

Selected Notes on the use of Ecosystem Models for Assessing the Indirect Ecosystem Impacts of Fisheries

Éva E. Plagányi

Department of Mathematics and Applied Mathematics
University of Cape Town, Rondebosch 7701, South Africa

Email: Eva.Plaganyi-lloyd@uct.ac.za

November 2007

SUMMARY

A few summary points are listed below and expanded in the accompanying talk to summarise some recent developments concerning fisheries ecosystem modelling and its role in providing management advice. As has been the convention at several recent international workshops, the term fisheries ecosystem model here broadly refers to all fisheries models that include more than a single species, given that multi-species models are often a first step towards a broader ecosystem approach to fisheries (EAF) (FAO 2003). The first document is a detailed technical report that consolidates, classifies and compares the range of ecosystem models currently in existence (Plagányi 2007). This report served as the background document for a FAO Workshop on Modelling Ecosystem Interactions for Informing an Ecosystem Approach to Fisheries: Best Practices in Ecosystem Modelling (Italy 3-6 July 2007). Another key workshop referenced is the first U.S. National Ecosystem Modelling Workshop (California, 29-31 August 2007) aimed, *inter alia*, at determining the feasibility of establishing a national ecosystem modelling toolbox, national standards for ecosystem modelling within the United States and how to use ecosystem models for providing management advice.

Methods available for assessing the impacts of ecological (indirect) interactions between species and fisheries and their implications for marine fisheries management.

- Review of over 20 different ecosystem models currently in use or under development.
- Summarises the results and conclusions reached by previous studies and workshops on the subject, including the ICES/SCOR Symposium on Ecosystem Effects of Fishing, the Workshop on the Use of Ecosystem Models to Investigate Multispecies Management Strategies for Capture Fisheries, the IWC Modelling Workshop on Cetacean-Fishery Competition, the North Atlantic Marine Mammal Commission (NAMMCO) workshops and the Workshop on Ecosystem Approaches to Fisheries in the southern Benguela.
- Comparison of models using criteria such as level of complexity and realism, types of functional responses, how uncertainties in model structure, parameters and data are treated, incorporation of environmental effects etc.
- Identification of a set of commonly asked questions pertaining to EAF with discussion of the potential of the various modelling approaches to address these questions (concluding that a range of different model constructions are needed; no one model is necessarily superior to all others in all respects).

Whole ecosystem models attempt to represent all trophic levels in an ecosystem in a balanced way. In contrast, models which represent only a subset of the ecosystem and are thus restricted to represent a limited number of species most likely to have important interactions with a target species of interest are termed Minimally Realistic Models. Models that focus on inter-species interactions only are termed Dynamic multi-species models. In contrast, Dynamic system models incorporate the environment and lower trophic levels, although this is often at the expense of not representing the higher trophic levels in sufficient detail (when considered in a fisheries management context). ESAM (Extended Single-species Assessment Models) are those that expand on current single-species assessment models taking only a few additional interactions into account. In classifying models further, it was noted it is important to differentiate between models that take age structure and spatial aspects into account.

Considerable scope exists for significant future developments in multi-species and ecosystem models, particularly with respect to their use as tools in EAF. Some of the major areas of current research include:

- investigations pertaining to the effects of model complexity – in particular, the effect of specific formulations (often feeding functional responses) on model outputs;
- the treatment of uncertainty;
- representation of socio-economic factors and human behavioural drivers;
- multiple sector dynamics and management (with OMPs being an increasingly popular method); and
- the effective (and feasible) representation of biodiversity.

Uses of Ecosystem Models

- Ecosystem models are intended to complement not replace single-species models in providing management advice, noting nonetheless that there are many questions that can only be addressed using ecosystem models.
- They can be used in different ways, ranging from contributing to conceptual understanding, providing information for strategic decisions through to making tactical decisions.
- Ecosystem models are rarely used as yet for making tactical decisions – rather, strategic modelling will likely mainly be used to inform an EAF and assist in broad and long term strategic planning.

Best Practice

- FAO (2007) focused on identifying some guidelines as to what constitutes best practice with respect to each of a series of key model attributes, such as those related to model aggregation, model components, external forcing, model structure, technical and non-trophic aspects, methods for dealing with uncertainty and model uses and outputs.
- Stressed that the best practice guidelines are an achievable set of practices that should guide thinking as to the importance of different model attributes and suggested approaches for handling each of these. Although it is recommended

that these practices should be followed to the extent possible, it is not anticipated that these practices will be achievable or required in every case.

- At the other extreme, some bodies (eg CCAMLR, NMFS) are simultaneously attempting to define minimum acceptable standards or benchmarks for specific model applications as a means of agreeing a minimum level of rigour as to ecosystem models that are considered suitable for providing management advice. Both these approaches are essential in moving forwards with an EAF.
- The Management Strategy Evaluation [MSE] (or analogously Management Procedure [MP]) approach has been identified as best practice in ecosystem modelling because of its focus on the identification and modelling of uncertainties, as well as through balancing different resource dynamics representations and associated trophic dependencies and interactions.
- Stakeholder participation and dialogue need to be integral components of an EAF.

Some conclusions from the workshop reports/papers listed below

Strategic ecosystem models will typically contribute both to understanding and may inform data requirements. Strategic modelling will likely mainly be used to inform an EAF and assist in broad and long term strategic planning. Some of these strategic models may inform the development of tactical models for providing management advice, or tactical models may be constructed without the need for a strategic forerunner. However, as noted earlier, the best practice approach involves using ecosystem models as Operating Models within a MP/MSE framework. Loosely constructed ecosystem models should not be used to justify a preferred point of view. The choice of an appropriate model depends not only on the question to be addressed (and data availability) but also on other logistical constraints such the person power and associated costs.

Literature cited

- CCAMLR In prep. Report of the joint WG-EMM and WG-FSA Workshop on “Fisheries and Ecosystem Models in the Antarctic (FEMA)”, July 2007, Christchurch, New Zealand.
- FAO [Food and Agriculture Organization] 2003. The ecosystem approach to fisheries. *FAO Technical Guidelines for Responsible Fisheries*. No. 4, Suppl. 2. FAO, Rome. 112 pp.
- FAO [Food and Agriculture Organization] 2007. Report of the workshop on Modelling ecosystem interactions for informing an EAF: Best practices in ecosystem modelling, Tivoli, Italy, 3-6 July 2007.
- Link, J. et al. In prep. Report of the National Ecosystem Modeling Workshop (NEMoW), August 29-31 2007, NMFS Santa Cruz Laboratory.
- Plagányi, É.E. 2007. Models for an Ecosystem Approach to Fisheries. FAO Fisheries Technical Paper No. 477. Rome, FAO. 2007. 108p. ISBN 978-92-5-105734-6.
- Plagányi, É.E., Fulton, E. and G. Watters. submitted. Towards formalising a framework for fisheries ecosystem modelling. *Fish and Fisheries*