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Extended abstract

Mesopelagic community structure on the southern Kerguelen Axis

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From January to March 2016, the Antarctic Climate and Ecosystems Corporate Research Centre (ACE CRC) led an integrated ecosystem survey voyage on the Southern Kerguelen Axis (the region spanning BANZARE Bank and the Princess Elizabeth Trough (PET), south toward the Antarctic continental shelf and Prydz Bay). The voyage track spanned 8 850 km, comprised of eight sampling transects, which were designed to encompass major environmental transitions in the area (Figure 1). Overarching goals of this voyage were to characterise pelagic food-web structure and major energy pathways in the region, and to pilot methodologies for future ecosystem observation and monitoring. A key component of the study was sampling the mesopelagic community to resolve key drivers of the abundance and biomass of major mesopelagic taxa (fishes, crustaceans, squids and gelatinous zooplankton), which are key prey for higher-trophic levels, and represent an important alternative energy pathway to krill.

The mesopelagic community was sampled at 36 stations along the voyage track, from the surface to 1 000 m, using an International Young Gadoid Pelagic Trawl net (IYGPT, with an opening of 188 m^2) equipped with a multiple opening and closing codend device (MIDOC). The MIDOC comprises six separate codends (with a mesh size of 20 mm, terminating in a removable 'soft' codend bag made of 0.5 mm mesh). The MIDOC allows codends to be opened sequentially at pre-programmed intervals, such that each codend samples a different depth stratum. The first codend was open as the net descended from the surface to a maximum depth of 1 000 m, then the remaining five codends each sampled a 200 m depth band as the net returned to the surface (1 000–800 m, 800–600 m, 600–400 m, 400–200 m and 200 m–surface). Nets were towed for 30 min at an average speed of 2.7 knots for each 200 m depth band (covering a mean distance of 1.35 n miles, and sweeping a mean volume of 450 800 m^3), and at 3.9 knots for 60 to 90 minutes for the first descending codend (covering a mean distance of 5.95 nautical miles and sweeping a mean volume of 1.98×10^6 m^3).

Catch was converted to densities by dividing numbers and weights by the volume swept for each codend. Acoustic backscatter in the water column was characterised during tows using a Simrad EK60 echosounder operated at 38 kHz. Acoustic data were filtered, and quality controlled prior to the derivation of the total nautical area scattering coefficient (NASC) for the time period and depth range corresponding to each depth stratum. NASC is an acoustic density measure, corresponding to the acoustic energy per unit distance, which can be translated into biologically more meaningful biomass or abundance estimates, if the species composition and the sound scattering of an individual of the given species group is known.

Cnidarians typically dominated the catch in terms of absolute wet weight, with salps making substantial contributions at several stations, particularly around the PET (Figures 2 and 3). Fish represented a smaller but consistently important component of the catch. The biomass of krill and cephalopods were similar (generally less than that of fish) at most stations (Figures 2 and 3).

Patterns of catch contribution were relatively consistent across the study region, with the exception of stations where salps dominated. Cnidarians and fish contributed

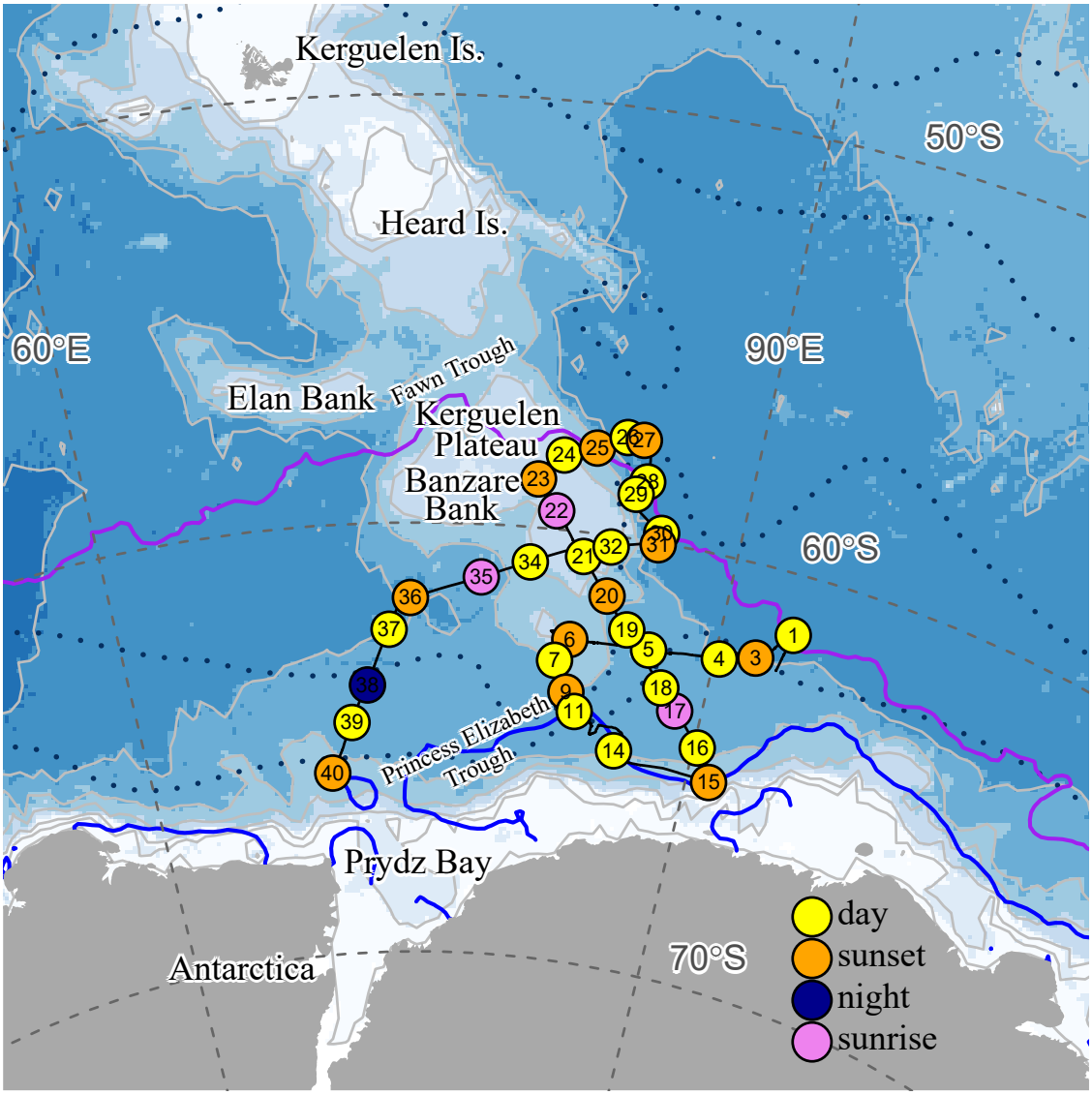

Figure 1: Stations where the mesopelagic community of the southern Kerguelen Axis was sampled by midwater trawling in January to February 2016. Colour of points indicates the timing of sampling relative to sunrise and sunset. Dotted blue lines indicate climatological locations of the major Antarctic Circumpolar Current (ACC) fronts (north to south: Polar front; southern ACC front, southern boundary of the ACC) following Orsi et al. (1995). Purple and blue contours respectively indicate the winter maximum (November 2015) and summer minimum (January 2016) sea-ice extent (>15% sea-ice concentration) for the study season.

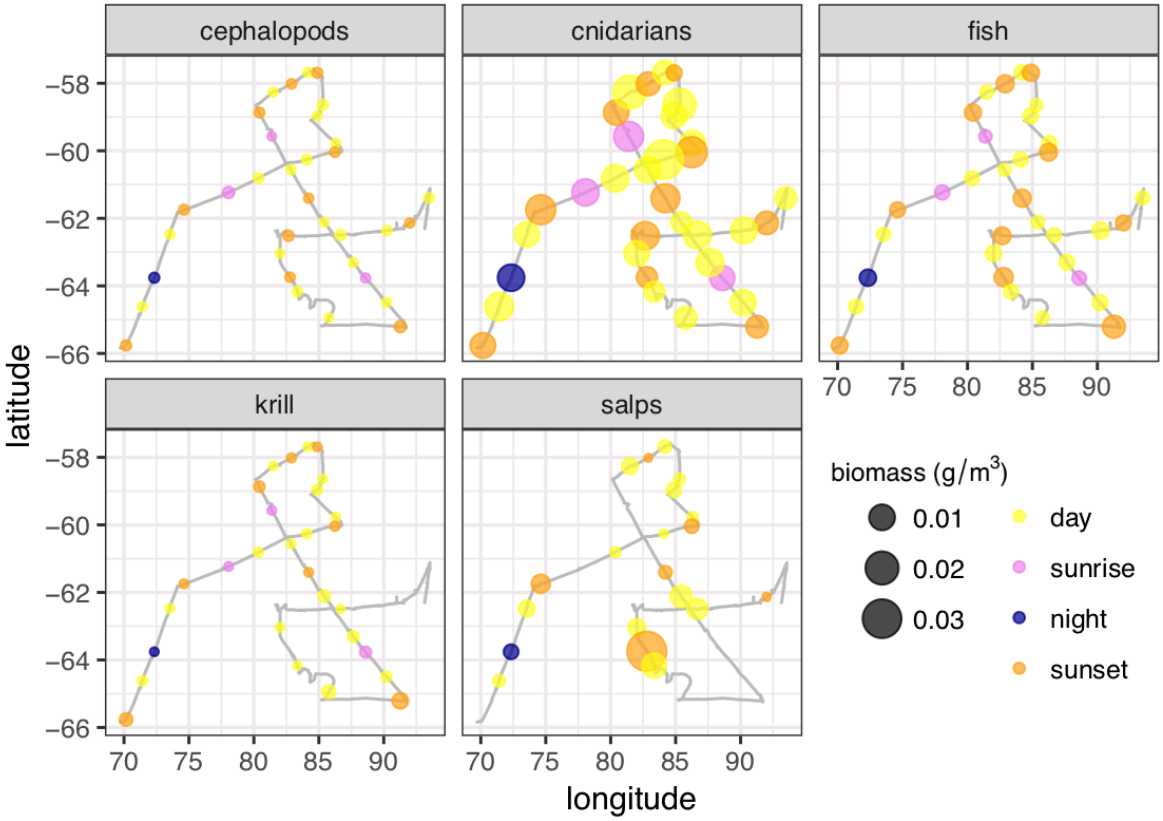

Figure 2: Biomass density of catch of major groups from midwater trawl sampling over the southern Kerguelen Plateau (across all ascending codends, from 1 000 m to the surface).

to catch biomass across all depth strata (Figure 3), while substantial salp and krill catches were mainly restricted to the upper 400 m and 200 m respectively.

The most obvious diurnal pattern in catch composition was that the relative contribution of fish to total biomass tended to be greatest in deeper strata (below 600 m) during day trawls, with a greater proportional contribution of fish biomass closer to the surface being more typical of crepuscular (sunrise and sunset) trawls (Figure 3). Only one station (MIDOC 38) was a full night trawl (i.e. with the net both deployed and retrieved between sunset and sunrise); this station had a substantial contribution of fish biomass across all depth strata. No clear diurnal pattern was evident for cephalopod biomass (Figure 3).

Total acoustic backscatter (the sum of NASC for the depth-stratum of the water column corresponding to each codend) was most strongly associated with biomass density of fish in the 200–400 m depth stratum ($R^2 = 0.4$; Figure 4). Relationships between acoustic backscatter and catch biomass density were weak for other taxa and depth strata.

Energy flow through mid-trophic levels, particularly those in ocean ecosystems dominated by mesopelagic fishes and squids, is a key area of uncertainty in efforts to understand and model the structure and function of food webs in the Southern Ocean and more widely (Young et al., 2015; Hofmann et al., 2016). Resolving this relies upon knowledge of community structure as presented here (and in a forthcoming special issue in the journal *Deep-Sea Research Part II: Topical Studies in Oceanography*), trophic linkages and environmental drivers of both. Trophic linkages in the fish caught on the Kerguelen Axis voyage have been explored using molecular tools (Clarke et al., 2018, 2019), stable isotopes (Woods et al., 2019), and visual analysis of stomach contents (Riaz et al., submitted).

These studies build upon information from the more northern part of the Kerguelen Plateau (e.g. Williams et al., 2011; Duhamel et al., 2014), elsewhere in the Southern Ocean (e.g. Saunders et al., 2017; Flynn and Williams, 2012), and at lower latitudes (e.g. Choy et al., 2016), working towards an integrated picture of Southern Ocean mesopelagic community structure and trophodynamics, and helping to provide the necessary information for the development and evaluation of ecosystem models (e.g. McCormack et al., 2019).

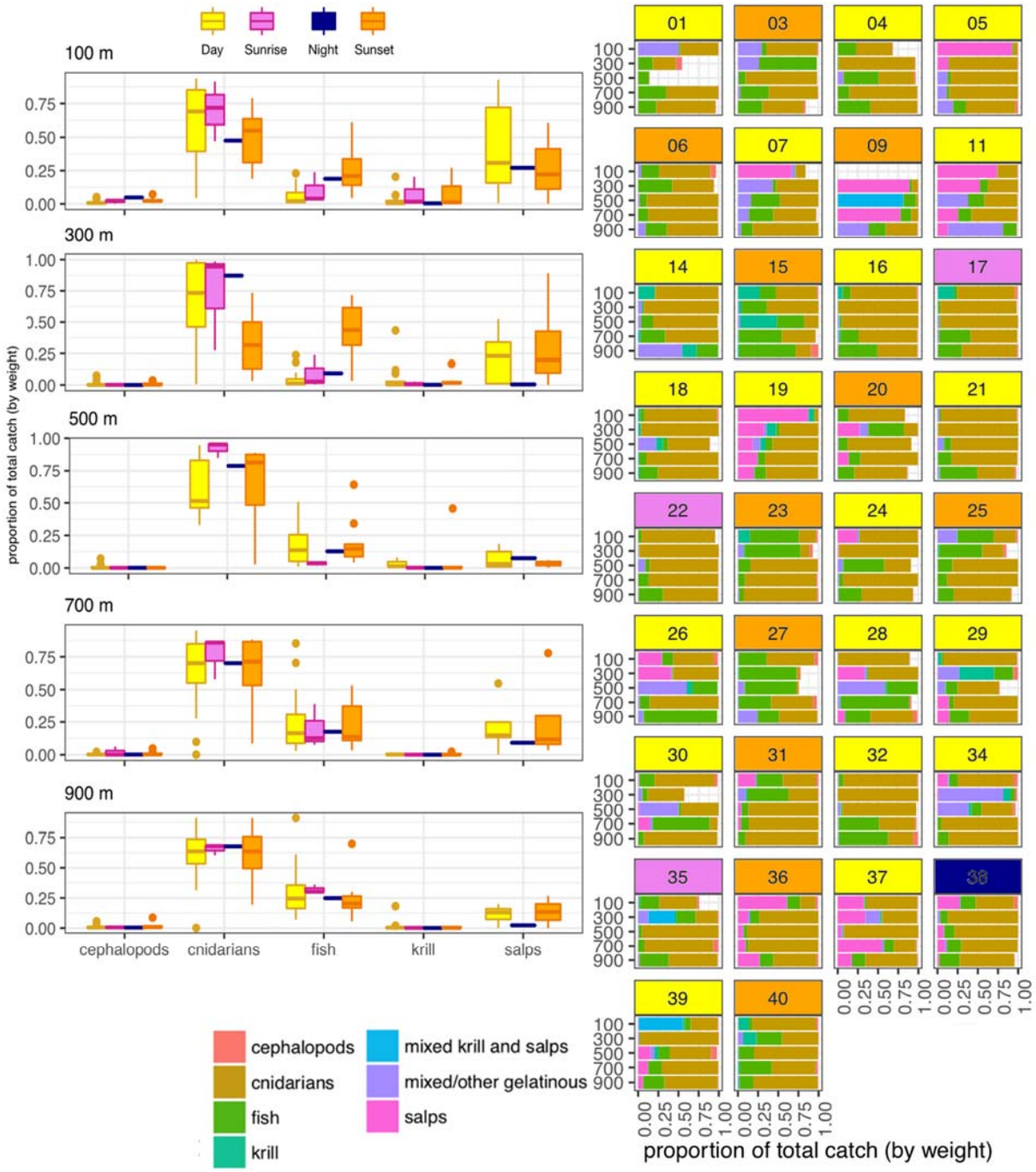

Figure 3: The proportional contributions of major groups to the total catch (in terms of wet weight) from midwater trawl sampling. LHS shows variation across depth strata (depth labels correspond to the mid-point of each 200 m stratum) and with time of day using boxplots (mid-lines – means, box span – 25% to 75% quantiles, whiskers span to 1.5 × interquartile range beyond boxes, points show outliers beyond this). RHS shows relative contributions of taxa to catch by depth strata for each MIDOC station (colouring of title bars corresponds to colour code in LHS panel for time of day of each shot).

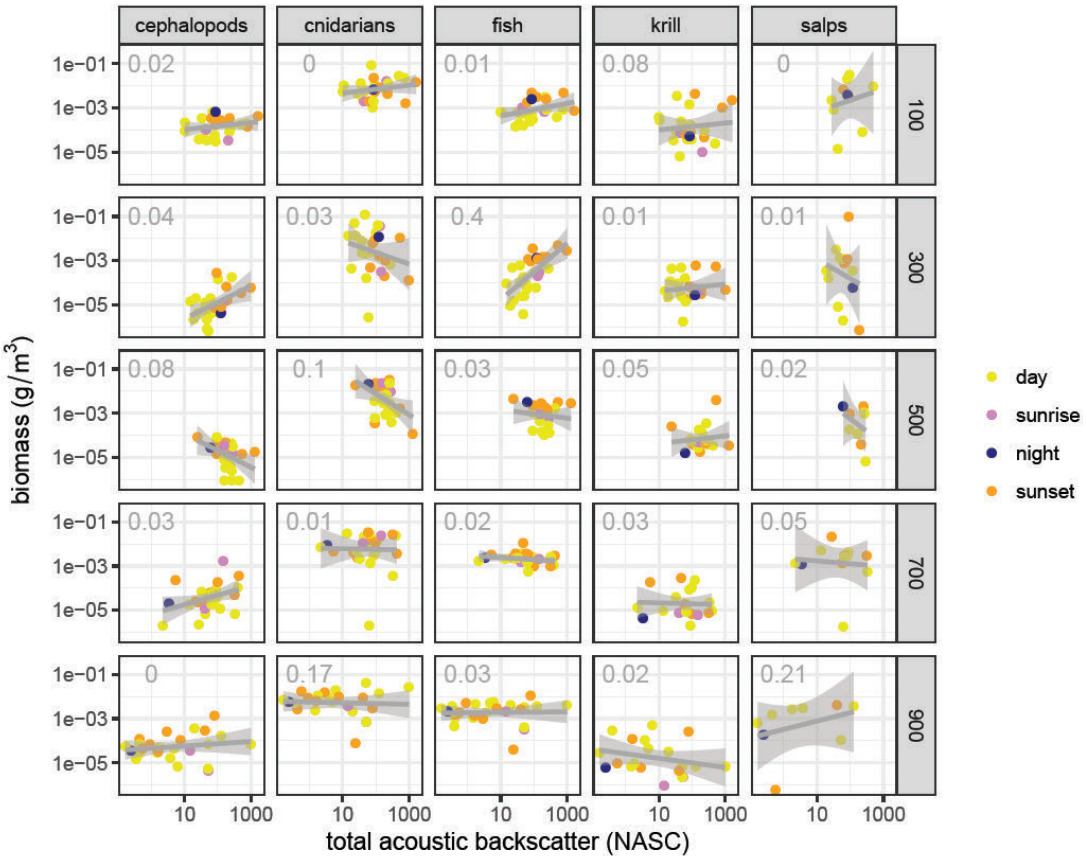

Figure 4: The relationship between total acoustic backscatter (the sum of the nautical area scattering coefficient for filtered data) and biomass density of major taxa caught in each codend (200 m depth strata) from mesopelagic trawls. Numbers in each panel show pairwise Pearson correlation coefficients (R^2). Lines and error bars show linear regression with 95% confidence intervals.

Acknowledgements

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References

Choy, C.A., C. Wabnitz, M. Weijerman, P.A. Woodworth-Jefcoats and J.J. Polovina. 2016. Finding the way to the top: how the composition of oceanic mid-trophic micronekton groups determines apex predator biomass in the central North Pacific. *Mar. Ecol. Prog. Ser.*, 549: 9–25.

Clarke, L.J., R. Trebilco, A. Walters, A.M. Polanowski and B.E. Deagle. 2018. DNA-based diet analysis of mesopelagic fish from the southern Kerguelen Axis. *Deep-Sea Res II*.

Clarke, L.J., R. Trebilco, A. Walters, A.M. Polanowski and Deagle B.E. 2019. What DNA in fish stomachs can tell us about the Southern Ocean. In: Welsford, D., J. Dell and G. Duhamel (Eds). *The Kerguelen Plateau: marine ecosystem and fisheries. Proceedings of the Second Symposium*. Australian Antarctic Division, Kingston, Tasmania, Australia: this volume.

Duhamel, G., P.-A. Hulley, R. Causse, P. Koubbi, M. Vacchi, P. Pruvost, S. Vigetta, J.-O. Irisson, S. Mormède, M. Belchier, A. Dettai, H.W. Detrich, J. Gutt, C.D. Jones, K.-H. Kock, L.J. Lopez Abellan and A.P. Van de Putte. 2014. Part 7. Biogeographic patterns of fish. In: De Broyer, C. and P. Koubbi (Eds). *Biogeographic Atlas of the Southern Ocean*. Scientific Committee on Antarctic Research, Cambridge, UK: 328–362 pp.

Flynn, A.J. and A. Williams. 2012. Lanternfish (Pisces: Myctophidae) biomass distribution and oceanographic - topographic associations at Macquarie Island, Southern Ocean. *Mar. Freshwater Res.*, 63 (3): 251–263.

Hofmann, E.E. and the IMBeR Scientific Steering Committee (Eds.). 2016. *IMBeR 2016–2025: Science Plan and Implementation Strategy*. IMBeR International Project Office, Bergen, Norway.

McCormack, S.A., R. Trebilco, J. Melbourne-Thomas, A. Constable, J.L. Blanchard. 2019. A food web model for the southern Kerguelen Plateau region. In: Welsford, D., J. Dell and G. Duhamel (Eds). *The Kerguelen Plateau: marine ecosystem and fisheries. Proceedings of the Second Symposium*. Australian Antarctic Division, Kingston, Tasmania, Australia: this volume.

Orsi, A.H., T. Whitworth III and W.D. Nowlin Jr. 1995. On the meridional extent and fronts of the Antarctic Circumpolar Current. *Deep-Sea Res. I*, 42: 641–673.

Riaz, J., A. Walters, R. Trebilco, S. Bestley and M. Lea. (Submitted). Stomach content analysis of mesopelagic fish from the southern Kerguelen Axis. *Deep-Sea Res II*.

Saunders, R.A., M.A Collins, G. Stowasser and G.A. Tarling. 2017. Southern Ocean mesopelagic fish communities in the Scotia Sea are sustained by mass immigration. *Mar. Ecol. Prog. Ser*., 569: 173–185.

Williams, R., B.P.V. Hunt, S.R. Davenport and T.D. Lamb. 2011. Population structure, feeding biology and predation impact of midwater fishes in predator feeding areas around Heard and McDonald Islands, Southern Indian Ocean. In: Duhamel, G. and D. Welsford (Eds). *The Kerguelen Plateau: marine ecosystem and fisheries*. Société Française d'Ichtyologie, Paris, France: 181–182.

Woods, B., R. Trebilco, A. Walters and M.A. Hindell. 2019. Isotopic niches of Mesopelagic fish on the southern Kerguelen Axis: variation and overlap. In: Welsford, D., J. Dell and G. Duhamel (Eds). *The Kerguelen Plateau: marine ecosystem and fisheries. Proceedings of the Second Symposium*. Australian Antarctic Division, Kingston, Tasmania, Australia: this volume.

Young, J.W., B.P.V. Hunt, T.R. Cook, J.K. Llopiz, E.L. Hazen, H.R. Pethybridge, D. Ceccarelli, A. Lorrain, R.J. Olson, V. Hélène Allain, C. Menkes, T. Patterson, S. Nicol, P. Lehodeym, R.J. Kloser, H. Arrizabalaga and C. Anela Choy. 2015. The trophodynamics of marine top predators: Current knowledge, recent advances and challenges. *Deep-Sea Res. II*, 113: 170–187.