THE KERGUELEN PLATEAU: MARINE ECOSYSTEM + FISHERIES
Proceedings of the Second Symposium
heardisland.antarctica.gov.au/research/kerguelen-plateau-symposium

KERGUELEN PLATEAU
Marine Ecosystems & Fisheries • SYMPOSIUM 2017

Extended abstract

A food-web model for the southern Kerguelen Plateau region

Stacey A. McCormack[1,2✉], Rowan Trebilco[2], Jessica Melbourne-Thomas[2,3], Julia L. Blanchard[1] and Andrew Constable[2,3]

[1] Institute for Marine and Antarctic Studies (IMAS), University of Tasmania, Locked Bag 129, Hobart, Tasmania 7001, Australia

[2] Antarctic Climate & Ecosystems Cooperative Research Centre (ACE-CRC), University of Tasmania, Private Bag 80, Hobart, Tasmania 7001, Australia

[3] Australian Antarctic Division, 203 Channel Hwy, Kingston, Tasmania 7050, Australia

✉Corresponding author: stacey.mccormack@utas.edu.au

Energy flow in Southern Ocean ecosystems is often described in terms of the relatively short trophic pathway transferring energy from primary producers to higher trophic levels via the regionally abundant Antarctic krill (*Euphausia superba*). In the past few decades, several studies have questioned the ubiquity of the pivotal role of Antarctic krill (Pinkerton et al., 2010; Murphy et al., 2012), with the complexity of Southern Ocean food webs becoming increasingly recognised and emphasis placed on understanding alternative energy pathways, such as those where fish, squid and salps dominate mid-trophic levels (Smith et al., 2007). Despite this, short krill-dominated food chains are the focus of many existing food-web models for the Southern Ocean (Erfan and Pitcher, 2005; Hill et al., 2012; Suprenand and Ainsworth, 2017), therefore limiting their utility for exploring alternative structures where other mid-trophic level organisms play important roles in energy transfer.

Food-web models, such as the widely applied mass-balance approach Ecopath with Ecosim (Polovina, 1984; Christensen and Pauly, 1992), provide a means to test hypotheses regarding the strength of various energy pathways throughout an ecosystem. Alternative energy pathways through mesopelagic groups (especially fishes and squid) remain a key area of uncertainty in understanding the structure and functioning of Southern Ocean ecosystems (Hill et al., 2012), and this is particularly true for areas where existing food-web models have yet to fully resolve energy pathways through mid-trophic levels, such as the Kerguelen Plateau region of the Indian sector of the Southern Ocean. This study aims to develop a quantitative description of Prydz Bay and

the southern Kerguelen Plateau region through development of an Ecopath model (Figure 1) aimed at identifying major pathways of energy flow and evaluating the trophic roles of mesopelagic fish, squid and krill.

The Ecopath with Ecosim tool is the most commonly implemented approach for quantitative modelling of marine food webs in the Southern Ocean. Ecopath is based on the assumption of mass-balance over a given time period and provides a snapshot representation of the food web which can be used to explore the structure and function of aquatic ecosystems (Christensen and Walters, 2004). Developing an Ecopath model is a challenging task that requires many decisions to be made regarding which aspects of the system need to be captured in detail and which can be omitted or simplified. Some of these key decisions include the spatial representation of the model, how species will be represented, what data will be used to parameterise the model and how components of the system will be addressed when no data is available for them.

Prydz Bay is a high-latitude embayment along the East Antarctic margin between 66°E and 79°E (Figure 1). For the purposes of this study, the boundaries of Prydz Bay and the southern Kerguelen Plateau region (i.e. the model domain) were defined as south of 60°S to the Antarctic continent and between 60°E and 90°E to encompass the Australian stations Mawson and Davis. The northern boundary of the model also encompasses BANZARE Bank along the 3 000 m contour to capture important ecological processes relevant to the system and ensure congruence with other ecosystem models
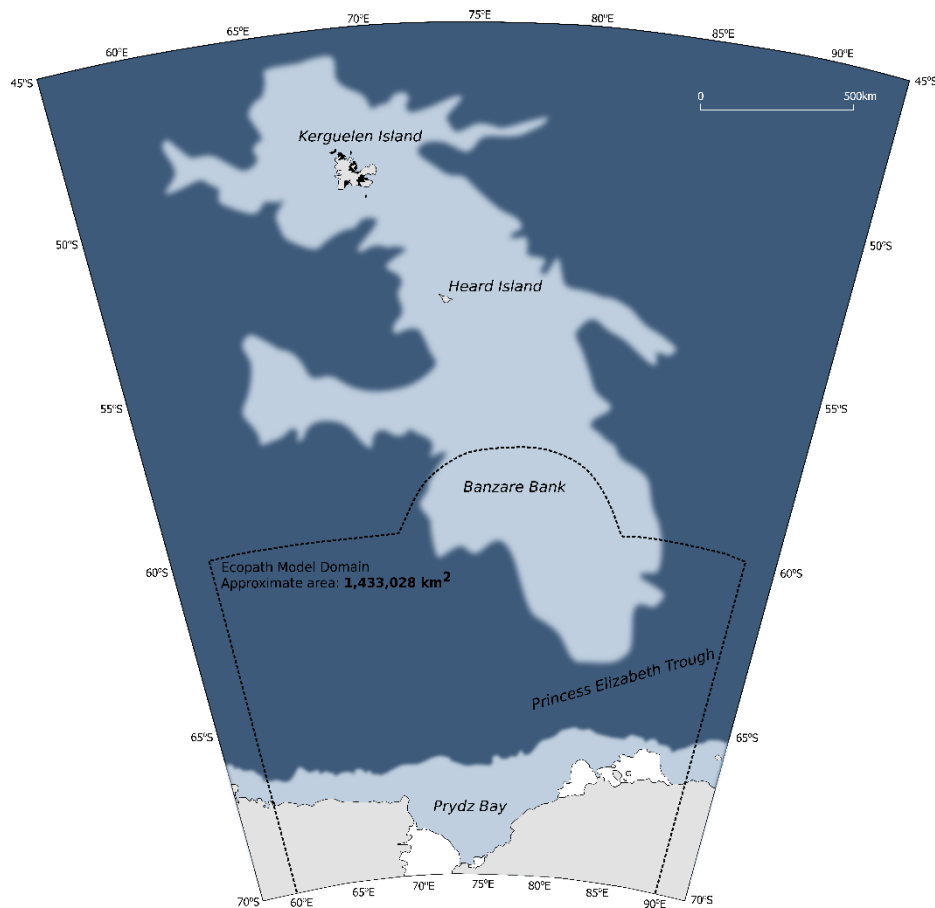
Keywords: Ecopath, energy flow, food web model

Figure 1:   Ecopath model domain (dashed line) for Prydz Bay and the southern Kerguelen Plateau region.

currently under development for the region. This domain was chosen with data availability in mind with sampling occurring in early 2016 (*Aurora Australis* voyage, V3 – the 'Kerguelen Axis' study) that provides updated biological information for model parameterisation.

To ensure all assumptions were made explicit and our decisions were justified during the development of the Prydz Bay Ecopath model, the implementation of the model has been documented on the Southern Ocean knowledge and information wiki (SOKI), developed by the Southern Ocean Ecosystem Change group at the Australian Antarctic Division (http://soki.aq/). Shared platforms such as SOKI provide a dynamic environment where food-web models can be transparently documented and peer-reviewed openly by registered users. This means that uncertainties related to model construction and errors in input data can be clearly flagged during the model's development.

The structure of the Prydz Bay Ecopath model was developed to capture the prevalent trophic interactions within the system and coincide with limitations in available data. This was achieved through the development of a decision framework for aggregating species

into functional groups coupled with information from the Southern Ocean dietary database (Raymond et al., 2011; McCormack et al., 2017). The process contributed to ensuring the limitations and assumptions within the model were transparent to external users and assisted in determining the appropriate level of species aggregation for our research purposes (McCormack et al., 2017).

A common approach for accounting for uncertainties arising from differences in model structure is to develop an ensemble of ecosystem models to identify the greatest uncertainties arising from differences in model structure (Woodworth-Jefcoats et al., 2015). The Prydz Bay Ecopath model is a part of a larger effort to assess food-web structure and energy flow within the Indian sector of the Southern Ocean. Currently an ensemble of ecosystem models are under development for the Indian sector, including another Ecopath model for the northern Kerguelen Plateau region, a size-based ecosystem model (Scott et al., 2014) and implementations of SEAPODYM (Lehodey et al., 2014) and Atlantis (Audzijonyte et al., 2017). Future research will aim to develop a model inter-comparison study to provide greater confidence in model outputs and a better understanding of the relative importance of drivers of change in the region.

Whilst considerable work is still required to implement the Prydz Bay Ecopath model successfully, the steps taken to clearly document the model's development, including the use of an open-source platform such as SOKI and utilising the Southern Ocean dietary database to inform the appropriate model resolution, are valuable actions that will help facilitate further collaboration and research efforts within the region. Ecosystem models will be important tools for the future integrated management and scientific exploration of the Kerguelen Plateau region with the development of successful model ensembles an important goal for improving confidence in the knowledge gained from model outputs. The Ecopath model SOKI pages can be found at http://soki.aq/x/AoCxAQ.

Acknowledgements

References

Audzijonyte, A., R. Gorton, I. Kaplan and E.A. Fulton. 2017. *Atlantic User's Guide Part I: General Overview*. Physics & Ecology. CSIRO document.

Christensen, V. and D. Pauly. 1992. ECOPATH II – a software for balancing steady-state ecosystem models and calculating network characteristics. *Ecol. Model.*, 61: 169–185.

Christensen, V. and C.J. Walters. 2004. Ecopath with Ecosim: methods, capabilities and limitations. *Ecol. Model.*, 172: 109–139.

Erfan, A. and T.J. Pitcher. 2005. An ecosystem simulation model of the Antarctic Peninsula. *Modelling Antarctic marine ecosystems: Fisheries Centre Research Reports*, 13: 5–20.

Hill, S.L., K. Keeble, A. Atkinson and E. J. Murphy. 2012. A foodweb model to explore uncertainties in the South Georgia shelf pelagic ecosystem. *Deep-Sea Res. II.*, 59: 237–252.

Lehodey, P., A. Conchon, I. Senina, R. Domokos, B. Calmettes, J. Jouanno, O. Hernandez and R. Kloser. 2014. Optimization of a micronekton model with acoustic data. *ICES J. Mar. Sci.*, 72: 1399–1412.

McCormack, S.A., J. Melbourne-Thomas, R. Trebilco, J.L. Blanchard and A. Constable. 2017. Simplification of complex ecological networks – species aggregation in Antarctic food web models. In: Syme, G., D. Hatton MacDonald, B. Fulton and J. Piantadosi (Eds). *MODSIM2017, 22nd International Congress on Modelling and Simulation*. Modelling and Simulation Society of Australia and New Zealand, December 2017: 264–270.

Murphy, E.J., R.D. Cavanagh, E.E. Hofmann, S.L. Hill, A.J. Constable, D.P. Costa M.H. Pinkerton, N.M. Johnston, P.N. Trathan, J.M.Klinck, D.A. Wolf-Gladrow, K.L. Daly, O.Maury and S.C. Doney. 2012. Developing integrated models of Southern Ocean food webs: including ecological complexity, accounting for uncertainty and the importance of scale. *Prog. Oceanogr.*, 102: 74–92.

Pinkerton, M.H., J.M. Bradford-Grieve and S.M. Hanchet. 2010. A balanced model of the food web of the Ross Sea, Antarctica. *CCAMLR Science*, 17: 1–31.

Polovina, J.J. 1984. Model of a coral reef ecosystem. *Coral Reefs*, 3: 1–11.

Raymond, B., M. Marshall, G. Nevitt, C.L. Gillies, J. Van Den Hoff, J.S. Stark, M. Losekoot, E.J. Woehler and A.J. Constable. 2011. A Southern Ocean dietary database. *Ecology*, 92: 1188–1188.

Scott, F., J.L. Blanchard and K.H. Anderson. 2014. mizer: an R package for multispecies, trait-based and community size spectrum ecological modelling. *Methods Ecol. Evol.*, 5: 1121–1125.

Smith, W.O., D.G. Ainley and R. Cattaneo-Vietti. 2007. Trophic interactions within the Ross Sea continental shelf ecosystem. *Phil. Trans. R. Soc. Lond. B.*, 362: 95–111.

Suprenand, P.M. and C.H. Ainsworth. 2017. Trophodynamic effects of climate change-induced alterations to primary production along the western Antarctic Peninsula. *Mar. Ecol. Prog. Ser.*, 569: 37–54.

Woodworth-Jefcoats, P.A., J.J. Polovina, E.A. Howell and J.L. Blanchard. 2015. Two takes on the ecosystem impacts of climate change and fishing: Comparing a size-based and a species-based ecosystem model in the central North Pacific. *Prog. Oceanogr.*, 138: 533–545.