 20 working days after the date specified in the advertisement for that purpose (being a date that is not earlier than the date on which the advertisement is first published)”.

Subsection (5) was substituted, as from 13 March 1996, by section 26(1) Conservation Amendment Act 1996 (1996 No 1).

Subsection (5A) was inserted, as from 13 March 1996, by section 26(1) Conservation Amendment Act 1996 (1996 No 1).

Subsection (7) was inserted, as from 13 March 1996, by section 26(2) Conservation Amendment Act 1996 (1996 No 1).