Fisheries New Zealand
Tini a Tangaroa

NIWA
Taihoro Nukurangi

Potential Fisheries New Zealand/NIWA Scholarship Thesis Topics

Note that this list is far from exhaustive, and students are encouraged to suggest alternative relevant research topics.

The following projects have been suggested by NIWA advisors. Should a student be interested in one of these projects, they will be put in touch with the potential NIWA advisor if they successfully get to stage 2 of the application process.

1. Develop or improve, and apply existing statistical models for assessing the status of a selected fishstock. At the core of this research is analysing data, and then constructing and fitting a population model(s) to those data, in order to estimate quantities (such as stock size) that a fishery manager would want to know.

Previous projects have focused on building of a population model from first principles, typically using R; these models have assumed simplified biomass dynamics, or full demographic (age) structure, and been fitted to various observational data using likelihood or Bayesian methods. All projects will include collation and analysis of data; the data sets are often substantial, and will require some learning of fisheries data and problems. This project has the potential to provide information of value to fishery managers. The species and stocks that might be assessed are numerous, but include, for example:

- Common by-catch (non-target or non-commercial) species, such as deep-water sharks, spikey oreo, Johnson's cod, or rattail (macrourid) species.
- Commercial species such as ghost shark, leatherjacket, redbait, red snapper, rough or smooth skate, warehou, or Ray's bream (some of these already have data collations).
- An important commercial species but a poorly studied stock, for example an orange roughy stock in the subantarctic, or around the north of the North Island. This research would almost certainly require the use of Bayesian methods.

Likely objectives:
(i) to assemble and analyse existing biological and fisheries data for the selected fishstock;
(ii) to develop and/or use a mathematical model to determine whether the selected fishstock is currently near or above its target biomass level;
(iii) to develop and/or use a mathematical model to estimate current exploitation rates being applied by the fishery; and
(iv) to determine whether current catches or exploitation rates are likely to be sustainable and whether they will move the stock towards its target biomass level.
(v) to assess uncertainty in the application of any model.

2. Investigate and evaluate alternative stock assessment approaches. This research might modify existing models for species that have already been studied, use "alternative" methods based on having, for example, only length-based or only age-based data, or compare several models of different levels of realism and complexity (see also 3 below). Compared to (1) above, this research would involve multiple models or approaches, and because of this extra work it would probably require the use of an existing assessment as a base-case, and/or simpler data sets, models, and fitting methods. The species studied might include, for example:

- Sea perch
- Spiny dogfish
- Blue moki
- Lookdown dory
- Invertebrate bycatch species (using low information stock assessment methods)

Likely objectives:
(i) to assemble and analyse existing biological and fisheries data for one or more selected fishstocks;
(ii) to explore alternative stock assessment methods for determining stock sizes, exploitation rates and/or catches relative to targets or other relevant benchmarks; and
(iii) to determine priorities for future research in order to improve the state of knowledge for the fishstocks.

3. Investigating spatial patterns in population dynamics. Build and test models of population dynamics that allow for explicit, or different spatial structures. The models might try to reflect real observations of patchiness in fish stocks, for example localised aggregations of fish, ontogentic movements (i.e., movements with size and/or age), or localised variability in growth or maturation etc. The research might compare how "wrong" a conventional model assuming a single, homogenous stock, would be compared to this approach. The species that might be studied include, for example:

- Deep-sea oreos and their aggregations on underwater features
- Various shellfish fisheries, with small-scale patches of distribution
- Various inshore finfish fisheries that are managed in spatial units that are smaller than the stock area (e.g., hapuku, tarakihi, school shark)

4. Develop new, or modify existing, management strategy models. Management Strategy Evaluation models are used to evaluate the performance of different approaches to managing fisheries, for a selected fishstock or stock complex. This is a simulation modelling exercise, and would probably be based upon existing fish stock assessment models. Management strategy evaluation uses multiple simulation model runs to evaluate the relative performance of a set of different harvest (usually catch) control rules; the aim being to identify the harvest control rule that works best across a wide and credible range of different simulation model assumptions. An overview of the management strategy approach is given here http://www.cmar.csiro.au/research/mse/. The species that might be considered include, for example:

- Trevally
- Hake
- Ling
- A multispecies inshore fishery

Objectives:
(i) to assemble and analyse, if necessary, existing biological and fisheries data for a selected fishstock; and
(ii) to develop and/or modify a management strategy simulation model to compare the relative performance of alternative management approaches in the face of uncertainty about the state of knowledge of current and future stock size and stock dynamics.

An additional or alternative objective related to this approach is:
To investigate the use of multi-criteria decision making (MCDM) in this context. MCDM is explained by Henig & Buchanan 1998 Solving MCDM problems: Process concepts. Journal of Multi-Criteria Decision Analysis 5: 3-21 available at http://www3.interscience.wiley.com/journal/23929/abstract?CRETRY=1&SRETRY=0

5. Ageing and development of biological parameters for poorly-known species. This research would be done where the biology of the species is unknown or deficient. This would include estimation of the parameters for models of growth (i.e., length at age), variability of length at age, length-weight relationship, natural mortality rate (M), and proportion mature at length or age. These are required for stock assessment using demographic (age structured) models. The student would be expected to collate and analyse data, fit models, and provide the parameter estimates. The student might also consider whether the standard (i.e., most frequently used) models and fitting methods used are appropriate to the data. Species studied might include:

- Common by-catch (non-target or non-commercial) species such as basketwork eels, selected deepwater sharks or chimaeras, one or more of the common rattail (macrourid) species, slickheads, robust cardinalfish, or warty or spikey oreo.

This project might include collection of samples (fish), and may also include some laboratory work preparing and analysing samples. As a result, this project may be better suited to a biology/statistics double major.

6. Testing assumptions of population models. This research would look to test some of the underlying assumptions of stock assessment (population) models, in particular those that are typically assumed to be constant. This includes growth (length at age), length to weight conversions, and maturity at age. The research will evaluate how much difference it would make if these were allowed to vary. Research questions could include:

Objectives:

- Estimate a representative average growth, length-weight, maturity, or other relationship for the stock, and the variability and trend that this parameter has (or could have). The method to do this will vary depending on the data source, e.g., commercial fishery samples or stratified (area-weighted) research survey, and on the parameter being examined. Analyses of these data might involve a GLM, GAM, or cluster analysis.

- Build or modify a stock assessment model to examine what influence time-varying parameters have on stock size and status estimates, and therefore on fishery management, compared with constant parameters.

7. Should stock assessment MCMCs use nuisance or free parameters? Nuisance parameters (e.g. catchabilities) can be estimated analytically in MCMCs, and doing so may aid with convergence of MCMCs. However, estimating analytically is only valid asymptotically and may lead to underestimates of the uncertainty in parameters estimates.

8. Developing joint species distribution models (JSDMs) to support assessments and management efforts for data-limited species. JSDMs allow for inferences for multiple species simultaneously while estimating associations among multiple species. These models are particularly useful for sharing information across multiple species, thereby providing estimations for some data-limited species that are difficult to obtain or are unattainable otherwise. This project would help develop JSDMs which would allow for the generation of spatial distribution or abundance estimates that could assist stock, habitat, risk assessment efforts, or management efforts for some data limited species in New Zealand.

9. **Develop conceptual or qualitative models in support of ecosystem-based fisheries management.** As New Zealand is trying to implement ecosystem-based fisheries management (EBFM), tools need to be developed, including stock assessments incorporating environmental and ecosystem considerations and ecosystem simulation models such as Atlantis models. To inform the development of these tools, it can be valuable to develop conceptual or qualitative models beforehand. Conceptual and qualitative models represent the ecosystem of interest qualitatively using simple depictions, which show ecosystem's components or connection; they typically represent an important first step towards the development of quantitative ecosystem models such as Ecopath with Ecosim or Atlantis models. This project would consider a priority EBFM case study for Fisheries New Zealand and, for that case study, would develop conceptual and/or qualitative models (e.g., loop analysis, Bayesian networks and/or DSEMs) which would be useful to develop more complex ecosystem models and tools for the EBFM case study of interest in the future.

10. **Designating habitats of significance in the face of climate change.** This project would help develop and use species distribution models (SDMs) for habitat forming taxa (e.g. kelp, seagrass, corals) that are important to critical life stages (juveniles or spawners) of some commercially important species. These SDMs would inform Fisheries New Zealand about the quality of nursery/spawning habitat for the commercially important species of interest. Forecasts would be made with the SDMs under climate change scenarios. The maps of habitat-forming taxa from the SDMs would contribute to a climate-informed prioritization of protection/restoration efforts for these taxa in New Zealand. This prioritization would primarily target areas that are within the envelope of suitable habitat conditions for the critical life stages of commercially important species and are less susceptible to extreme events such as heatwaves in a context of climate change.

Richard Arnold and Nokuthaba Sibanda (School of Mathematics and Statistics, Victoria University) are interested in topics of a statistical nature. For more information and contact details see:
http://www.victoria.ac.nz/sms/about/staff/richard-arnold
http://www.victoria.ac.nz/sms/about/staff/nokuthaba-sibanda

Russell Millar (Department of Statistics, University of Auckland) is interested in the use of state-of-the-art stock assessment tools, especially the increasingly popular TMB (Template Model Builder). A typical project might involve writing an existing stock assessment model in TMB and using the power of TMB to extend and improve the assessment. For further details on this topics see the website:
http://www.stat.auckland.ac.nz/showperson?firstname=Russell&surname=Millar or contact Russel directly at https://www.stat.auckland.ac.nz/~millar/