The role of simulation modelling in Fisheries Research: future needs and requirements.

A personal view

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Simulation modelling is important for fisheries stock assessment in the following applications:

- Stock assessment model functionality testing and validation
- Data generation for testing and designing fishery monitoring programmes e.g. trawl surveys, mark-recapture programmes, CPUE analytical approaches.
- Management Strategy Evaluation:
  - Classical operating model -estimator model management procedural analyses
  - YPR-type projection modelling to evaluate equilibrium yield implications of alternative harvest strategies, e.g. yield implications of changing gear selectivity in the face of alternative incidental mortality assumptions
- Stock projections are essentially simulations

Simulation model future development questions

Most fisheries stock assessment models can be configured to function as data simulators

Most of the current main SA software packages have simulation functionality built in.

The obvious conclusion is: next gen SA packages will also need to include simulation functionality.

Simulation model future development questions

In recognition of their role as simulators in this talk I would like to address the following questions:

1. What additional simulation capabilities and design features are required in next gen SA packages?
2. Given next gen SA packages are likely to have expanded simulation capability will there still be a need for independent simulation models and frameworks?

What follows are some insights gained from the development of two simulation modelling tools:

1. An Agent Based Model simulator: ABM (McKenzie, Bentley and Bian)
2. NIWA's spatially partitioned model simulation platform: SPM (Dunn , Rasmussen, Mormede)

But before discussing these I would like to:

Firstly present my views as to the level of complexity to include in a stock assessment or simulation

Secondly briefly discuss the purpose, components and requirements of what I term as a "classic fisheries MSE".

How much complexity should be included in estimation and simulation models?

In my opinion this should be governed by two things:

1. **Management advice requirements**

- Level of risk and precision managers require from the management modelling process
- The nature of management advice required (i.e. do they require tactical or strategic management advice?)

Aside (hopefully useful) definition:

Strategic management is the process of defining management objectives and evaluating strategies to achieve them

Tactical management is finding the best approach for achieving these objectives for a given management strategy.

Fisheries stock assessment estimation models are, by-in-large, **tactical**.
Fisheries MSE modelling frameworks are by definition **strategic**

How much complexity should be included in estimation and simulation models?

2. **The power in the observational data to: support the level of model complexity required for management**.

Although it is a common requirement to introduce higher complexity into simulation model constructs, e.g. to investigate the assessment's robustness to alternative structural hypothesis, management utility is likely to be sharply diminished when operating model constructs are not strongly supported by (able to be conditioned by) the observational data.

What role next gen SA package models likely to play in MSE simulation modelling frameworks?

Simulation models are integral component of a “classical MSE” and a consideration of the purpose and requirements of this process might provide useful insight into the role the next gen models will commonly have in MSE i.e. as estimators or operating models or both.

Where do the Next Gen of fisheries models fit in MSE simulation modelling framework

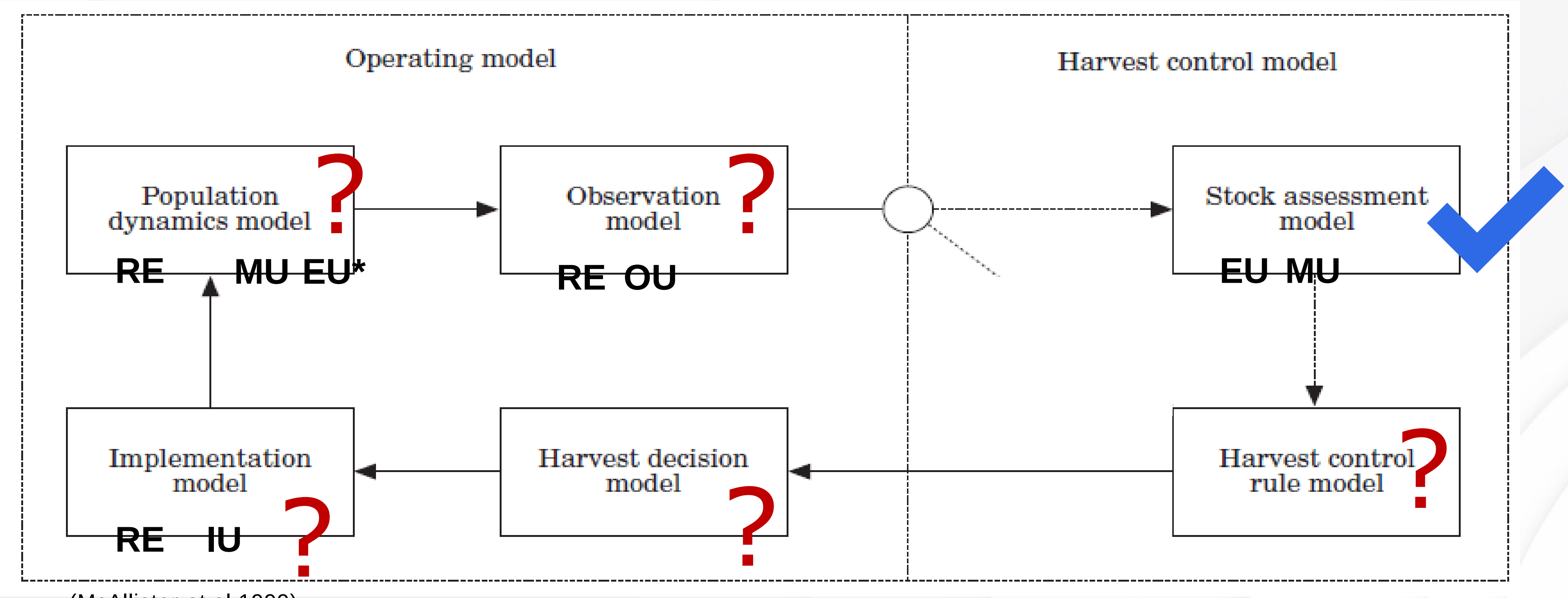
What are some of the main assessment uncertainties we need to account for in MSE?

Francis and Shotton (1997) defined 6 types of uncertainty that need to be formally considered in what they termed fisheries risk assessment

In my opinion at least the following 5 should be explicitly or implicitly functionally present into all MSE simulation modelling frameworks.

1. Random effects (termed “Process uncertainty” by F & S) **RE**
2. Observational uncertainty **OU**: data sampling variation, sampling error and biases
3. Model uncertainty **MU**: degree of structural mismatch between the model and the “real world”
4. Estimation uncertainty **EU**: estimator computational performance limitations
5. Implementation uncertainty **IU**: uncertainty as to the whether the management policies will be successfully implemented

Where do the Next Gen of fisheries models fit in MSE simulation modelling framework



(McAllister et al 1999)

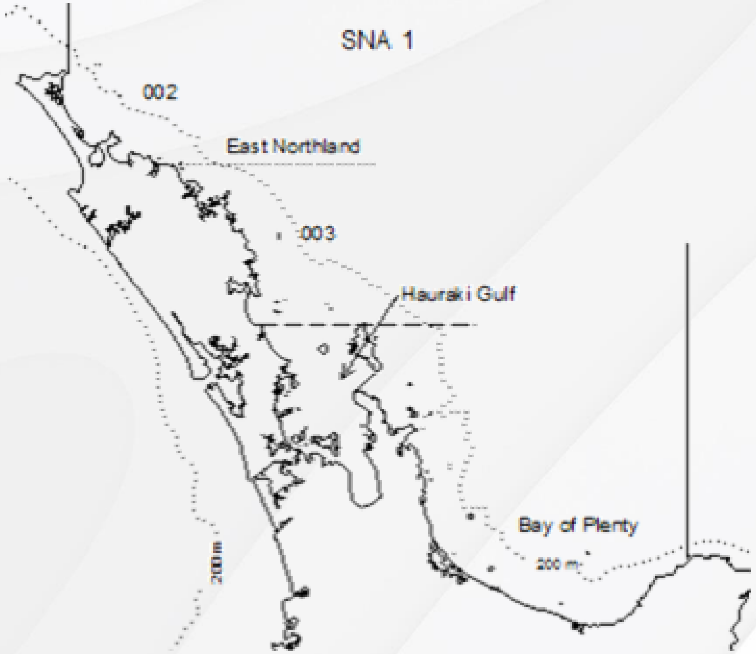
* Estimation error associated with operating model data conditioning process

The motivation and thinking behind NIWA's development of an ABM simulator

The NIWA AMB simulator was largely developed to be an MSE operating model for investigating some of the fundamental uncertainties in New Zealand snapper stock assessments, in particular the assessment for the main spatially disaggregated stock complex we call SNA 1.

Snapper are a relatively long-lived (60+ max age) but most of the exploitable biomass is between 5 to 20 years of age.

SNA 1 is believed to compress three productively units (stocks) and is assessed as having three stock areas with some movement interchange between using a spatially-disaggregated CASAL 1 age-based model.



NIWA
Taihoro Nukurangi

The motivation and thinking behind NIWA’s development of an ABM simulator

Some key uncertainties in the SNA 1 assessment relate to spatial stock structure and movement.

Other complexities include:

- temporal growth change
- temporal change in the spatial distribution of the fisheries and their associated selectivities.

Future concerns relate to ocean warming and acidification and continued loss of juvenile habitat due to land-based effects.

To adequately represent all these concerns and potential complexities we needed our simulator to be capable of higher spatial-temporal complexity than currently assumed by the estimator.

Because many of the uncertainties relate to length based observations and processed i.e. tagging data and spatial-temporal change in length-based fishing pressures our simulator needed to be fully length-age capable.

One of the main reasons we chose to develop an ABM as opposed to an SPM simulator was we felt it was important that when fish crossed into a new partition that information on their characteristics from the past partition was not lost.

For example, in SPM when fish most from a slow growth area moves to a high growth area it is immediately assigned the mean weight at-age for the new area. To due agent-memory this does not happen in ABM simulation models and is one of there main advantages over partition models.

The motivation and thinking behind NIWA's development of an ABM simulator

Another advantage we saw in the ABM approach over SPM was the ability more easily specify and mange high spatial-temporal model complexity.

In an AMB spatial-temporal complexity are agent attributes and as such the memory management of spatiotemporal complexity is largely bound up with the memory management of agents. The main performance limitations of ABMs are the number of agents and the number of time-steps in the simulation less so the degree of model partitioning.

There are significent computational differences between AMBs and the CASAL partition model estimator that also made them attractive as the snapper MSE operating models for providing insight into estimator uncertainty.

The motivation and thinking behind NIWA’s development of an ABM simulator

The summary reasons for choosing ABM simulation approach for snapper were:

- True length-age integration
- Complex partition capability
- Past-partition agent memory
- Computationally different to the partition-based CASAL estimator

The motivation behind NIWA's development of the SPM simulator

Although more of a generic tool than the snapper ABM SPM was originally developed as an aid to better understand spatial uncertainty in the CCAMLAR Antarctic toothfish assessment. It was originally not used in a MSE framework.

Antarctic toothfish tagging data indicated the stock is highly spatially complex however the assessment itself was unable take of account of this spatial complexity and assessment results were highly dependent on the spatial assumptions used. SPM was developed to explore alternative spatial hypothesis and identify those more plausible to include in the assessment.

SPM is highly spatially configurable and is also capable of highly complex movement simulations largely driven by preference functions

I understand it is both length and age based

Opinions:

Clearly some degree of simulation capability does need to factored into next gen SA packages, but in my experience the complexity requirements of simulation are typically higher than that of estimation therefore it may not be cost effective to incorporate the level of complexity required for example a complex MSE simulation into what is primarily intended to be an estimation platform.

I believe it is not desirable to use the same operational code-base as both estimator and operating modules in a MSE type framework. Greater insight into estimation issues is likely gained if different computational code-bases are used (again based on ABM experience).

This thinking favours the continued parallel development of next gen SA packages to enable the development community to be able to assess estimation performance of one based on simulated data from another.

Currently I see estimator independent simulation model platforms are necessary and I think continued development of these is needed.

1. What additional simulation capabilities and design features are required in next gen SA packages?

2. Given next gen SA packages are likely to have expanded simulation capability will there still be a need for independent simulation models and frameworks?