Marine population modelling in the Antarctic – international contributions

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Quantitative population dynamics models are required to contribute to understanding of Antarctic marine ecosystem structure and functioning as well as to provide tactical management advice pertaining to important harvested resources such as krill (*Euphausia superba*) and toothfish (*Dissostichus eleginoides*). Moreover, world-wide there has been a move towards an Ecosystem Approach to Fisheries such that there is a need for the development of species-interaction models that can take ecosystem aspects into account[1]. Four different aspects of marine population dynamics modelling in the Antarctic are described. The first pertains to a request by CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) for scientific advice regarding the subdivision of the precautionary catch limit for krill among 15 small-scale management units (SSMUs) in the Scotia Sea to reduce the potential impact of fishing on land-based predators. In response, a Spatial Multi-species Operating Model (SMOM) of krill-predator-fishery dynamics has been developed[2-3]. The operating model is assumed to simulate the "true" dynamics of the resource and is used to test decision rules for adjusting fishing activities (e.g. catch limits) based on field data in the future. Preliminary results have been useful in evaluating different spatial allocations of krill catches. Moving to an Antarctic-wide spatial scale, earlier work[4] of pertinence to both CCAMLR and the IWC (International Whaling Commission) saw the development of a model involving the interactions of krill, four baleen whale and two seal species in an attempt to explain their abundance trends over the past two centuries. Recent initiatives seek to determine whether the incorporation of a further species with faster dynamics, such as squid, would lead to qualitative changes in predictions, and further whether supporting evidence can be found for this model's prediction that Antarctic fin whales (*Balaenoptera physalus*), of which some 700 thousand were taken, were early beneficiaries of a "krill surplus" and thus not initially as numerous as customarily supposed. Allied to this are assessments to determine the current status of the recovering populations of humpback whales (*Megaptera novaeangliae*) off the African west and east coasts as part of the IWC's comprehensive assessment of this species[5,6]. Finally population models have been developed to provide scientific advice for setting appropriate catch levels for the toothfish resource off South Africa's Prince Edward Islands[7]. Recent information from the length distributions of catches by the fishery suggest that the resource may not have been as depleted by earlier illegal fishing as previously supposed, and a feedback management procedure that takes due account of the associated uncertainties is under development as the basis for providing future advice on catch levels in this fishery[8].

1. Plagányi, É.E. Models for an Ecosystem Approach to Fisheries. FAO Fisheries Technical Paper No. 477. Rome, FAO. 2007. 108p. ISBN 978-92-5-105734-6 (2007).

2. Plagányi, É.E. & Butterworth, D.S. A Spatial Multi-species Operating model of the Antarctic Peninsula krill fishery and its impacts on land-breeding predators. Commission for the Conservation of Antarctic Marine Living Resources Document WG-SAM-07/12. 33 pp. (2007).

3. Plagányi, É.E. & Butterworth, D.S. An illustrative management procedure for exploring dynamic feedback in krill catch limit allocations among small-scale management units. Commission for the Conservation of Antarctic Marine Living Resources Document WG-EMM-06/ 28. 17 pp. (2006).

4. Mori, M. & Butterworth, D.S. 2006. A first step towards modeling the krill-predator dynamics of the Antarctic ecosystem. *CCAMLR Science* **13**, 217–277 (2006).

5. Johnston, S.J. & Butterworth, D.S. Initial stock assessments of the Southern Hemisphere humpback whale Breeding Sub-Stock B1. International Whaling Commission document SC/59/SH03. 8pp. (2007).

6. Johnston, S.J. & Butterworth, D.S. Further assessments of the Southern Hemisphere humpback whale Breeding Stock C and its component Sub-Stocks. International Whaling Commission document SC/59/SH04. 22pp. (2007).

7. Brandão, A. & Butterworth, D.S. 2006 assessment of the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity. Commission for the Conservation of Antarctic Marine Living Resources Document WG-FSA-06/58. 34pp. (2006).

8. Brandão, A. & Butterworth, D.S. Extension of the development of a management procedure for the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity. Commission for the Conservation of Antarctic Marine Living Resources Document WG-SAM-07/10. 25pp. (2007).