

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN AUSTRALIA

May 1st, 2016 to April 30th, 2017

New scientific results

The GEOTRACES Process Study ‘K-Axis’ (“Assessment of habitats, productivity and food webs on the Kerguelen Axis in the Indian Sector of the Southern Ocean”) in 2016 examined the principal drivers of ecosystem structure and processes around the southern Kerguelen plateau and included a trace element biogeochemistry component. Depth-profiles of dissolved iron ($<0.2 \mu\text{m}$, dFe) to a depth of 2000 m were measured at 25 stations in the vicinity of Banzare Bank in the Indian sector of the Southern Ocean during austral summer 2016. Observed dFe concentrations in surface waters (≤ 100 m depth) ranged from below the detection limit ($\text{DL} = 0.042 \pm 0.027 \text{ nmol kg}^{-1}$) to $0.34 \text{ nmol kg}^{-1}$, with almost 50% of values below DL. Such low dFe values suggest drawdown of this essential micronutrient by phytoplankton over the summer. At depth (300-2000 m), the median dFe concentration was $0.28 \text{ nmol kg}^{-1}$, with maximum values near the coast (up to $1.27 \text{ nmol kg}^{-1}$). The cruise track crossed several fronts, enabling us to sample water masses reaching from south of the Southern Boundary (SB) to north of the south Antarctic Circumpolar Current front (sACCF). Observed dFe distributions and analysis of the physical oceanography in the region indicate a diverse mosaic of dFe supply mechanisms. We also note distinct contrasts between: (i) the ‘southern’ Banzare bank Fe supply, where waters South of the bank are mainly supplied from the Antarctic shelf and sea ice sources, while upwelling and divergence around the flanks and in the Princess Elizabeth Trough (PET) result in sustained phytoplankton blooms in the PET and around the flanks of Banzare bank, and (ii) the ‘northern’ Kerguelen Plateau where sediment and glaciers deliver Fe over the shallow and well-mixed plateau and horizontal transports deliver Fe downstream in the plume, resulting in a sustained phytoplankton bloom over the plateau compared to a “bloom and bust” in the plume.

New publications (published or in press)

- Boyd, P.W., Ellwood, M.J., Tagliabue, A. and Twining, B.S. 2017. Biotic and abiotic retention, recycling and remineralization of metals in the ocean. *Nature Geoscience*, 10(3): 167-173.
- Boyd, P.W. and Bressac, M., 2016. Developing a test-bed for robust research governance of geoengineering: the contribution of ocean iron biogeochemistry. *Philosophical Transactions of the Royal Society A*, 374(2081), pp.20150299–22.
- Durand, A., Chase, Z., Townsend, A.T., Noble, T., Panietz, E. and Goemann, K. 2016. Improved methodology for the microwave digestion of carbonate-rich environmental samples. *International Journal of Environmental Analytical Chemistry*, pp.1–19.
- Hassler, C.S., van den Berg, C.M.G., and P.W. Boyd. 2017. Toward a Regional Classification to Provide a More Inclusive Examination of the Ocean Biogeochemistry of Iron-Binding Ligands, *Front. Mar. Sci.*, 01, <https://doi.org/10.3389/fmars.2017.00019>
- Holmes, T.M., Chase, Z., van der Merwe, P., Townsend, A.T., Bowie, A.R. In Revision. The impact of hydrothermal vents on ocean iron concentrations and biogeochemistry: a review. *Marine and Freshwater Research*.

- Hutchins, D.A. and Boyd, P.W., 2016. Marine phytoplankton and the changing ocean iron cycle. *Nature Climate Change*, 6(12), pp.1072–1079.
- Heller, M.I., Wuttig, K. and Croot, P. L. 2016. Identifying the Sources and Sinks of CDOM/FDOM across the Mauritanian Shelf and Their Potential Role in the Decomposition of Superoxide (O₂⁻). *Front. Mar. Sci.* 3:132. doi:10.3389/fmars.2016.00132
- Lannuzel, D., Chever, F., van der Merwe, P., Janssens, J., Roukaerts, A., Cavagna, A.J., Townsend, A.T., Bowie, A.R., and Meiners, K.M. 2016. Iron biogeochemistry in Antarctic pack ice during SIPEX2, *Deep Sea Research II*, 131 pp. 111-122.
- Lemaitre, N., Planquette, H., Dehairs, F., van der Merwe, P., Bowie, A.R., Trull, T.W. Laurenceau-Cornec, E.C., Davies, D., Bollinger, C., Le Goff, M., Grossteffan, E., and Planchon, F. 2016. Impact of the natural Fe fertilization on the magnitude, stoichiometry and efficiency of particulate biogenic silica, nitrogen and iron export fluxes”, *Deep Sea Research. Part 1*, 117 pp. 1127.
- Ratnarajah, L. and Bowie, A.R., Nutrient cycling: are Antarctic krill a previously overlooked source in the marine iron cycle? 2016. *Current Biology*, 26 (19) pp. R884–R887.
- Ratnarajah, L., Nicol, S., Kawaguchi, S., Townsend, A.T., Lannuzel, D., Meiners, K.M. and Bowie, A.R. 2016. Understanding the variability in the iron concentration of Antarctic krill, *Limnology and Oceanography*, 61 (5) pp. 1651-1660.
- Samanta, M., Ellwood, M.J., Sinoir, M. and Hassler, C.S. In Press. Dissolved zinc isotope cycling in the Tasman Sea, SW Pacific Ocean. *Marine Chemistry*. <http://doi.org/10.1016/j.marchem.2017.03.004>
- Schallenberg, C., van Der Merwe, P., Chever, F., Cullen, J.T., Lannuzel, D., and Bowie, A.R. 2016. Dissolved iron and iron(II) distributions beneath the pack ice in the East Antarctic (120 °E) during the winter/spring transition, *Deep Sea Research: Part II*, 131 pp. 96–110.
- Scholz, F., Löscher, C. R., Fiskal, A., Sommer, S., Hensen, C., Lomnitz, U., Wuttig, K., Göttlicher, J., Kossel, E., Steininger, R., and Canfield, D. E. 2016. Nitrate-dependent iron oxidation limits iron transport in anoxic ocean regions. *Earth and Planetary Science Letters* 454: 272-281
- Sinoir, M., Ellwood, M.J., Butler, E.C.V., Bowie, A.R., Mongin, M., and Hassler, C.S. 2016. Zinc cycling in the Tasman Sea: Distribution, speciation and relation to phytoplankton community. *Marine Chemistry* 182, 25-37.
- Tagliabue, A., Bowie, B., Boyd, P., Buck, K., Johnson, K., and Saito, M. 2016. The integral role of iron in ocean biogeochemistry. *Nature* 543, 51–59, doi:10.1038/nature21058
- Velasquez, I.B., Ibisami, E., Maas, E.W., Boyd, P.W., Nodder, S. and Sander, S.G. 2016. Ferrioxamine Siderophores Detected amongst Iron Binding Ligands Produced during the Remineralization of Marine Particles, *Front. Mar. Sci.*, 22 September 2016 | <https://doi.org/10.3389/fmars.2016.00172>
- Villa-Alfageme, M., Mas, J.L., Hurtado-Bermudez, S., and Masqué, P. 2016. Rapid determination of ²¹⁰Pb and ²¹⁰Po in water and application to marine samples, *Talanta*, Volume 160, Pages 28-35, <https://doi.org/10.1016/j.talanta.2016.06.051>.
- Winton, V.H.L., Edwards, R., Bowie, A.R. Keywood, M., Williams, A.G., Chambers, S.D., Selleck, P.W., Desservettaz, M., Mallet, M.D. and Paton Walsh, C. 2016. Dry season

aerosol iron solubility in tropical northern Australia. *Atmospheric Chemistry and Physics*, 16 (19) pp. 1282912848. ISSN 16807316 (2016)

Cruises

Voyages completed:

- *RV Akademik Tryoshnikov*: Leg 1, 20 December 2016 – 17 January 2017. Southern Ocean (GEOTRACES PI: Ellwood).
- *RV Aurora Australis* Voyage V1, December – January 2017, Antarctica, Mertz glacier region (GEOTRACES PIs: Lannuzel, Noble). Sea water and sea-ice samples were collected for micro-nutrient and Nd isotope measurements.
- *RV Investigator*, Jan – March 2017, Sabrina Seafloor Survey Antarctic margin (Totten glacier) (GEOTRACES PI: Noble). Sediment cores and large-volume seawater samples for Nd isotopic analysis were collected to investigate the interaction of the Totten Glacier with the Southern Ocean during the last deglaciation
- *RV Investigator* March 2017. Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site (GEOTRACES PIs: Boyd, Ellwood, Bowie). Collected dissolved and particulate trace metal samples. First successful deployment of the RESPIRE particle interceptor trap, for coupled measurement of trace metal remineralization and respiration rates.

Voyages scheduled for the next 12 months:

- SR3-GEOTRACES repeat transect (GEOTRACES PI: Bowie) “Detecting Southern Ocean Change From Repeat Hydrography, Deep Argo And Trace Element Biogeochemistry” (Southern Ocean section from Tasmania to Antarctica) voyage in January/February 2018 (45 days). The SR3 section was previously occupied during IPY-GEOTRACES in 2008, and we have the opportunity to expand the GEOTRACES measurements and spatial resolution on the 2018 voyage. To be proposed as full GEOTRACES section
- SOTS time series (GEOTRACES PIs: Boyd, Ellwood, Bowie) “Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site” (Subantarctic Southern Ocean south of Tasmania voyage in March 2018 (20 days)
- Two transit voyages around Australia under the project “Natural iron fertilisation of oceans around Australia: linking terrestrial dust and bushfires to marine Biogeochemistry” (PI Bowie) will provide GEOTRACES compliant aerosol data

New projects and/or funding

- ARC DP170102108 “Spinning the ferrous wheel: how is iron cycled in Southern Ocean waters?” Ellwood, Boyd, Armand, Wilhelm, Twining
- ARC LIEF funding, “A multi-institutional environmental radioactivity research centre” GEOTRACES CIs Masque, Boyd, Chase

Two shiptime awards for 2018-19 season:

- PIs Ellwood, Boyd, Chase, Abbott, Bowie. “Constraining external iron inputs and cycling in the southern extension of the East Australian Current”, \$2,185k in kind (23 days shiptime on *RV Investigator* in 2018-19)

- Pls Boyd, Ellwood, Bowie. “Surface and subsurface subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site”, \$1,520k (16 days shiptime on *RV Investigator* in 2018-19)

PhD theses

- Moneesha Samanta (submitted): Zinc isotopes as a tool to investigate zinc biogeochemical cycling in the SW Pacific Ocean, Australian National University
- Lavenia Ratnarajah, 2017. Effects of natural iron fertilisation by baleen whales and Antarctic krill on the Southern Ocean carbon cycle, University of Tasmania. Supervisors: Bowie, Lannuzel, Nicol, Meiners
- Axel Durand, 2017. Ocean Deoxygenation, a paleo-proxy perspective, University of Tasmania. Supervisors: Chase, Noble, Townsend, Bindoff
- Scott Meyerink (2016): Effects of Iron limitation on Silicon Metabolism and Silicon Isotopic Discrimination in Southern Ocean Diatoms, Australian National University

Meetings

Australian GEOTRACES scientists co-authored and presented results at the following meetings, including Goldschmidt 2016, AGU Fall Meeting 2016, SCAR 2016 and the Gordon Research Conference on Ocean Biogeochemistry 2016:

- Constable et al., 2016. Assessing Antarctic marine food webs on the Kerguelen Axis. SCAR Open Science Conference, Malaysia 2016.
- Noble et al., 2016. Testing the ice-ocean feedback mechanism: Reliable extraction of proxy data from surface sediments on the East Antarctic Margin. SCAR Open Science Conference, Malaysia 2016.
- Noble et al., 2016. Tracing Antarctic Bottom Water formation in the Adélie and George V Land: A proxy calibration study. International Conference on Paleoceanography, Utrecht. 2016
- Gonzalez et al., 2016. Fe and Cu organic ligands in natural incubation experiments. XVIII Seminario Ibérico de Química Marina. 20-22 July 2016. Universidad de Alicante. <http://www.vsimposioccmr.com/seminario-iberico-de-quimica-marina>
- Townsend et al., 2016. Novel resin extraction and preconcentration methods for the analysis of trace metals in open ocean seawater samples with sector field ICP-MS detection. RACI Australian Analytical and Environmental Conference, Adelaide July 2016
- Cabanes et al., 2016. Iron speciation and distribution of “usual suspects” binding ligands along the GEOTRACES (GP13) southwestern Pacific section. Gordon Research Conference on Ocean Biogeochemistry. June 12-17, The Chinese University of Hong Kong. <https://www.grc.org/programs.aspx?id=17297>
- Hassler et al., 2016. Linking nutrients to phytoplankton in the Pacific Ocean. Gordon Research Conference on Ocean Biogeochemistry. June 12-17, The Chinese University of Hong Kong. <https://www.grc.org/programs.aspx?id=17297>
- Bowie et al., 2016. The distribution of dissolved trace elements across a zonal section of the southwest Pacific Ocean. Goldschmidt 2016, Yokohama, Japan. 26 June - 1 July 2016.

- Ellwood et al., 2016. The Distribution of Dissolved Iron and Nutrients Across a South Pacific Zonal Section. Goldschmidt 2016, Yokohama, Japan. 26 June - 1 July 2016.
- Chase et al., 2016. Late summer distribution and stoichiometry of dissolved N, Si and P in the south central Kerguelen Plateau, Southern Ocean. AGU Fall Meeting, San Francisco, 12-16 December 2016. <https://fallmeeting.agu.org/2016/>
- Coffin et al., 2016. Volcanism, Iron, and Phytoplankton in the Heard and McDonald Islands Region, Southern Indian Ocean. AGU Fall Meeting, San Francisco, 12-16 December 2016.
- Watson et al., 2016. Submarine geology and geomorphology of active sub-Antarctic volcanoes: Heard and McDonald Islands. AGU Fall Meeting, San Francisco, 12-16 December 2016.
- Holmes et al., 2016. Iron speciation in proximity to an active volcanic hotspot, Kerguelen Plateau, Southern Ocean. AGU Fall Meeting, San Francisco, 12-16 December 2016.
- Spain et al., 2016. Heard Island and McDonald Islands acoustic plumes: split-beam echo sounder and deep tow camera observations of gas seeps on the Central Kerguelen Plateau. AGU Fall Meeting, San Francisco, 12-16 December 2016.
- Schofield et al., 2016. AIRBOX - a mobile air chemistry laboratory. Australian Meteorological and Oceanographic Society (AMOS) and Meteorological Society of New Zealand (MSNZ), in conjunction with the Australian/New Zealand Climate Forum (ANZCF) from Tuesday 7 to Friday 10 February 2017. Australian National University.

Outreach activities

- HEOBI voyage IN2016_v01 Subsea Volcanoes, Discovery Channel, V310305_SUBSEA_VOLCANOES_SA. Posted by: Shelley Ayres, date Posted: Jun 16, 2016 at 09:18. <https://review.bellmedia.ca/view/1191292658>
- ABC News article summarising the *RV Investigator* voyage to Antarctic waters (Sabrina Coast), and radio interview with Taryn Noble on the local ABC 06/03/17: <http://www.abc.net.au/news/2017-03-06/antarctic-mission-hobart-tasmania-csiros-investigator-icebreaker/8328096>

Other activities

- Philip Boyd was awarded the ASLO G. Evelyn Hutchinson Award for 2017 “*For his pioneering work on the complex interactions of biogeochemistry, climate change multiple drivers, and their impacts on ocean planktonic ecosystems.*”

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