Thoughts on the Role of the Ecosystem Modelling Working Group

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We provide thoughts on the future of the Ecosystem Modelling Working Group (EM), particularly its function and relevance to the larger IWC Scientific Committee and potential collaborations with other institutions. As background to that discussion, we provide a brief summary of the history of EM, including why it was created and its accomplishments to date. Furthermore, we discuss how the IWC can use ecosystem models to inform management decisions, and we highlight the issues that comprise the core of the Working Group's ongoing discussions. We conclude with recommendations surrounding four questions that are key to the future of EM:

1) How can the SC evaluate ecosystem models with respect to the fundamental issues inherent in ecosystem modelling?

2) How can EM provide the best advice on ecosystem model input requirements, including assessment on data collected for this purpose and the general precision requirements for estimates used for inputs?

3) How can the IWC best collaborate with other institutions and researchers that are actively developing and implementing ecosystem models?

4) How can EM ensure relevance to other SC SubCommittees?

Our recommendations should not be considered a rigid prescription for the future functioning of the Working Group; rather, they provide talking points to focus discussions within EM to help steer the course for the future.

EM was first convened in 2007, during the 59th meetings of the IWC SC. Initial goals for EM were twofold: 1) to address the issues of developing ecosystem models and the estimation of input parameters relevant for modelling linkages between whales and their environment; and 2) to facilitate the collaboration with other institutions, CCAMLR in particular (IWC, 2008). EM was instrumental in organizing and conducting the Joint CCAMLR-IWC Workshop to Review Input Data for Antarctic Marine Ecosystem Models, which was held in August, 2008. The Workshop's primary aim was to 'attempt to develop some prioritization of data needs for ecosystem models which focus on krill and krill-based predators' (IWC, 2009). Three general questions guided the Workshop discussions:

1) How might fishing on a species, in particular krill, impact predators of that species?

2) How might changes in abundances of predators, for example those recovering from prior exploitation, influence other components of the ecosystem?

3) How might the environment and environmental change impact the abundances of fished species and their predators, and conservation objectives?

The Workshop produced recommendations for future investigations into the Southern Ocean physical environment, primary producers, pelagic species (krill and other zooplankton, squid, and fish), seals, seabirds, whales, and the exploitation of Southern Ocean marine species. Publications resulting from the workshop are nearing completion and ready to be submitted to the journals of the IWC and CCAMLR for publication. The Workshop was considered a success in bringing experts from diverse yet complementary disciplines together to discuss the complex issues of ecosystem modelling, and in progressing efforts to develop a standardized approach to the use of data from Southern Ocean ecosystems in modelling by CCAMLR and the IWC. Overall, EM has been an efficient forum for review and discussion of a broad range of ecosystem models and ecological linkage papers presented to the IWC SC. In particular, EM has broadened the context of these discussions from

simple, whale-centric models to considerations of state-of-the-art marine ecological modelling spanning a range of modelling approaches.

Some discussions within EM have addressed the question of whether the IWC can use ecosystem models to inform management decisions. A distinction has been made between 'tactical' and 'strategic' models. An example of a tactical model is a single model used to set catch limits; there is general agreement among the scientific community that ecosystem models are currently incapable of successfully providing tactical advice. In contrast, multiple strategic models are often successfully used in concert to test simpler models (including the underlying model assumptions) and hypotheses; they could be used within an ecosystem modelling framework to test aspects of models such as the IWC's Revised Management Procedure and the krill surplus hypothesis.

Several ecological and analytical issues have been recurrent in EM discussions to date and in the ecosystem modelling community in general. Ongoing discussions center around the physical, biological, climatological, and anthropogenic drivers of ecosystem processes. For example, uncertainty exists in our understanding of ecosystem responses to trends (climate change) and variability in the physical environment on interdecadal (*e.g.*, Pacific Decadal Oscillation) or interannual (such as El Niño Southern Oscillation and North Atlantic Oscillation) time scales. In addition, we are currently unable to adequately quantify or predict ecosystem responses to anthropogenic disturbances such as noise (*e.g.*, from shipping, research, military, and petroleum industry activities), pollutants, fisheries, and catastrophic disasters (*e.g.*, oil spills). Scales of competition, characterising predator-prey interactions and understanding the relative forcing of top-down and bottom up processes provide significant additional sources of uncertainty to model structure and function. Understanding and modelling competition requires understanding the spatial and temporal partitioning within the ecosystem, the different ecological mechanisms of competition, and the distinctions between mathematical and ecological definitions of competition (note that EM have attempted to deal with the latter by agreeing on a definition of competition). Uncertainties in understanding predator-prey interactions result in uncertainties in parameterizing the functional response, relative feeding time, duration and location of the feeding season, feeding time adjustment rate, prey switching vulnerability, and food consumption estimation. The extent to which ecosystem models incorporate biological, physical, climatological, and anthropogenic forcing is broad, ranging from narrowly-focused models with relatively few interacting components to comprehensive models requiring a multitude of parameters, linkages, and assumptions. The diversity of ecosystem models result from the diversity of modelling techniques (model structure, function, inputs, parameterization, and uncertainty estimation methods); sampling, analytical, and prediction scales related to space, time, ecology, and taxonomy; and assumptions about ecological phenomena, such as exploitation history, equilibrium vs. non-equilibrium states, and climate change projections. Unresolved debates persist on the utility of continuing or integrating existing research into ecosystem models, including but not limited to genetics, body condition and animal health, the acoustic environment ("noise"), and stomach content data from lethal sampling. Finally, consensus does not exist on acceptable proxies for unmeasurable or unmeasured variables. When taken together, understanding the consequences of these information gaps can help generate recommendations for collecting data or developing new analytical tools.

How can the SC evaluate ecosystem models, given the numerous uncertainties alluded to above? We recommend a collection of tools to help with this process:

1) Standardized templates should be developed for documenting metadata and analytical techniques.

2) Performance criteria should be established, including testing model fit to historic or present data and assessing its ability to generate ecologically reasonable predictions into the future.

3) Sensitivity analyses should be conducted to quantify and perhaps better understand the importance of model inputs (which can guide data collection priorities) and assumptions on model outputs.

4) The IWC should allow all SC members access to the code and relevant background information of ecosystem models considered in informing management decisions. This access would be achieved via the Secretariat.

5) Ecosystems are complex and dynamic; therefore, the IWC SC should explore different ecosystem modelling approaches for a system in order to compare performance across models.

6) Intersessional meetings should be used, when necessary, to allow in-depth examination of competing models.

7) Finally, the EM Working Group should continue to convene every year, or as needed, at the annual SC meetings to address issues relevant to the SC.

Although this list might not be exhaustive, it is inclusive of the ideas that have been raised during previous EM sessions.

The IWC should also identify ways to collaborate with other institutions (*e.g.*, FAO, CLIOTOP, ICED, CCAMLR, and NPRB) and researchers developing and working with ecosystem models. Although logistically challenging, successful collaboration will likely expedite understanding and application of ecosystem models within the IWC decision making process. Our recommendations for facilitating this process include soliciting input from Invited Participants during the annual SC meetings; having SC members attend outside meetings, conferences, or workshops and reporting back to the SC; discussing recently published scientific literature during EM sessions at annual SC meetings; and the use of IWC SC initiatives (*e.g.*, the Southern Ocean Research Partnership [SORP]) as mechanisms to provide cetacean data as inputs into broader modelling efforts, such as those of ICED, CLIOTOP, and CCAMLR.

Finally, the EM working group should ensure relevance of its activities to other SC SubCommittees via the development of terms of reference and strategic work plans and by holding shared sessions on key issues.

In conclusion, the EM working group has been a successful forum in which to discuss ecological and analytical issues pertaining to the relationship of whales and their ecosystems, and ecosystem modelling in particular, with an emphasis on models relevant to IWC scientific concerns. In this paper, we have made recommendations for a framework in which EM can operate to make further contributions to the IWC. The critical components of our approach include open and engaging discussion of scientific issues; transparent documentation of model code, inputs, assumptions, and structures; development of a flexible approach to quantitatively and qualitatively evaluate ecosystem models; and collaboration with other institutions and individuals who are actively engaged in ecosystem modelling. We welcome feedback on these ideas and additional input on how to proceed.

REFERENCES

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