

Modelling the ecological impacts of low trophic level fisheries

A.D.M. Smith

CSIRO Marine and Atmospheric Research

Hobart, Australia

This short paper is a supplement to a presentation to the Ecosystem Modelling Working Group in June 2013. The presentation describes the results of an analysis undertaken several years ago to examine the trophic impacts of fishing species that are low in the food chain (low trophic level or LTL species) such as krill, anchovy, sardine and mesopelagic species such as lantern fish. The formal report of the study is in Smith *et al.* (2011). The study was commissioned by the Marine Stewardship Council as part of a process to refine its assessment methods for low trophic level species. This paper briefly describes the results of this study, and comments on the relevance of some of the models used to issues in the management of marine mammals, including whales.

The study used existing ecosystem models to explore the effects of different levels of depletion of LTL species on the abundance of other groups and species in the ecosystem. Three different ecosystem models were used – Ecopath with Ecosim (EwE), OSMOSE, and Atlantis. This allowed the robustness of the results to choice of model structure to be examined. Results were obtained in five different ecosystems – the southern Benguela, the northern Humboldt, the California current, the North Sea, and south eastern Australia. The simulation protocol involved selecting LTL species one at a time for each model and applying fishing mortality rates from zero up to the level which resulted in extirpation of the stock. The impacts on other parts of the ecosystem (species and groups in the ecosystem model) were evaluated for depletions of 25, 60, 80 and 100% (depletion here refers to reductions of the target LTL stock below the level with zero fishing mortality). The impacts were measured in various ways, but the main performance measure used was the proportion of groups whose abundance changed by more than 40%, relative to the level where fishing mortality on the LTL species was zero.

The details of the results are in the presentation and the published paper. Briefly, results showed (not unexpectedly) a trade-off between yield from the LTL species and impacts on the rest of the ecosystem. Broad results were relatively robust to the type of ecosystem model used, but predictions about impacts of and on particular species or groups varied considerably between models, suggesting that their use for tactical purposes is not yet warranted. Attempts were made to identify characteristics of LTL species that might be used to predict the impacts of their depletion. The relative size of the group in the ecosystem was important, and there was some relationship with the level of connectance of the species in the food web (proportion of total trophic linkages). The latter factor has been analysed further by Tim Essington (University of Washington, Seattle) and Eva Plaganyi (CSIRO, Brisbane), who have identified a better measure of connectance.

Both the EwE and Atlantis models include marine mammals in one or more groups, and so the impacts of fishing LTL species on these groups could be examined. OSMOSE models used in this study did not include marine mammal groups, but a recent application of the model has included marine mammals. All the models used were developed to explore fishery management issues, so the focus on marine mammals was not high and differentiation of species not large. However several current implementation of Atlantis at high latitudes (including in the Southern Ocean) have a greater focus on marine mammals.

All of the models used in this study were tuned to time series data of abundance for species or groups where such data were available. None of the models used standard statistical parameter estimation methods though such methods are under development for EwE and OSMOSE. The extent to which some of the models fit time series data will be illustrated in the presentation.

References:

Smith A.D.M., Brown C.J., Bulman C.M., Fulton E.A., Johnson P., Kaplan I., Lozano-Montes H., Mackinson S., Marzlon M., Shannon L., Shin Y-J and Tam J. 2011. Impact of fishing low-trophic level species on marine ecosystems. *Science* 333:1147-1150.