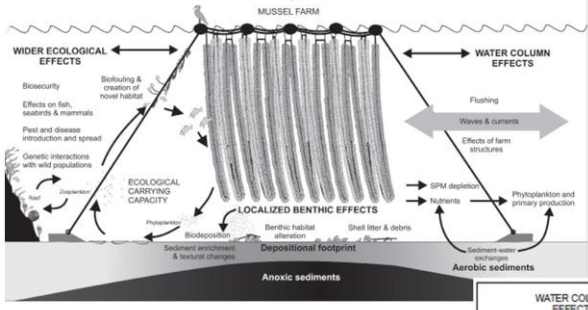
Tradeoff for any resource use (+ves and –ves) , I will focus mainly there are –ves but potentially some +ves as well.

Overview - ecological effects of aquaculture

- Uncertainty of effects
- Consensus scientific approach
- Low intensity – low risks
- Non-overlapping species
- Thresholds unknown – system dependant
- Precautionary development – adaptive management
- Not repeat mistakes from overseas

Overview of effects

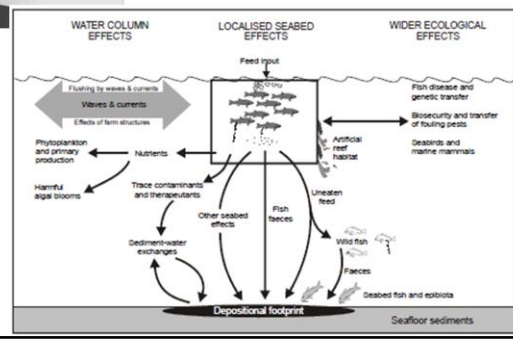


(Keeley et al. 2009)

Consented
- 209 ha. Intertidal oyster
- 1480 ha. Mussel

Unused fish farming
- 90 ha. In Wilsons Bay
- 300 ha. CMFZ.

(Forrest et al. 2007)



A broad range of potential impacts – but which are important...

Ranking of threats MacDiarmid et al. 2012 – Aquaculture

- NZ EEZ average across habitats
  - Aquaculture: Benthic accumulation of shells, food, faeces 0.7 = 19th =
  - Aquaculture: Decrease in primary production 0.4 = 36th =
  - Aquaculture: Increase in habitat complexity 0.4 = 36th =

- **Most important in the shallow and sheltered (benthic accumulation):**
  - Sheltered Coast: Mud 2-9 m 2.6 4th
  - Harbour and Estuaries: Seagrass 2.3 3rd
  - Harbour and Estuaries: Subtidal mud 2.1 8th equal
  - Sheltered Coast: Sand 10-29 m 2.0 6th
  - Harbour and Estuaries: Intertidal mud 2.0 11th equal
- >2 (major) – 1 trophic level affected, 1-10km^2 affected, recovery time 1-10 years, medium certainty.

Canvassed scientific experts – 65 threats and 62 habitats.

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

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, to
  - Regional Councils
  - Applicants
  - Public
  - Science Providers

Aquaculture Risk Screening Tool and will provide guidance to decision-makers on the types of things they should be looking for when reviewing planning and resource consent documents.

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.

These species chosen as potential to be farmed in the next 5 to 10 years

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

Some are really well known some not,

What you don't get with this approach is priority between these areas

3. Relative risk - Ranking of potential risks

	Feed-added species		Filter-feeder species	
Potential ecological effects	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

- 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).

Trial which gave a logical result, not give too much emphasis on small differences. (note the error)!

Biosecurity most important, (potentially large scale irreversible effects)
Consistency in rank order between feed-added and filter-feeders for risks 1-3

Pelagic risks higher relative importance for feed-added species.

Marine mammals due to public concern, then benthic

Cummulative impacts not covered here but recognised.

Biosecurity

Aquaculture can be a source or stepping stone

Needs to be considered in context

Can only manage not eliminate biosecurity risk

For fish farming disease prevention (Zeldiss 2008):

- •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

Dredge oysters, Trout and paua, (hapuku and kingfish, - risk ID and mgmt options) . Potentially scope expanded later.

Pelagic effects mussels– Firth of Thames

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

Crude estimates
A 56 ha. farm in northern Firth of Thames may extract 20% of the phytoplankton that pass through it or 1-2% (by volume) of phytoplankton in that area (Broekhuizen et al 2002).

The footprint = size of the farms or over several kms downstream

Fish egg extraction maybe 2-6% (@2004) cf. no farms, and 2.5-15% cf. no farms for 2004+ Western AMA.

Multiple scenarios

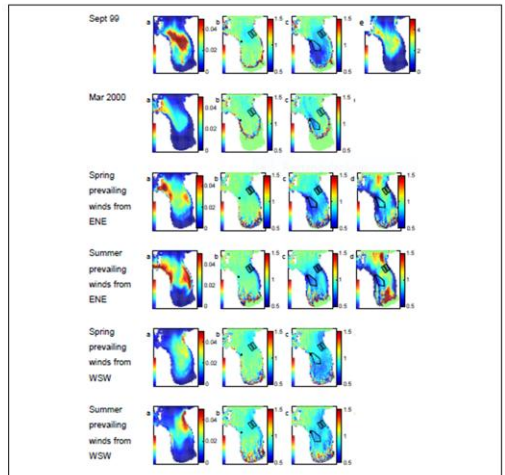


Figure 2: Simulated concentrations (individuals m^{-3}) of 7-8 d old larval snapper under scenario NF (a), relative differences between the concentrations for the scenario NF/scenario 0 (b), scenario 1/NF (c). (d) relative deviation between results for scenario1, neutrally buoyant eggs/larvae and scenario NF, weakly buoyant eggs/larvae; ENE winds only). The top-most row also shows the time-series averaged abundance of snapper eggs<1 d old under Sept 1999 conditions (Figure 2e).

Size of footprint dependant upon phytoplankton growth rate

Pelagic effects – fish farms – Firth.

Rivers contribute 50-70% of N to the Firth (Zeldis 2008) There have been some summer oxygen minima detected in the middle of the Firth (Zeldis).

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

This effect is likely to be strongest closest to the farms

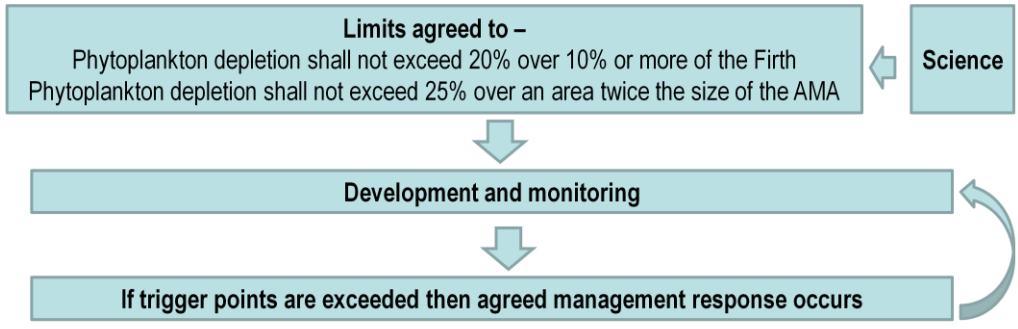
Modelling suggests Harvest of 10 t of mussels needed to remove the N from 1 t of finfish farming (but location crucial).

Work underway on better ways to monitor

Adaptive Management example - pelagic

Set precautionary limits then.....

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.

Trigger points are reached collaboratively, can be improved upon as science progresses understanding, and management is certain and transparent. But feedback from Waikato suggests implementation of this framework has not been straightforward.

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).

Best practice = minimal waste and lights, tight ropes to prevent entanglement

Benthic impacts

Relatively easy to model and monitor

Can result in decreased seafloor diversity to oxygen minima. The latter is undesirable for the farmers

Locally minimised with good location -spread the effect, but thins it.

Mussel shell also can locally increase diversity

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

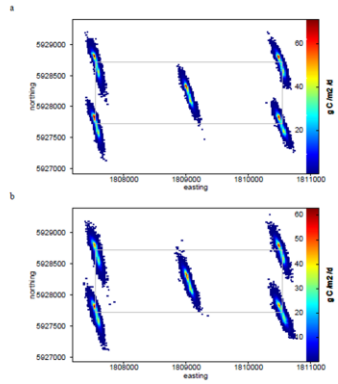


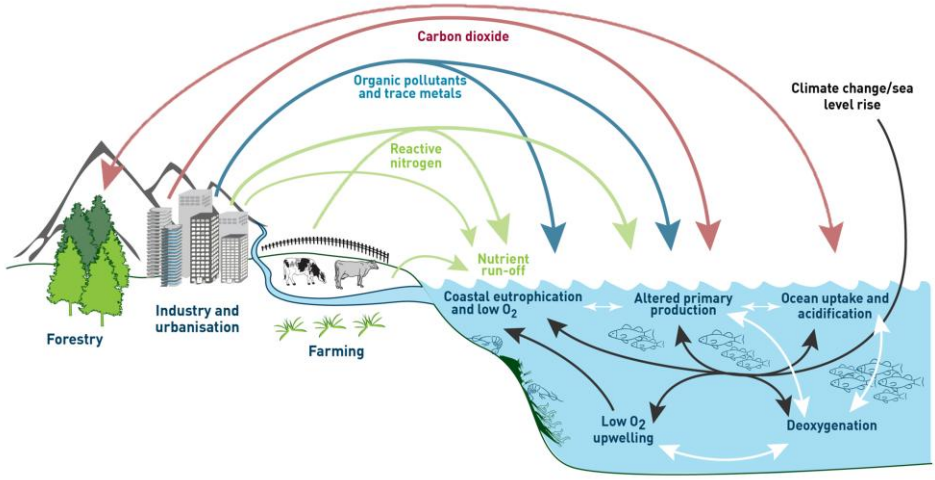
Figure 4.3: Predicted deposition footprints (g C m^{-2} d^{-1}) from five cages placed at each of the four corners of the proposed fish-farming zone and at the centroid. Within each of the two individual simulations, a total of approximately 135,000 particles were released in total over 30 days. Each 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.

Good location = deep water, fast flowing and ubiquotous soft sediment communities

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**.

1. Aquaculture risks don't occur in isolation



Examples you could use (from Overview) include additive effects (multiple farms), ecosystem flow on changes (eg food web), primary production changes, interactions between effects (eg sediment metals and org enrichment)

The effect of aquaculture on services

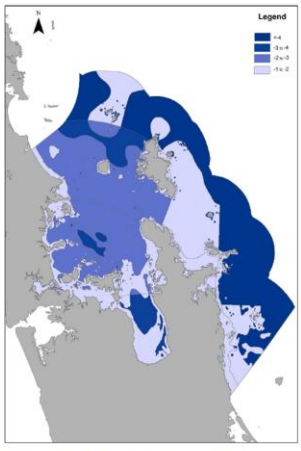


Figure 7-3: The rank effects of finfish aquaculture on the nutrient recycling service. The map is generated from the nutrient recycling service layer interacting with Tables 4-3 and 5-1. Negative values indicate adverse impacts, with lower negative numbers indicating worse effects.

Nutrient recycling (darker = worse)

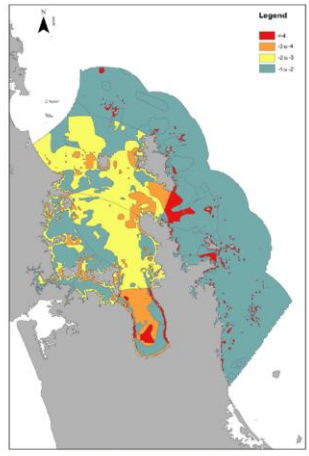


Figure 7-2: The rank effect of finfish aquaculture on biogenic habitat. The map is generated from the biogenic habitat service layer interacting with Tables 4-1 and 5-1. Negative values indicate adverse impacts, with lower negative numbers indicating worse effects.

Biogenic habitat (red = worse)

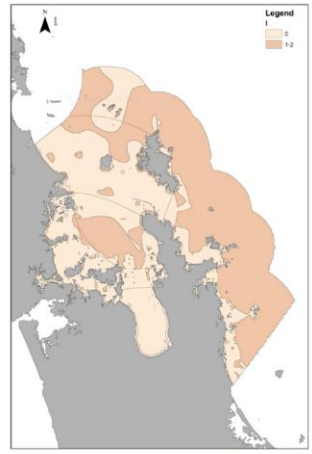


Figure 7-1: The rank effects of finfish aquaculture on the ecosystem productivity service. The map is generated from the ecosystem productivity service layer interacting with Tables 4-2 and 5-1. Zero scores do not imply an absence of effects, simply that the effects are intermediate between positive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

Ecosystem productivity (darker = better)

Can minimise impact or maximise suitability – but what do you care about?

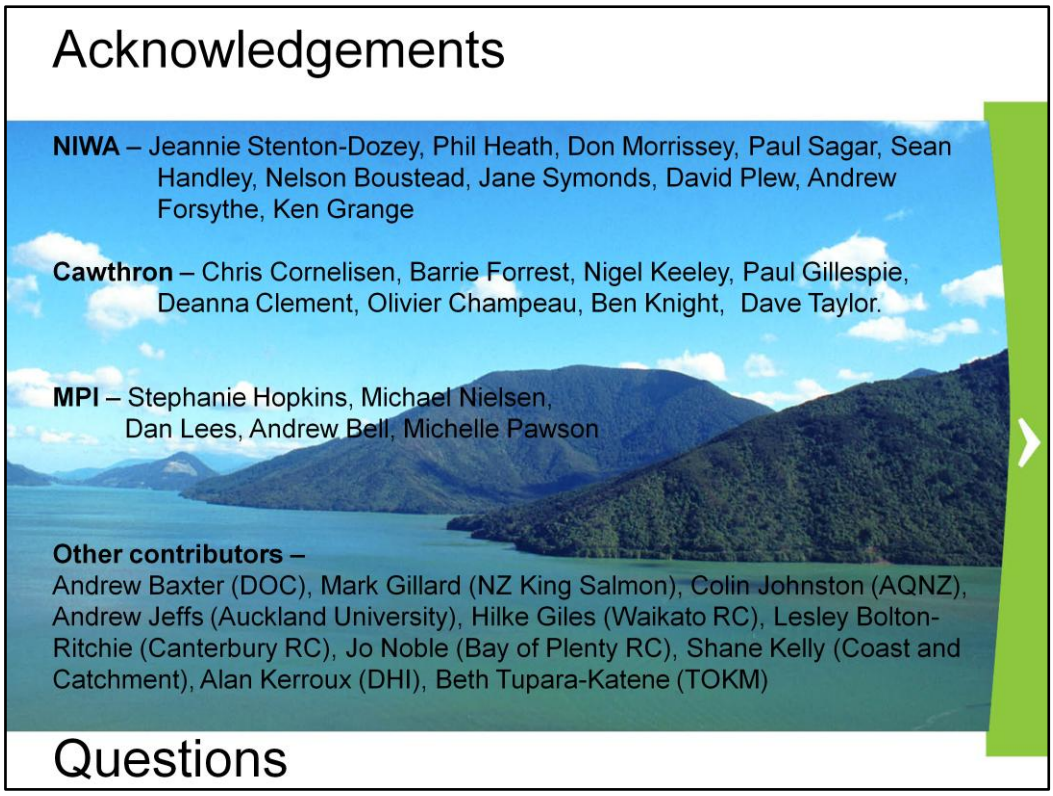
Take Home Messages

•At the moment aquaculture impacts are relatively minor, but most important for shallow embayed habitats.

•Aquaculture risks should not be considered in isolation.

•Biosecurity, water quality effects and effects on marine mammals are likely to be highest priority issues nationally.

•Best mitigation methods are good site selection, best management practices, precautionary approach and adaptively managing.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Questions

Cast of 33.