Beyond carbon sinks: the importance of feedbacks involving high trophic levels in Southern Ocean ecosystem models

Jessica Melbourne-Thomas[1], Stuart Corney[1] and Andrew Constable[1,2]
[1]*Antarctic Climate & Ecosystems Cooperative Research Centre, Hobart, Australia*
[2]*Australian Antarctic Division, Hobart, Australia*

End-to-end ecosystem models that capture coupled bio-physical processes from the level of top predators through to physical forcings are emerging as important tools to evaluate climate change impacts for Southern Ocean ecosystems. To date, climate change effects on pelagic ecosystems have been regarded as 'bottom-up' impacts, where changes in the physical environment affect biogeochemical processes at the base of the foodweb. In models, the emphasis has been on assessing potential changes in carbon cycling; any effects on higher trophic levels are regarded as second-order impacts, which may or may not be of interest for fisheries management. Indeed, dynamic responses of higher trophic levels have been dismissed as largely inconsequential to climate change debates because they are not seen to have any role in the carbon cycle, and are regarded merely as carbon sinks.

Recent findings regarding the potential role of whales in influencing the bio-availability of iron demonstrate how high-level biophysical feedbacks involving large predators may affect the carbon cycle in unforseen ways [1,2]. Such foodweb-level feedbacks may be important in moderating the mortality of primary producers or even in modifying habitats in ways that enhance or impede production. We discuss the need for revised thinking about the role of high trophic level taxa and functional groups in carbon cycling and ecosystem responses to climate change. We present example frameworks for capturing these effects in the form of network models (Fig. 1) and an end-to-end ecosystem model currently being developed by the Antarctic Climate & Ecosystems Cooperative Research Centre.

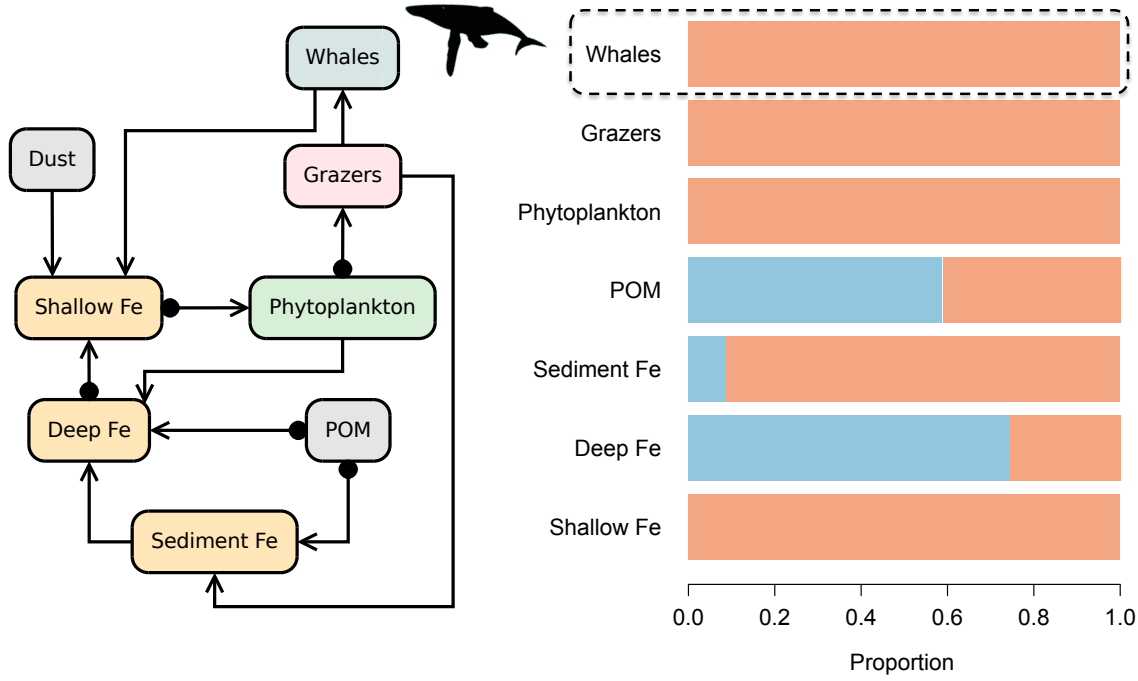

Figure 1. Example network model to capture the role of whales in iron recycling in the Southern Ocean (left), and simulation outcomes in response to increased populations of whales (right; red = positive change, blue = negative change).

[1] Nicol, S., A. Bowie, S. Jarman, D. Lannuzel, K. M. Meiners, and P. Van Der Merwe. 2010. Southern Ocean iron fertilization by baleen whales and Antarctic krill. *Fish and Fisheries* 11:203–209.
[2] Lavery, T. J., B. Roudnew, P. Gill, J. Seymour, L. Seuront, G. Johnson, J. G. Mitchell, and V. Smetacek. 2010. Iron defecation by sperm whales stimulates carbon export in the Southern Ocean. *Proceedings of the Royal Society B: Biological Sciences* 277:3527–3531.