



Effect of aquaculture in the Hauraki Gulf

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Growing and Protecting New Zealand

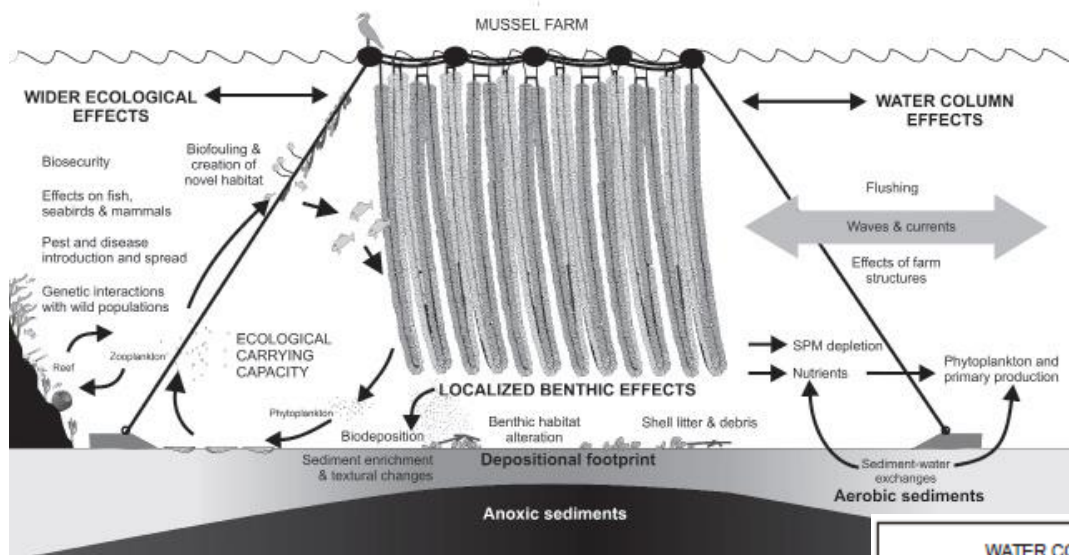


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Table 8: Threats to New Zealand marine habitats and threat source in decreasing order of mean impact of a threat across all habitats. Note the maximum possible mean weighted habitat impact score = 4.0. The mean certainty score for each threat is also shown. (MacDiarmid et al. 2012)

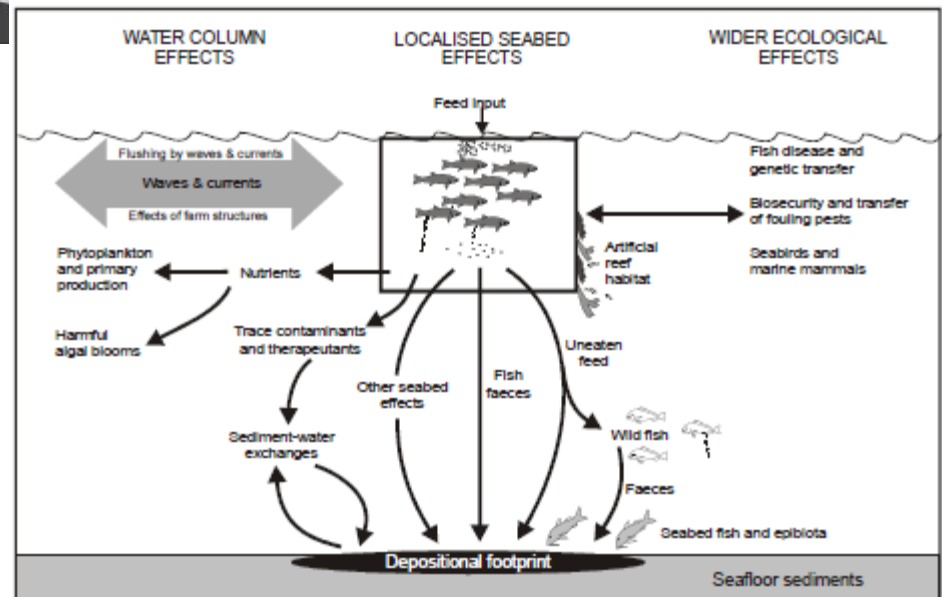
Threat	Threat source	Mean impact of threat across all habitats	Rank	Mean certainty score
Ocean acidification	Global	2.6	1	2.2
Climate change: Increased sea temperature	Global	1.6	2	2.9
Fishing: Bottom trawling	Marine	1.5	3=	3.1
River inputs: Increased sediment loading	Catchment	1.5	3=	3.0
Climate change: Change in currents	Global	1.2	5=	2.6
Climate change: Increased storminess	Global	1.2	5=	2.8
Fishing: Dredging	Marine	1.0	7	3.4
Invasive species: Space occupiers, competitors	Marine	0.9	8=	3.2
Engineering: Dumping of dredge spoils	Marine	0.9	8=	3.1
Climate change: Rise in sea-level	Global	0.9	8=	2.9
Algal blooms - both toxic and massive	Mixed	0.9	8=	2.9
Increased turbidity	Mixed	0.9	8=	3.2
Fishing: Line fishing	Marine	0.8	13=	3.2
Engineering: reclamation	Marine	0.8	13=	3.6
Climate change: Increased stratification	Global	0.8	13=	2.9
Pollution: Sewage	Catchment	0.8	13=	3.1
Pollution: Nitrogen & phosphorus load	Catchment	0.8	13=	2.8
Pollution: Oil or oil products	Mixed	0.8	13=	2.9
Fishing: Trapping	Marine	0.7	19=	3.1
Fishing: Long-lining	Marine	0.7	19=	3.1
Fishing: Shellfish gathering	Marine	0.7	19=	3.4
Climate change: Increased intertidal temperatures	Global	0.7	19=	3.4
Climate change: Increase in UV	Global	0.7	19=	3.0
Climate change: Altered rainfall	Global	0.7	19=	3.0
Pollution: Heavy metals	Catchment	0.7	19=	2.7
Aquaculture: Benthic accumulation of shells, food, faeces	Marine	0.7	19=	3.2

Overview of effects

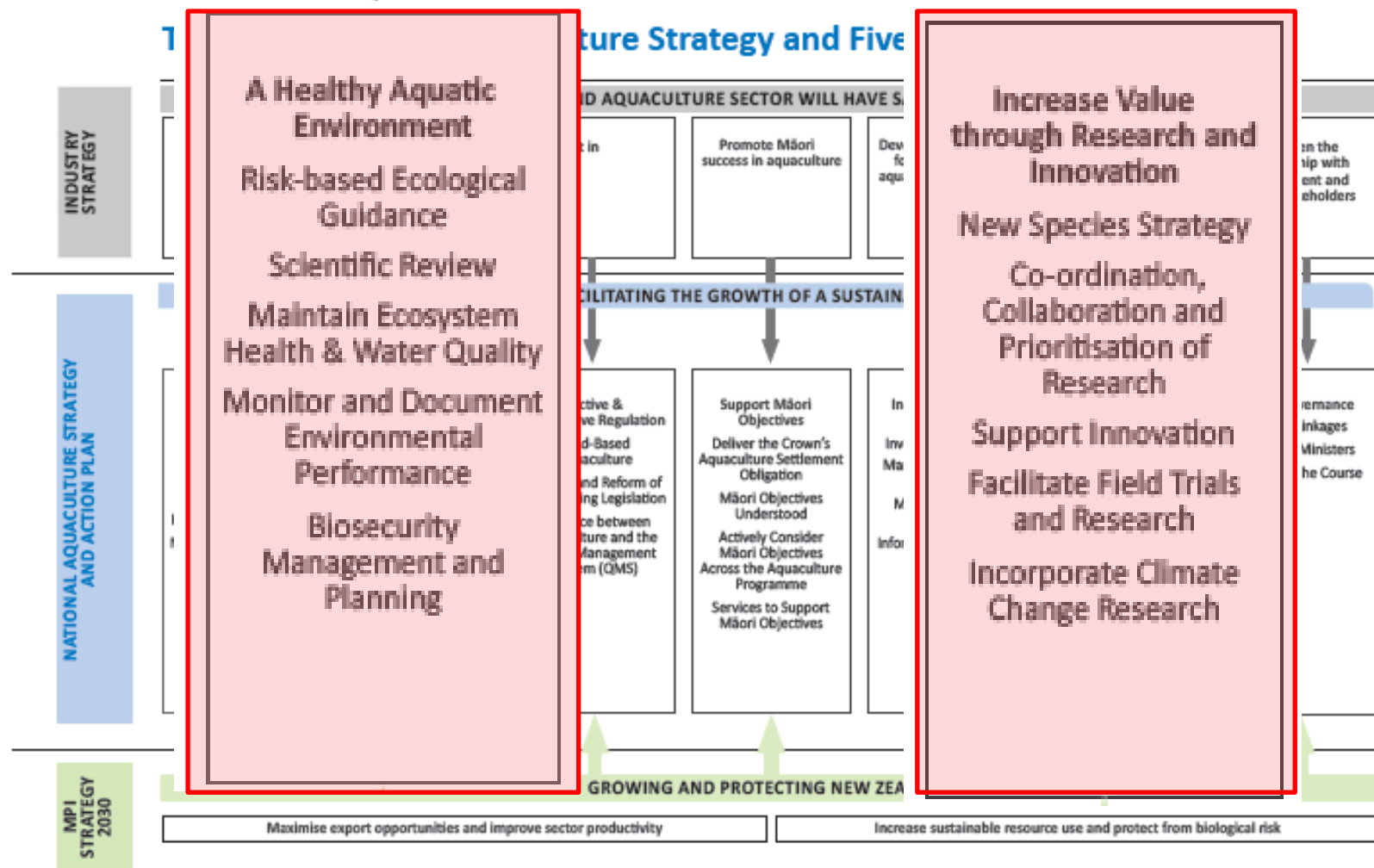


(Keeley et al. 2009)

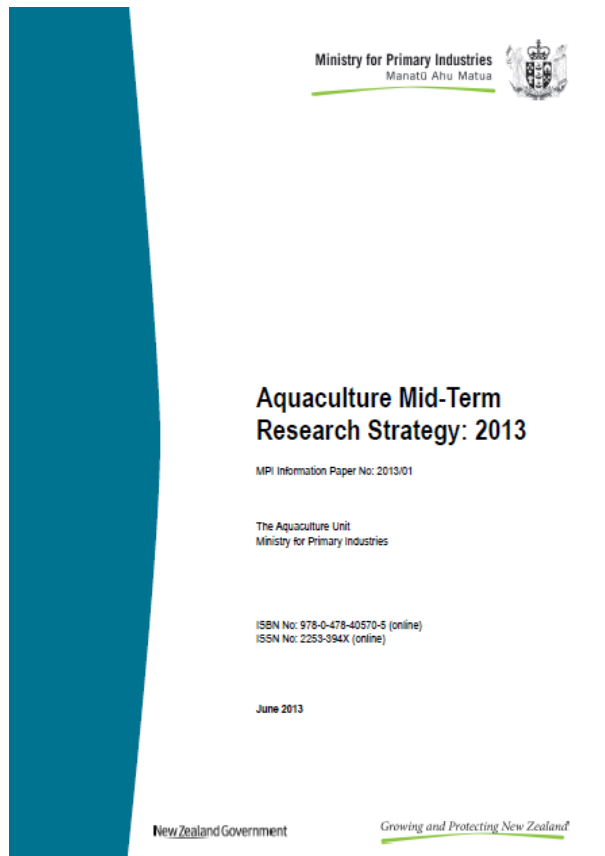
(Forrest et al. 2007)



Aquaculture growth



Research Strategy



- Biosecurity
- Animal Productivity
- Climate change
- Water
- New species
- Social license for aquaculture
- Consumers, products, markets
 - Objectives
 - Topics
 - Links and ongoing research

Aim of Ecological Guidance Package

To develop risk-based ecological impact assessment guidance to support nationally consistent RMA aquaculture decisions

- To provide credible, up-to-date scientific information on the ecological effects of marine-based aquaculture, and
- To minimise and identify risks and uncertainty and management options
- A broad audience of potential users
 - Regional Councils
 - Applicants
 - Public
 - Science Providers

What is the Ecological Guidance Package?

Phase 1: Literature Review

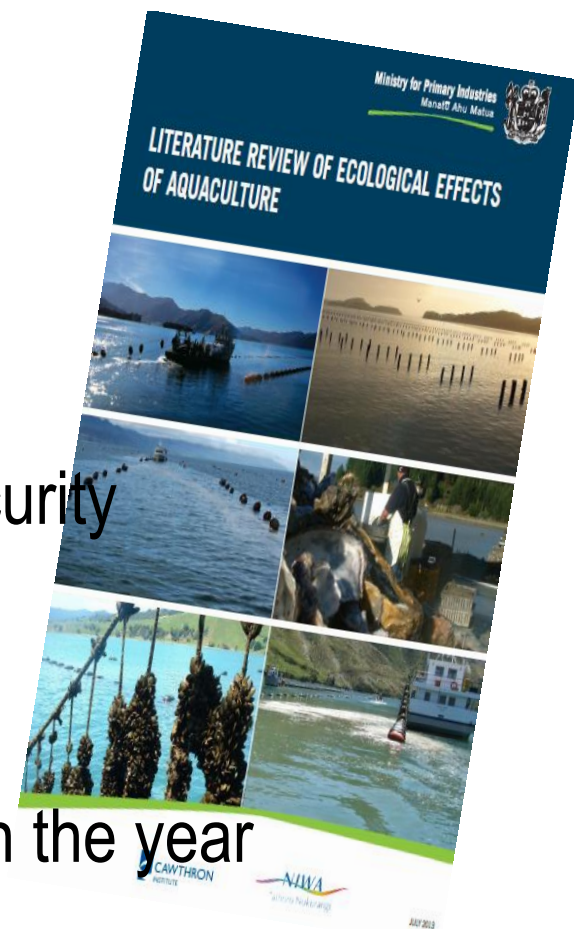
Phase 2: Overview of Ecological Effects

Phase 3: Risk Screening Tool

Phase 4: Ecological impacts of aquaculture

MTRP – baseline, modelling and biosecurity

- Phase 1 & 2 available now
- Phase 3&4 in development, available later in the year
- Web based to enable updates
- <http://www.fish.govt.nz/en-nz/Commercial/Aquaculture/default.htm>



Literature Review - Scope

- To compile and summarise the known and potential effects of marine-based aquaculture in NZ.
- Scope presently limited to salmon, hapuku, kingfish, mussels, oysters, *Undaria* and sea cucumbers.
- A document collaboratively authored by MPI, NIWA and Cawthron utilising 16 different authors or reviewers.



Literature Review - Chapters

- Introduction
- Pelagic
- Benthic
- Marine mammals
- Wildfish
- Seabirds
- Biosecurity
- Escapees
- Genetic modification
- Additives
- Hydrodynamics
- Cumulative Effects
- Feed-added, filter feeders and lower trophic level species considered within each chapter
- Use of summary tables

Risk assessment workshop

- Feb 2012 Risk assessment workshop
- Expert panel approach (16 participants) using an independent facilitator and internationally recognised methods.
- Input from scientists, regional councils, industry (ENGO community invited).



3. Relative risk - Ranking of potential risks

Potential ecological effects	Feed-added species		Filter-feeder species	
	RIW	Rank	RIW	Rank
Biosecurity threats	0.360	1	0.373	1
Pelagic effects	0.236	2	0.143	2
Marine mammal interactions	0.118	3	0.135	3
Benthic effects	0.090	4	0.088	5
Seabird interactions	0.079	5	0.092	4
Additive effects	0.042	6	0.019	9
Escapee effects	0.029	7	0.088	5
Wild fish interactions	0.026	8	0.021	8
Hydrodynamic alteration of flows	0.019	9	0.041	7

Biosecurity

Aquaculture can be a source or stepping stone

Needs to be considered in context

Can only manage not eliminate biosecurity risk

Zeldis 2008 recommends for fish farming:

- Single age class fish farms
- Farm spacing at least 1km with same management plan, at least 2.5 km if not.
- Other good practice
 - Cleaning barges and nets
 - inspection



The sea squirt
Didemnum on mussel lines

Biosecurity (ongoing)

- Aquaculture on-farm biosecurity management project
 - Proactive and preventative
 - Collaborative – (MPI, Aquac NZ and Fish and Game)
 - Major species first
 - 1. Review farm practices
 - 2. risks (emerging and introduced)
 - 3. Management options (some of which will be generic)
 - Identify gaps



Pelagic effects – literature review

- Pelagic / Feed added species
 - Main effects and their significance (summary table for each)
 - Dissolved nutrients
 - Solid waste
 - Oxygen depletion
 - Impact mitigation and management strategies
 - Mitigation
 - Monitoring and adaptive management
- Knowledge gaps



Pelagic effects mussels– Firth of Thames

Mussels filter water (+ve and –ve) and excrete

200ha consented and 6000 ha pending development (2004)

A 50 ha. farm may extract 1-2% (by volume) of phytoplankton (Broekhuizen et al 2002).

This footprint may be at the size of the farms or stretch over several kms downstream

Fish egg extraction maybe 2-15% cf. no farms, but a very crude estimate

Multiple scenarios

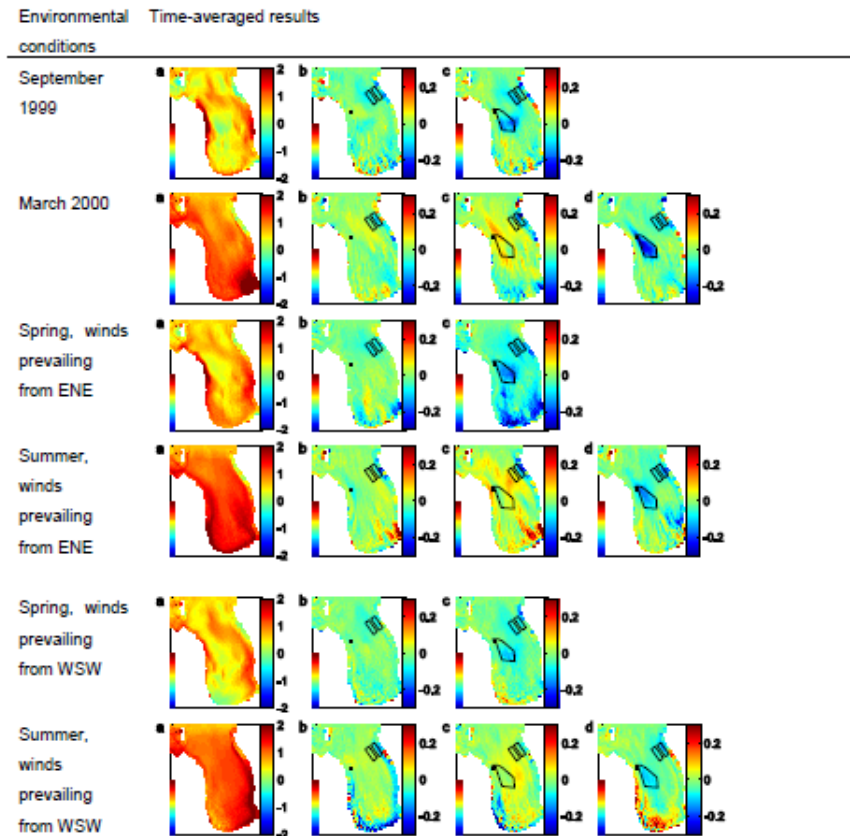


Figure 10:

Long-term (duration of simulation) average simulated concentrations of: (a) Phytoflagellates ($\log_{10}(\text{mg phytoflagellate carbon m}^{-3})$) under scenario NF; and $\log_{10}(\text{phytoflagellate carbon concentration-ratio relative to this default})$ for alternative scenarios: (b) scenario 0; (c) scenario 1 with default mussel excretion, (d) scenario 1 with minimal mussel DIN excretion. For ease of reference: $\log_{10}(100)=2$, $\log_{10}(0.01)=-2$, $\log_{10}(1.585)=0.2$, $\log_{10}(0.631)=-0.2$ (approximately).

Pelagic effects – fish farms – Firth.

Rivers contribute 50-70% of N to the Firth (Zeldis 2008)

1000-8000t fish farming range of scenarios contribute up to 11% of N input to the Firth

This effect is likely to be strongest closest to the farms

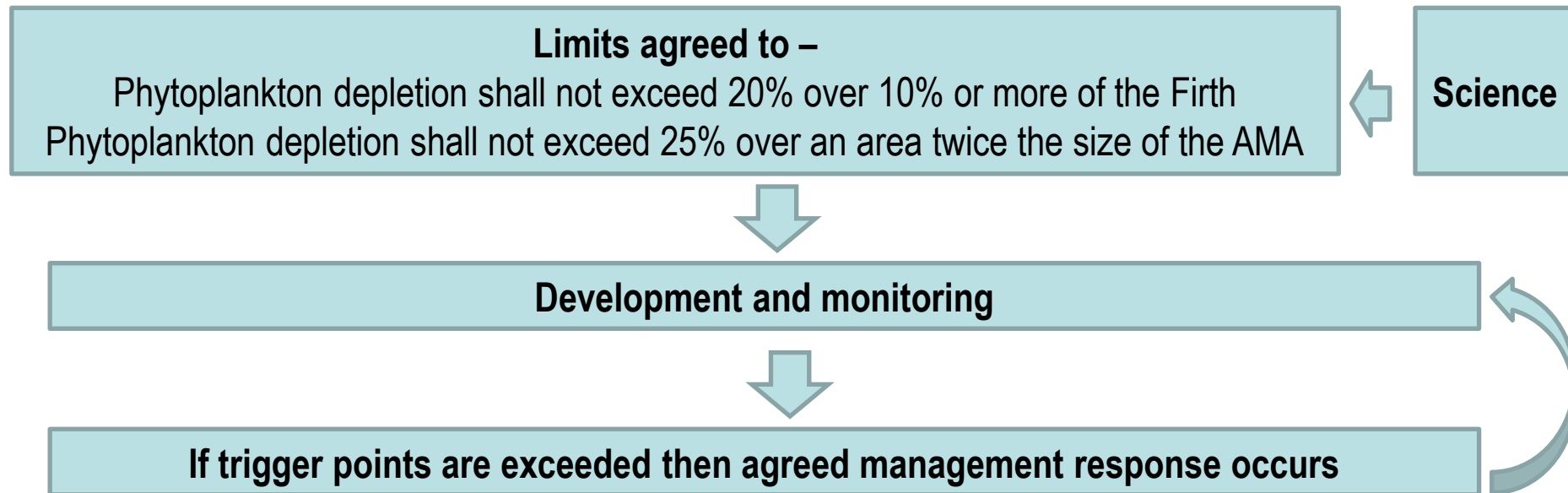
Harvest of 10 t of mussels needed to remove the N from 1 t of finfish farming (but location crucial)

There have been some summer oxygen minima detected in the middle of the Firth (Zeldis).



Adaptive Management example - pelagic

Limits of Acceptable Change (Zeldis et al. 2005) – Wilson Bay



Zeldis, J.R.; Felsing, M.; Wilson, J. (2005). Limits of Acceptable Change – a stakeholder-collaborative framework for managing environmental performance of New Zealand marine farming. Coastal News 30: October 2005.

Marine mammals

Potential interactions

- Competition for space (habitat modification or exclusion);
- potential for entanglement;
- underwater noise disturbance;
- attraction to artificial lighting;
- possible flow-on effects due to alterations in trophic pathways.

**Location of farms all important,
secondary mitigation is best practice.**

At present interactions not significant

Concern over expansion (particularly offshore).



Benthic impacts

Often focused on (particularly finfish aquaculture) as it is relatively easy to model and monitor

Can result in decreased seafloor diversity beneath cages and in the worst examples oxygen minima. The latter is undesirable for the farmers

Locally minimised with good location (deep fast flowing, ubiquitous soft-sediment communities), this does spread the effect, but thins it.

Mussel shell also locally can increase diversity

NZKS/MDC/MPI working on standardising consent monitoring for farms in Marlborough, and setting thresholds and responses.

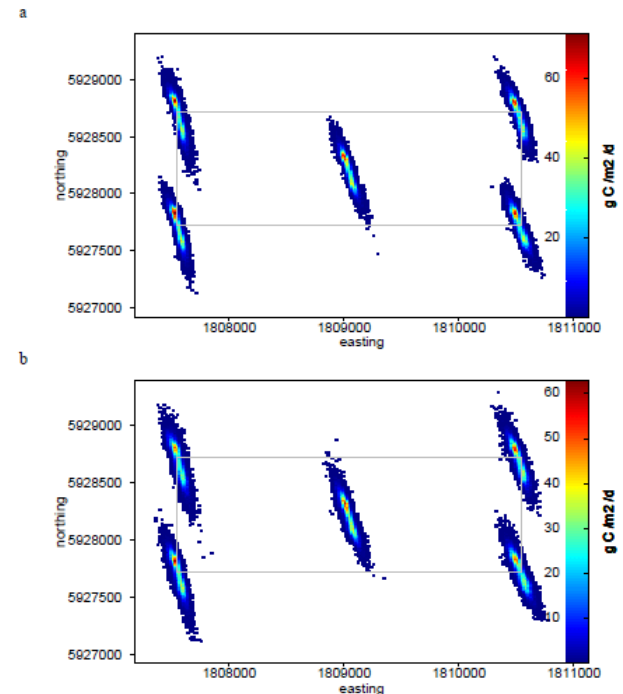


Figure 4.3:

Predicted deposition footprints ($\text{g C m}^{-2} \text{d}^{-1}$) from five cages placed at each of the four corners of the proposed fish-farming zone and at the centroid. Within each of the two individual simulations, a total of approximately 135,000 particles were released in total over 30 days. Each farm held 1000 tonnes annual fish production with EFCR of 1.7. The individual settlement locations were binned onto a grid (approximately 20 m x 10 m resolution) to yield this map of deposition intensity. The grey rectangle indicates the perimeter of the proposed fish-farming zone. (a) for a 30 d simulation using winds generally from the ENE. (b) for winds generally from the WSW. The hydrodynamics used to drive the particle-tracking model stem from a model with 750 m horizontal resolution (2 m vertical). They ignore cage-effects upon flow and turbulence.

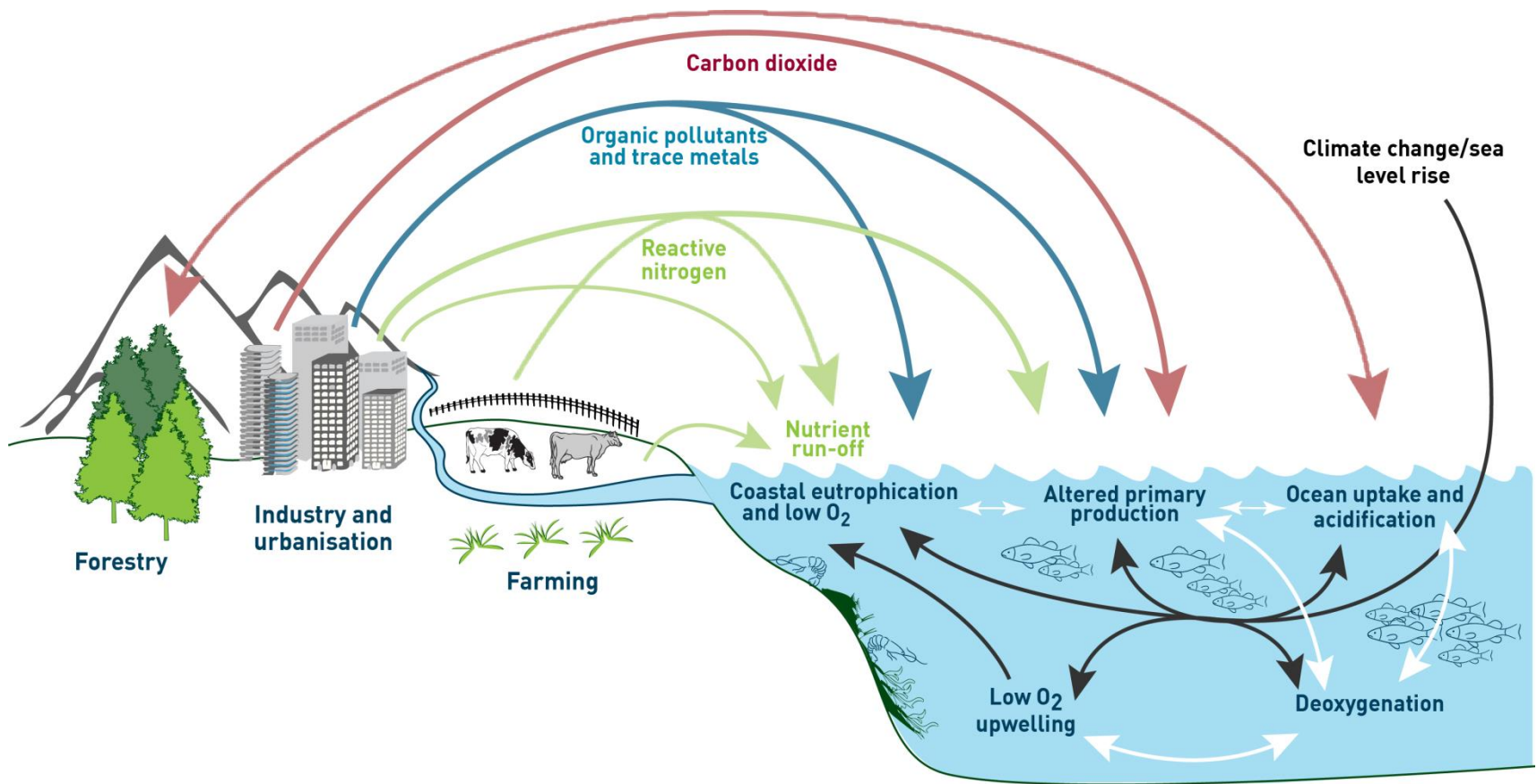
1. Repeated themes

- **Site selection** is crucial to minimise ecological effects
- **Best management practices** to deal with factors like escapees, biosecurity risks and minimising entanglements
- Uncertainty in some cases best managed by setting precautionary limits and **adaptively managing**.

Cumulative Effects – literature review

- "Ecological effects in the marine environment that result from the incremental accumulation and interacting effects of aquaculture development when added to other anthropogenic stressors/inputs and changes in ocean conditions (e.g. climate change)"
- Uncertainty
- Profile nutrient effects
- Managing – spatial planning, modelling of carrying capacity , IMTA, adaptive management, targeted monitoring and research
- Monitoring –indicators, mix of consent and State of the Environment monitoring
- Knowledge gaps

1. Aquaculture risks don't occur in isolation



The effect of services on aquaculture

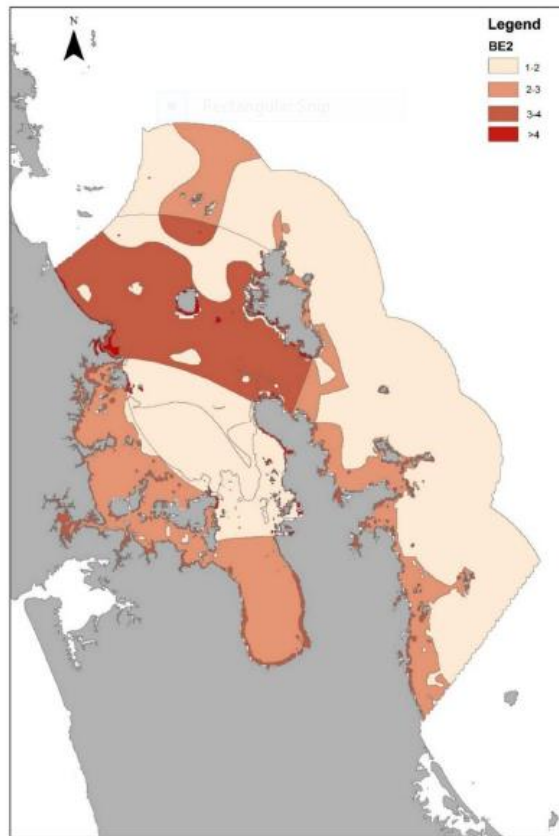


Figure 6-1: The ranked effects of the productivity service on shellfish (filter-feeding based) aquaculture. The map is generated from the ecosystem productivity service layer interacting with Tables 4-2 and 5-1. Positive values are benefits, with larger numbers indicating greater benefits.

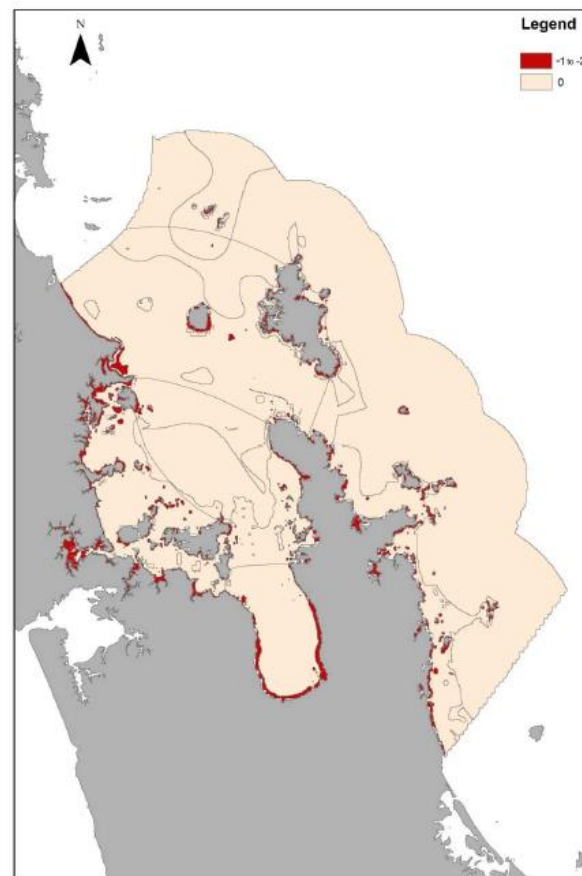


Figure 6-2: The rank effects of the productivity service on finfish aquaculture. The map is generated from the ecosystem productivity service layer interacting with Tables 4-2 and 5-1. Zero scores do not imply an absence of effects, simply that effects are intermediate between positive and negative scores. Negative values indicate adverse impacts.

The effect of aquaculture on services

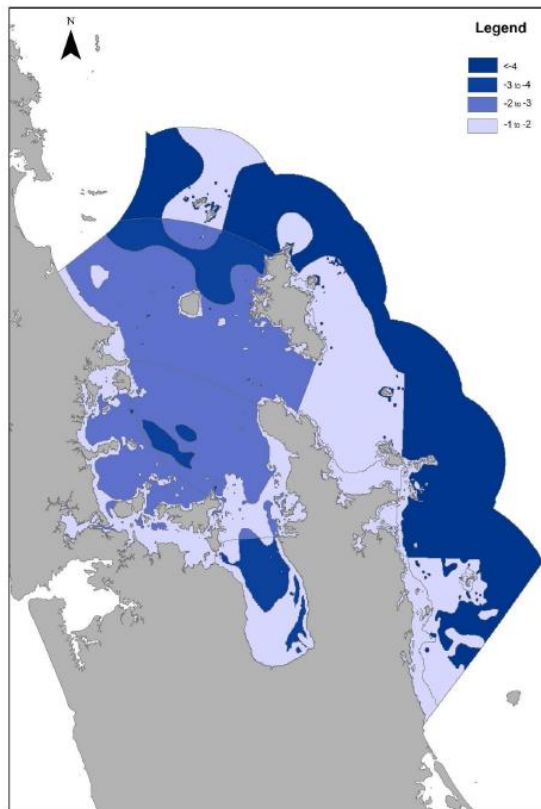


Figure 7-3: The rank effects of finfish aquaculture on the nutrient recycling service. The map is generated from the nutrient recycling service layer interacting with Tables 4-3 and 5-1. Negative values indicate adverse impacts, with lower negative numbers indicating worse effects.

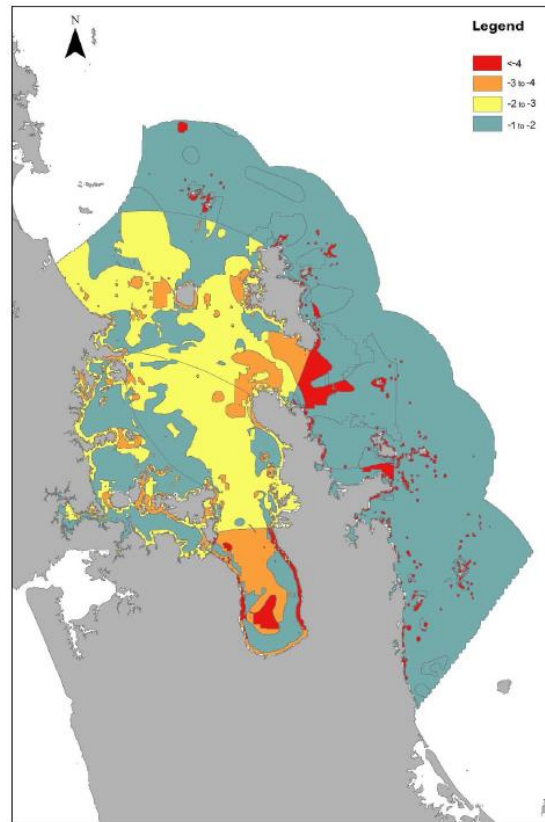


Figure 7-2: The rank effect of finfish aquaculture on biogenic habitat. The map is generated from the biogenic habitat service layer interacting with Tables 4-1 and 5-1. Negative values indicate adverse impacts, with lower negative numbers indicating worse effects.

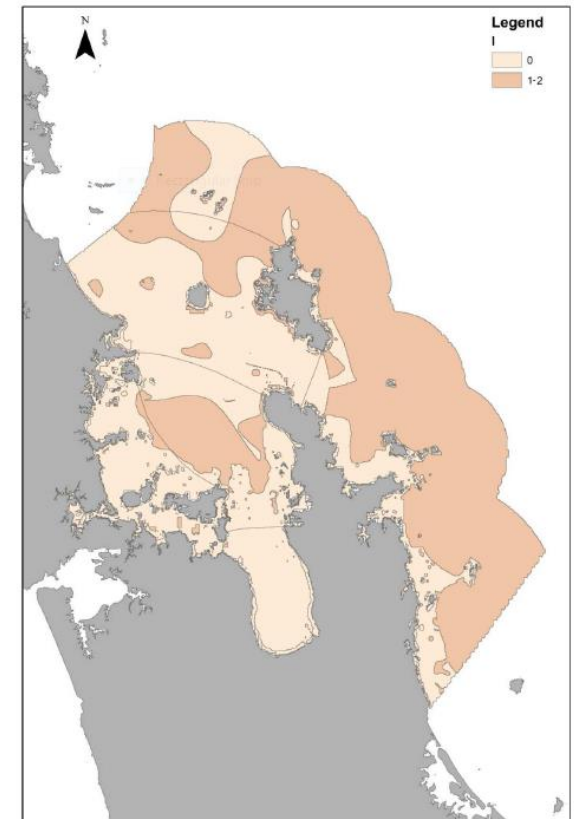
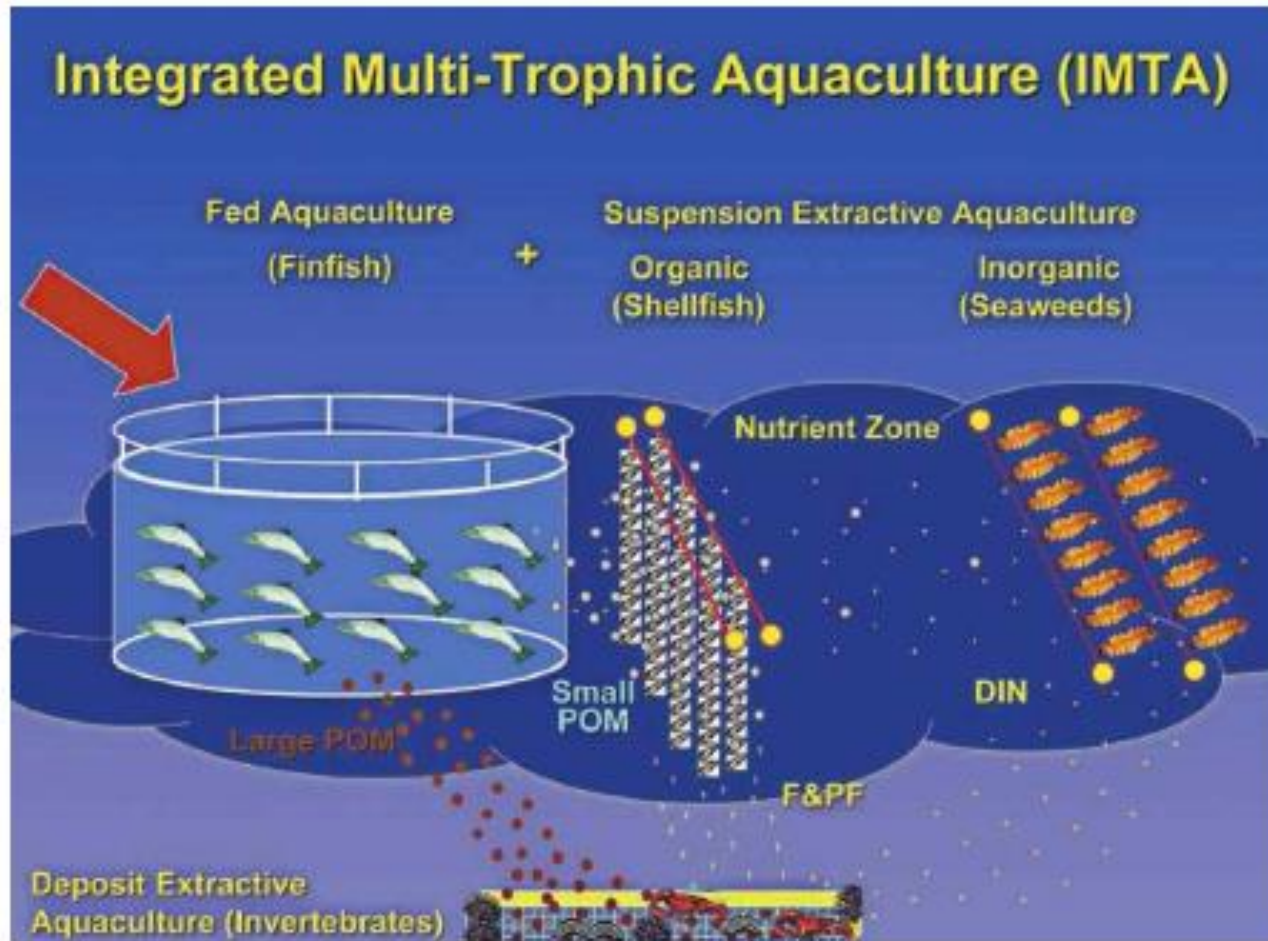


Figure 7-1: The rank effects of finfish aquaculture on the ecosystem productivity service. The map is generated from the ecosystem productivity service layer interacting with Tables 4-2 and 5-1. Zero scores do not imply an absence of effects, simply that the effects are intermediate between positive and negative scores. Positive values are benefits, with larger numbers indicating greater benefits.

Integrated Multi Trophic Aquaculture (IMTA)



Ongoing Research

ENV2012-01 Nitrogen levels and adverse marine ecological effects
Aquatic Environment and Biodiversity Annual Review

<http://www.mpi.govt.nz/news-resources/publications>

Aquaculture Planning Fund

<http://www.fish.govt.nz/en-nz/Commercial/Aquaculture/Supporting+Aquaculture/>

12/03 Marine Management Model (Waikato Regional Council)

12/04 Guidance for aquaculture monitoring in the Waikato region

Baseline monitoring, modelling and biosecurity probable priorities

Modelling comparisons (NIWA) Comparison of ROMS and Delft.

Nationally consistent and transparent reporting.

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Questions