ANTARCTIC CLIMATE & ECOSYSTEMS CRC

Antarctic Climate & Ecosystems Cooperative Research Centre
Location 20 Castray Esplanade, Hobart, Tasmania, 7000
Postal Private Bag 80, Hobart Tasmania 7001, Australia

www.acecrc.org.au

SCAR Fellowship Report 2015/2016

Rowan Trebilco, Antarctic Climate and Ecosystems CRC

Project Title: New models for understanding the role of mesopelagic fishes and squid in Southern Ocean ecosystems

Hosts

Professor Guy Duhamel, Muséum National d'Histoire Naturelle (MNHN)
Dr. Patrick Lehodey, Collecte Localisation Satellites (CLS)

Visit duration

May 5th – July 27th 2016

Introduction

The Southern Ocean is rapidly changing, with future environmental changes likely to have wide- reaching consequences for the structure and function of marine ecosystems (Constable et al. 2014). Along with well-designed observation programs, ecosystem models are the central means by which we can gain insight into how these changes affect ecosystems, providing the necessary information to guide management decisions into the future.

Mesopelagic fishes and squids, together with krill, dominate mid- trophic levels in Southern Ocean ecosystems, comprising the pathways by which energy from primary producers is made accessible to higher-order predators including whales, seals, penguins, flying seabirds, and large (often commercially valuable) fish (Kozlov 2006, Collins and Rodhouse 2006). The short, krill- dominated food chains are well studied and relatively well represented in ecosystem models (Hill et al. 2006, Murphy et al. 2012). However, squid and mesopelagic fish are far less well studied and represent a key area of uncertainty in current ecosystem modelling efforts (Hill et al. 2006, Murphy et al. 2012). Knowledge of mid- trophic levels has also been identified as a key uncertainty for understanding top predator trophodynamics globally (Young et al. 2015), and this knowledge gap represents a major impediment to the development of conservation and management strategies (Constable et al. 2014, IMBER 2015).

The ACE CRC is a unique collaboration between core partners the Australian Antarctic Division, the Bureau of Meteorology, CSIRO, the University of Tasmania, the Department of the Environment, the Alfred Wegener Institute for Polar and Marine Research (Germany), the National Institute of Water and Atmospheric Research (NZ) and a consortium of supporting partners. It is funded by the Australian Government's Cooperative Research Centres Programme.

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Given the importance of mesopelagic fish and squid in Southern Ocean foodwebs, there is a strong imperative to develop robust and informative model representations. Over the past decade, two modeling approaches have been developed that offer great promise in this regard. These are the SEAPODYM modeling framework (Lehodey et al. 2008, 2010) and dynamical size spectra models (Blanchard et al. 2011, Scott et al. 2014). Both approaches are particularly well-suited for improving model representation of mesopelagic groups and improving our understanding of their ecosystem role because: (i) these approaches account for the effects of diurnal vertical migrations on predator-prey interactions (including availability of mesopelagic prey to higher predators); and (ii) they do not require the detailed biomass and dietary data that present a stumbling block for other modeling approaches. Neither approach has yet been implemented fully in the Southern Ocean. Therefore, the goal of my fellowship were to:
(i) work with Guy Duhamel and his team at MNHN to progress the collation and synthesis of key data for the development and of dynamical size spectra models; and (ii) work with Patrick Lehodey and his team at CLS to develop an implementation of the SEAPODYM mesopelagic model for the Kerguelen Plateau region and more broadly for East Antarctica.

The overarching aim of this work is to establish consistent and comparable models for the region, which have model behaviours that can replicate available mesopelagic data, and it is part of wider effort within the ACE CRC to develop a model ensemble for this region. Once tested, these models are expected to be able to be used to:
(i) assess the food-web effects of finfish fisheries and climate change in the region;
(ii) identify and evaluate potential indicators of change, and;
(iii) understand the implications of change for higher trophic levels (marine mammals, seabirds and large fishes).
Having an ensemble of models available for these tasks will enable more robust assessment of whether the outcomes are sensitive to model assumptions [4]. The different models will also enable a greater breadth of ecosystem scenarios to be evaluated.

Outcomes of fellowship
At the start of 2016 (Jan-Mar), I co-led the fish sampling component of a research expedition led by the ACE CRC aiming to resolve the structure and key environmental drivers of the pelagic foodwebs on the Southern Kerguelen Plateau (the K-Axis voyage: http://k-axis.voyage/). On this voyage we sampled the mesopelagic community using an IYGPT (International Young Gadoid Pelagic Trawl) net equipped with a MIDOC (MIDwater Opening/Closing) multiple cod-end device

that allowed the catch to be split into five 200m strata to 1000m. This sampling provides a key source of information for model development and evaluation. A large proportion of my time at MNHN (May-July 2016) was therefore spent working with colleagues who had been involved in the planning of the K-Axis voyage, to process data collected on the voyage. In particular, we identified and measured some 17,000 individual fishes that had been photographed when processing catch at sea. At CLS (June 206), I worked with Patrick Lehodey and his team on tuning an implementation of SEAPODYM for the Kerguelen Plateau, and also assisted with a new larger-scope implementation for wider East Antarctica.

Progress made during my SCAR fellowship fed directly into two workshops held in Hobart in early September 2016. The first of these was the kick-off meeting and planning workshop for MESOPP (Mesopelagic Southern Ocean Predators and Prey), an EU-Australia research partnership aimed at improving understanding of the distribution, biomass and utilisation by top predators of mesopelagic prey resources in the Southern Ocean. The SEAPODYM and size spectra models I worked on during my SCAR fellowship will be a key component of the MESOPP work, along with additional models for the Tasman and Scotia Seas. The second workshop leading on from my SCAR fellowship was a workshop on dynamical size spectra models for the Southern Ocean, which I organised to engage local collaborators on this work. The goal of this workshop was to synthesise expert knowledge of other ecosystem components (zooplankton, seabirds, marine mammals, large predatory fishes) to ensure that they are realistically and usefully represented in the models.

Following on from these workshops, I will continue to lead the development of size spectra models, and engage with colleagues at CLS to continue the optimisation and evaluation of SEAPODYM implementations. I anticipate that the first publication on size spectra models will be submitted by the end of the year; with at least one SEAPODYM paper to follow in early 2017.

Presentations and manuscripts
I presented work undertaken during my SCAR fellowship at international conferences including:

- SCAR Open Science, August 2016, Kuala Lumpur (SCAR/COMNAP Fellows Session) Talk title: "*New models and data for understanding the role of mesopelagic fishes and squid in Southern Ocean ecosystems*"
- The Australian Society for Fish Biology Annual meeting, Hobart, September 2016. Talk Title: "*New data and models to resolve ecosystem status and trends on the Kerguelen Axis in the Southern Indian Ocean*".

The following manuscripts are in preparation for, submission over the coming year, incorporating work undertaken during my SCAR fellowship:

1. **Trebilco R.**, Melbourne-Thomas J., Constable A., Hindell M., Blanchard J., et al. A size-spectrum model to understand energy flows and biomass distribution in Southern Ocean ecosystems, intended submission: *Ecosystems*, early 2017.
2. **Trebilco R.**, Walters A., Duhamel G. Pruvost P., Koubbi P., Melbourne-Thomas J., Constable A., et al. Size-based insight into the structure and function of pelagic foodwebs in the Southern Indian Ocean, intended submission: *Deep Sea Research II*, early 2017.
3. McCormack S., **Trebilco R.**, Melbourne-Thomas J., Constable A. & Blanchard J. Energy flow in Southern Ocean ecosystems: comparing mass balance and size-based approaches, intended submission: *Progress in Oceanography*, late 2017.
4. **Trebilco R.**, Lehodey P., Conchon A., Melbourne-Thomas J., Constable A., et al. Modelling micronekton prey availability and predator habitat on the Kerguelen Plateau., intended submission: *Journal of Marine Systems*, late 2017.

Financial Statement:

Funds provided by the fellowship covered the cost of a 3-month stay in France. The full award amount of US$7000 was spent, with the majority divided between transport costs ($2300, including return airfares and trains between Paris and Toulouse) and accommodation ($3900). The remaining $800 was used for subsistence living costs.

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References

Blanchard J.L. *et al.* (2011) Coupled energy pathways and the resilience of size-structured food webs. *Theoretical Ecology,* 78, 270–280.

Collins M. A., & Rodhouse P. G. K. (2006). Southern Ocean Cephalopods. In *Advances in Marine Biology,* 50, 191– 265.

Constable A. J., Melbourne-Thomas J, Corney S, et al. (2014). Climate change and Southern Ocean ecosystems I: how changes in physical habitats directly affect marine biota. *Global Change Biology,* 20, 3004–3025.

Hill S.L., Murphy E.J., Reid K., Trathan P.N. and Constable, A.J. (2006) Modelling Southern Ocean ecosystems: krill, the food-web, and the impacts of harvesting. *Biological Reviews,* 81, 581–608.

Integrated Marine Biogeochemistry and Ecosytem Research (IMBER). (2015). Science Plan and Implementation Strategy.

Kozlov A. 2006. A review of the trophic role of mesopelagic fish of the family Myctophidae in the Southern Ocean ecosystem. *CCAMLR Science,* 2, 71–77.

Lehodey P. *et al.* (2008) A spatial ecosystem and populations dynamics model (SEAPODYM) – Modeling of tuna and tuna-like populations. *Prog. Oceanogr.,* 78, 304–318.

Lehodey P. *et al.* (2010) Bridging the gap from ocean models to population dynamics of large marine predators: A model of mid-trophic functional groups. *Prog. Oceanogr.,* 84, 69–84.

Murphy E. J., Cavanagh R., Hofmann E, et al. (2012). Developing integrated models of Southern Ocean food webs: Including ecological complexity, accounting for uncertainty and the importance of scale. Progress In Oceanography, 102, 74–92.

Scott F. *et al.* (2014) mizer: an R package for multispecies, trait-based and community size spectrum ecological modelling. *Methods Ecol. Evol., 5*, 1121–1125.

Young J., Hunt B., Cook T. et al. (2015). The trophodynamics of marine top predators: Current knowledge, recent advances and challenges. *Deep-Sea Research Part II,* 113, 170–187.