National SCIENCE Challenges

SUSTAINABLE SEAS

Ko ngā moana whakauka

System dynamic mapping and managing multi-species complexes

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Summary

This is a summary of a report by the Sustainable Seas National Science Challenge project *Policy and legislation for EBM,* (Project code 4.2)

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For more information on this project, visit: sustainableseaschallenge.co.nz/our-research/policy-and-legislation-for-ebm

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About the Sustainable Seas National Science Challenge

Our vision is for Aotearoa New Zealand to have healthy marine ecosystems that provide value for all New Zealanders. We have 75 research projects that bring together around 250 scientists, social scientists, economists, and experts in mātauranga Māori and policy from across Aotearoa New Zealand. We are one of 11 National Science Challenges, funded by the Ministry of Business, Innovation & Employment.

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System dynamic mapping and managing multi-species complexes

Key variables and linkages

The system was defined as Tasman and Golden Bays SNA7 by FNZ and Sustainable Seas.[1] The major focus of the systems mapping was to determine whether participants deemed it a useful exercise for FNZ management purposes, including whether it highlighted problems with specific types of actions.

A companion paper discusses the process and learnings. This paper reports on the components and connections that were developed, by the participants, during that process.

The participants selected 5 species commonly caught with snapper (Rig, Flatfish, Tarakihi, John Dory and Red Gurnard) to be considered as part of a multi-species management complex.

They then identified system components related to 5 categories and created causal links between these, namely:

1. Fish biology
2. Habitat functionality requirements
3. Activities and stressors affecting either of these
4. Fishers' activities and economic drivers
5. FNZ management

In particular, participants focussed on whether loops occurred and whether these loops would result in run-away behaviour (re-enforcing continual increases or decreases over time) or whether they stabilised the system (balancing components increases and decreases so that changes over time were minimal).

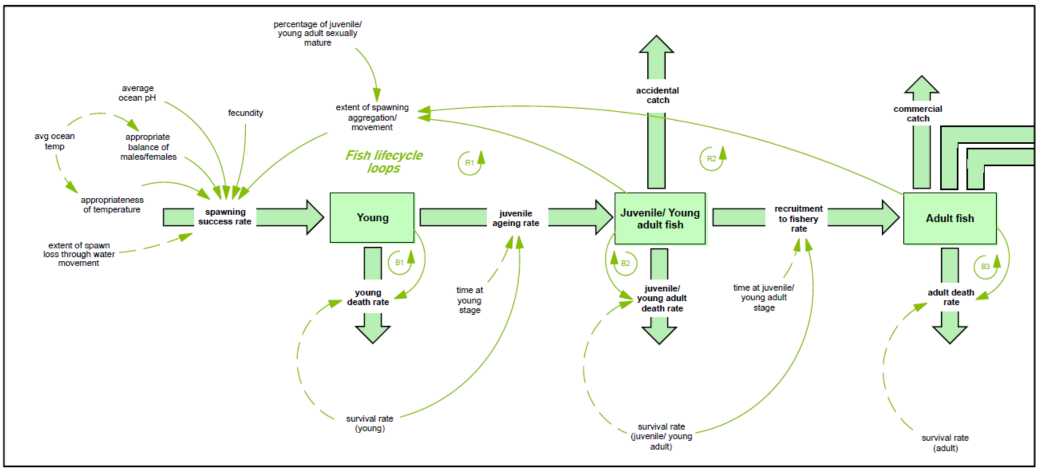
While the participants spent part of the four workshops discussing all 5 of the categories, most of the attention went to the Fish biology as it seemed likely that this would vary most between the 6 species. For **Fish biology** they identified

- Four fish life stages that needed to be included if fish habitats were to be preserved from human activities.
    1. Spawning/reproduction, including success
    2. Young (eggs and larvae), including ageing and mortality rates
    3. Juveniles and young adults, including ageing and mortality rates

[1] See Appendix 1 for list of participants

4. Adult stock

Figure 28. The fish lifecycle loops of influence – reproduction (reinforcing) and mortality (balancing)



- Three ways that fish species/groups of species could interact and affect the ability of fishers to earn and FNZ to manage multi-species complexes were identified as - .
  1. Competition for space
  2. Competition for food
  3. Predator-prey dynamics

Much of the data needed for this understanding was found to be lacking. For example, no information was found on how John Dory spawned, and, for many of the fish species, the time that was spent as young, juveniles and young adults was unavailable. While information on competition for space, dietary preferences and predator-prey interactions between fish groups was available for adults (stock size), most of this information was lacking for the other life stages.

For **Habitat** requirements they identified many different environmental conditions that created a functional habitat for the different life stages. These were;

- Temperature
- pH
- Depth
- Sediment type
- Productivity (primary and secondary)
- Current velocity
- 3D biogenic habitat structure on the seafloor

Note that climate change affects the first two. Information on habitat requirements was generally available to allow life stages/species to be allocated to gross sediment characteristics (e.g., rock, sand, water), depth (<30m, 30-250m, >250m) and whether 3D biogenic habitat structure was preferred or not. However, information on temperature, current velocity, and productivity was lacking.

Collation of what data was available on the proposed life stages suggested that these may need further splitting with young adults preferring different habitats to both older/larger adults and juveniles, as well as having different interactions with other species.

For the other three categories being considered the following components were identified[2].

For **Activities and stressors** affecting either Fish Biology or Habitat functionality:

- Activity on land (excess sediment, nutrients and contaminants). This also includes factors that create or reduce the production of these (such as wetlands, erosion controls), Financial and non-financial benefit from landuse, effort involved in landuse, urban footprints, urban growth and population.
- Invasive species
- Climate change
- Ocean bottom contact, including regulatory and non-regulatory efforts for mitigation
- Societal expectations

Figure 42. Activity on land and societal expectations

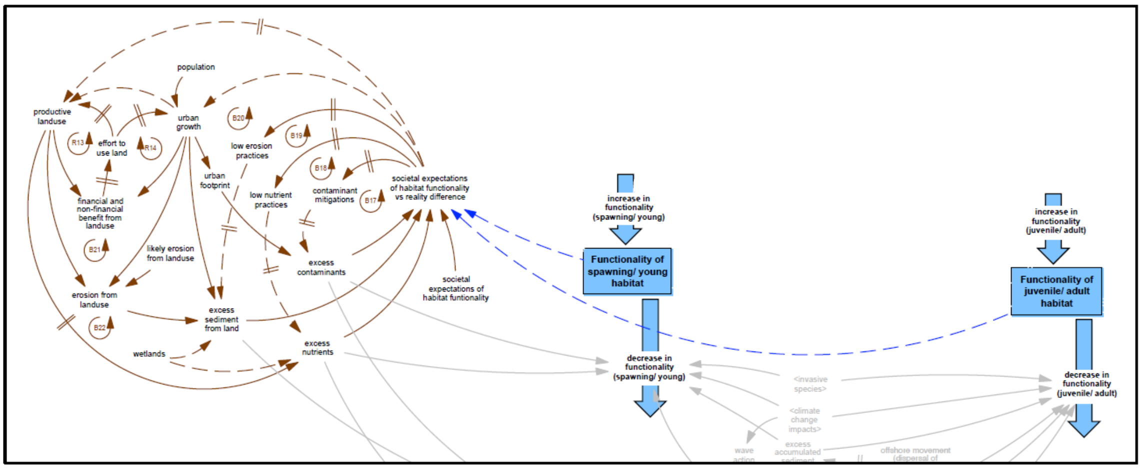


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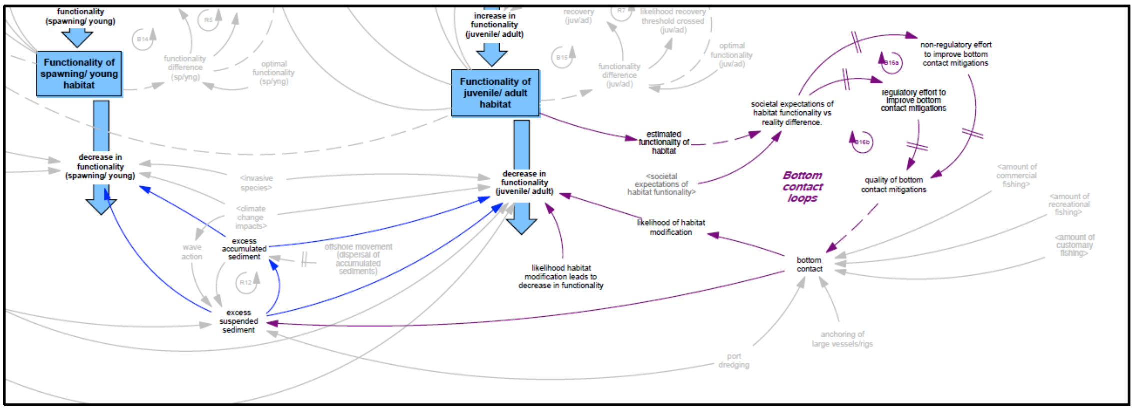
Figure 44. The loops driving mitigations of bottom contact



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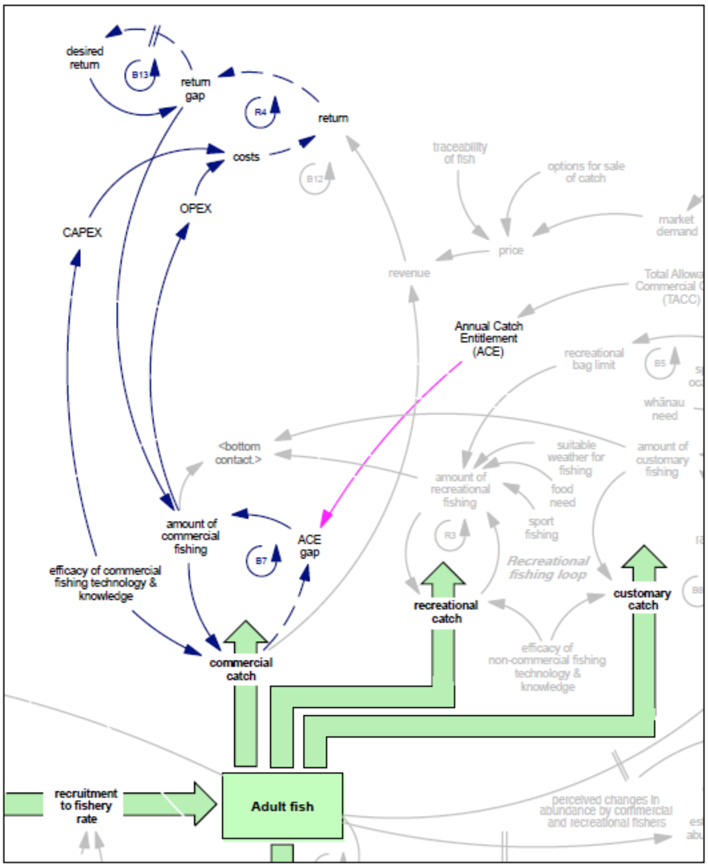
[2] Here we briefly list them and include excerpts of the system diagram that relate to them, along with the figure number in the full report.

For **fishers' activities and economic drivers**:

- Fish abundance
- Total Allowable Catch and, particularly, Total Allowable Commercial Catch
- Commercial Revenue/market influences, including traceability, market demand and size
- ACE prices
- By-catch

Other costs such as fuel and bait have not been included here - [see link to ABM paper]

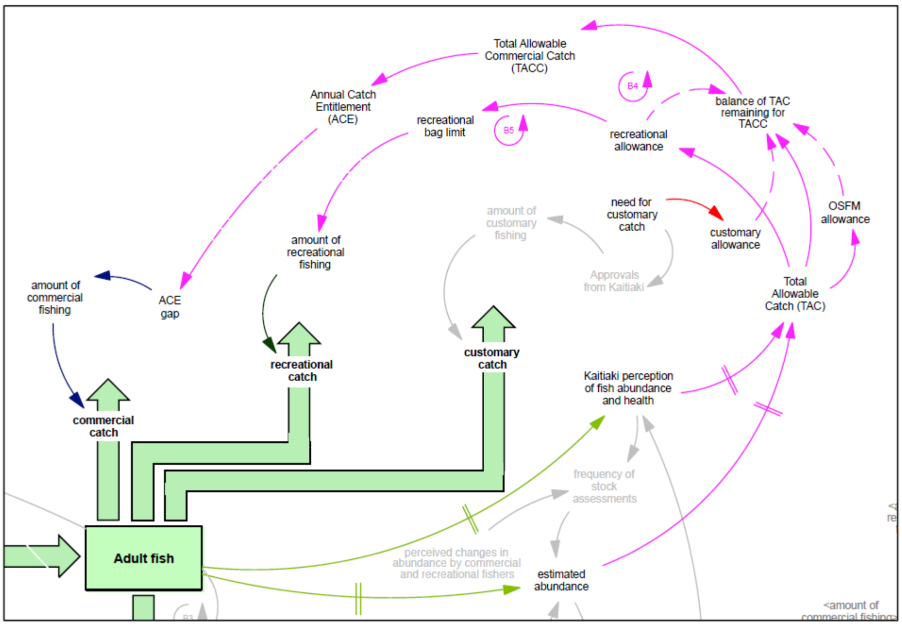
Figure 58. The drivers of commercial catch – costs (opex and capex)



And, for **FNZ management**:

- The Fisheries Act and therefore the QMS including; recreational bag and size limits, customary take, commercial fishers quota, and other regulatory tools (*e.g.* methods, area/seasonal restrictions.

Figure 47. The main QMS balancing feedback loops



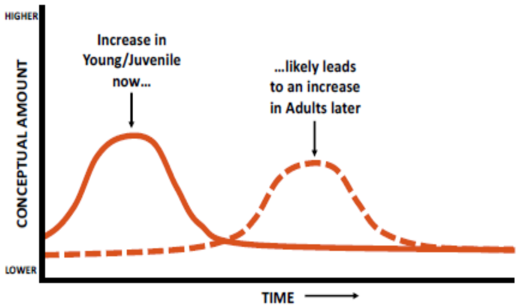
System diagram insights

An overview of the diagram that was developed in this case study, by the case study participants, is shown at the end of this paper.

A range of important dynamic insights into causes of trends over time are highlighted by the system diagram. These are all described individually, yet they are likely to interact given that they are all part of a complex set of inter-connected influences.

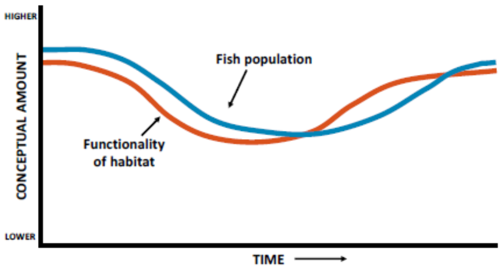
Important individual dynamics created by the system diagram connections are given below, with some simple examples of changes over time:

The abundance of the fish stock is dependent on abundances in the earlier life-stages of the species.

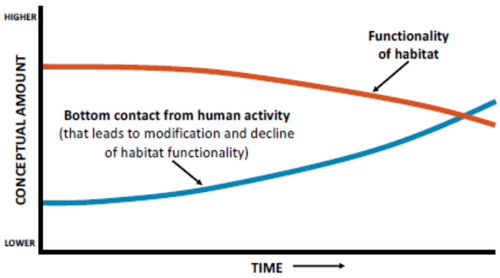


Dynamics described are not quantified and graphs are conceptual/indicative only

Habitat functionality supports species viability at each stage of fish life.

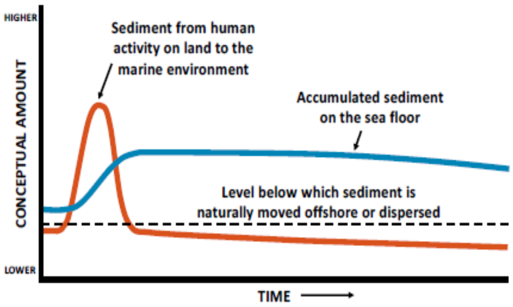


Bottom contact from human activity directly influences habitat functionality.



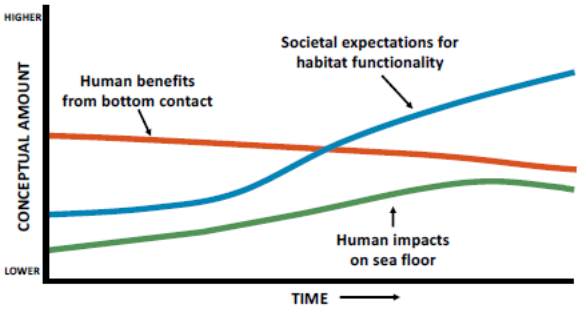
Low levels of habitat functionality inhibit its natural recovery.

Activities on land can have a significant impact on the functionality of habitat in the ocean. For example, the persistence of accumulated sediment is likely to be long lasting.

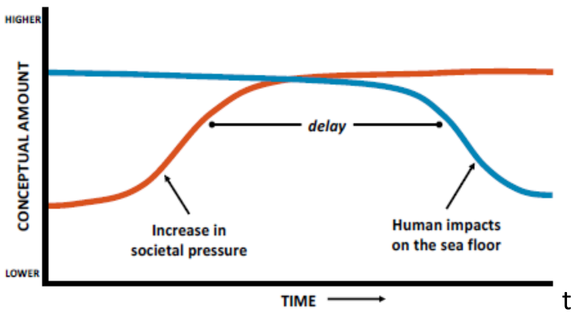


The lower the habitat functionality, the more likely that a recovery threshold for that habitat may be crossed.

Human impacts on the ocean are driven by reinforcing loops linked to human benefit and constrained by balancing loops of societal expectations (i.e. what society in general is willing to accept).

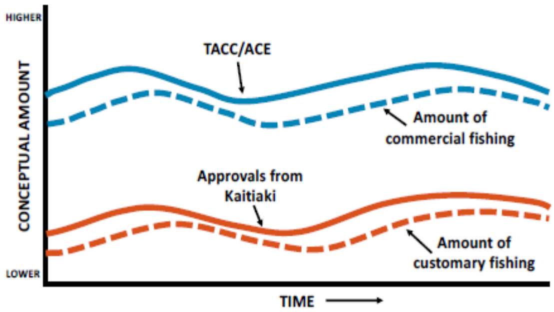


Delays involved with balancing loops between human impacts and societal pressure are likely to be significant.



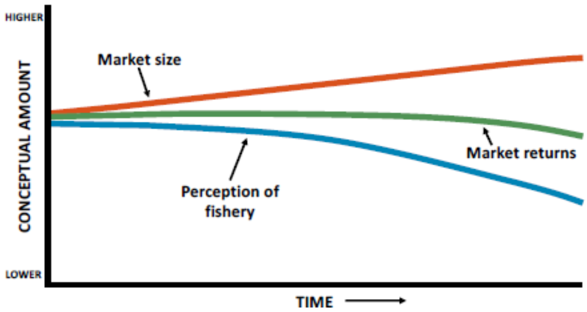
The QMS operates as a balancing loop, constraining and enabling catch.

Within the QMS, both commercial and customary catch operate within balancing loops that self-constrain the corresponding amount of fishing. Commercial is constrained by ACE, customary is constrained by approvals from Kaitiaki.

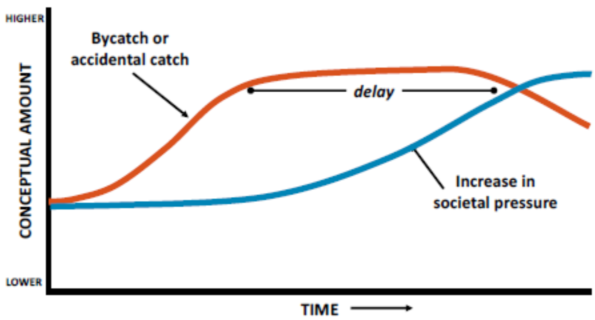


Recreational catch operates within a reinforcing loop that reinforces the amount of fishing based on catch. The amount of fishing is only partly influenced by recreational bag limits.

Market returns are influenced by both market size and their perception of the fishery.



Accidental catch (of commercial species) and Bycatch (of other and protected species) are constrained by societal expectations (i.e. what society in general is willing to accept) with long time delays.



MVA insights

The more similar the species are, in their biology and habitat requirements, the more likely that management as a unit will be successful. SS researchers trialled coding what information on fish biology and habitat requirements there was into tables. The tables were then analysed for similarities across the 6 fish groups using a multivariate classification method.

MVA can be used to inform what species are part of a multi-species complex, or what similarities there are within species already grouped in a multi-species complex. Here it was used for the latter, with a focus on species biology and habitat requirements. It could also be used to analyse commonalities in the sensitivity of species within a multi-species complex to non-fishing activities and stressors, as well as to changes in fishing practices. The MVA also provided additional insights around the quantity of data available for robust holistic management of the multi-species complex.

From the bio-physical data available, it was found that all species in the complex had commonality in their exposure and risk to competition for food at each life stage. However, while the broad range of food types was generally known, whether there were strong preferences within that range that would affect growth rates and competition was not. There was also a high level of overlap between species in terms of their predation risk; and the habitats in which they are found, but the timing of when species occupied/used these habitats was generally unknown thus spatial and temporal overlaps may be less than expected.

This work needs to be extended to more rigorously define the degree of similarity required for successful management and the role that more detailed information would play.

Conclusion

This study highlights that the work FNZ is presently suggesting around understanding Habitats of Significance for Fisheries Management (HoSFM) is critical for moving fisheries management forward. In particular, use of the System Dynamic Mapping with more understanding of Habitats of Significance for Fisheries Management will allow effects of other activities on fish habitat functionality, fish stocks and fishers activities and economic opportunities to be better understood and predicted.

Appendix 1 – List of project participants:

Jodi Milne	Fisheries New Zealand
John Taunton-Clark	Fisheries New Zealand
Ali Schwabb	Fisheries New Zealand
Karen Middlemiss	Department of Conservation
Carol Scott	Southern Inshore Finfish Management Company
Doug Loder	Talleys, NZ Federation of Commercial Fishers
Geoff Rowling	Regional and broad fisheries knowledge
Mike Connolly	Regional and broad fisheries knowledge
Fred Te Miha	Regional and Customary knowledge
Jo Martin	Nelson City Council
Rosalind Squire	Tasman District Council
Debs Martin[3]	Forest and Bird
Eric Jorgensen	Sustainable Seas and broad fisheries knowledge

[3] Commitments meant Debs was only able to participate up to, and including, the 3rd workshop (of 5 in total)