

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN AUSTRALIA

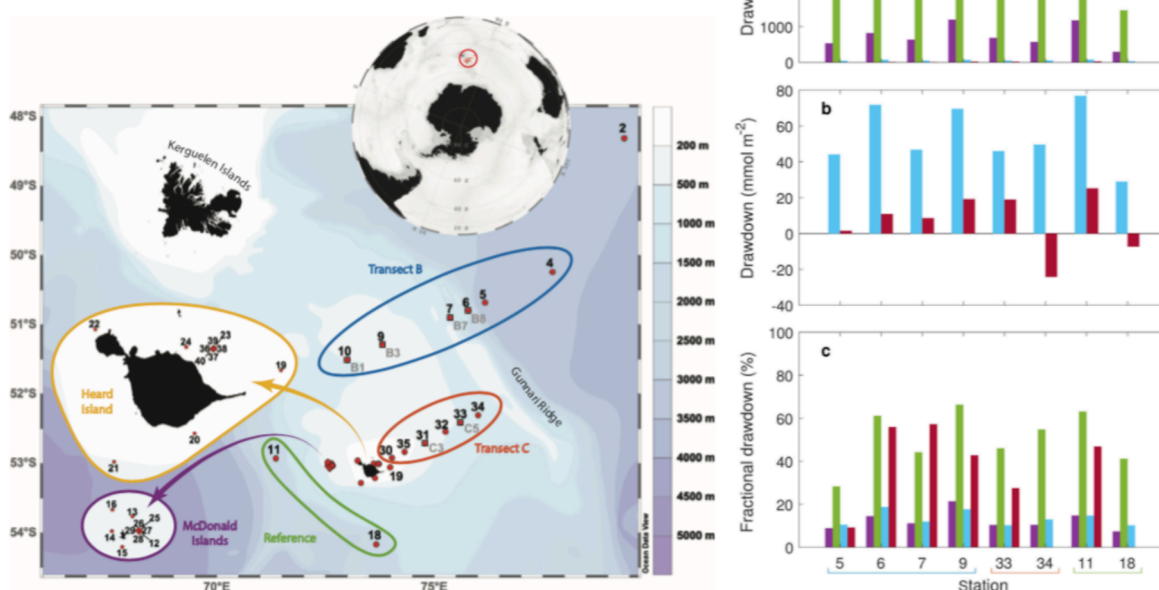
April 1st, 2018 to March 31st, 2019

New scientific results

New research by Holmes et al. (2019) shows that iron availability influences nutrient drawdown in the remote Heard and McDonald Islands region of the Southern Ocean.

Highlights:

- Dissolved iron availability drives macronutrient uptake on the Kerguelen Plateau.
- Iron availability increases the ratio of silica to nitrate drawdown near islands.
- Fe* shows dissolved iron limits plankton growth over plateau, except near islands.
- Distribution of dissolved iron varies between years, highlighting dynamic processes.



At the southern part of the northern Kerguelen Plateau (Southern Ocean) is an active volcanic hotspot, hosting volcanically active Heard Island and McDonald Islands (HIMI), the former of which is largely covered by glaciers. While offshore waters are persistently Fe limited, typical of the broader Southern Ocean, near shore waters over the Kerguelen plateau show variability in Fe distributions and support a high biomass of phytoplankton during austral spring-summer. This study investigates dissolved iron (DFe) and macronutrient distributions in waters surrounding HIMI during the Heard Earth-Ocean-Biosphere Interactions (HEOBI) voyage in January–February 2016. Comparison of surface DFe with macronutrient concentrations shows that the majority of the plateau is Fe limited in late summer and, based on comparison with previous voyages, also Fe limited in different years and earlier in the bloom season. The distribution of DFe drawdown from estimated winter inventories to observed late summer inventories shows that DFe availability drives macronutrient uptake on the plateau. The drawdown of silicic acid decreases relative to nitrate drawdown in proximity

to HIMI, in agreement with classical diatom nutrient uptake behaviour under iron replete conditions. Comparison of Fe: nitrate and Fe: phosphate drawdown ratios with expected uptake stoichiometry suggest that recycling of Fe increases with distance from Fe sources on the plateau. Lastly, comparison with data from previous voyages shows that DFe distribution varies inter-annually due to complex oceanographic conditions on the plateau, with greatest variability observed over the rough bathymetry and strongly tidally influenced region closest to HIMI. Together these data highlight the central role of Fe in driving nutrient uptake and stoichiometry in the HIMI region of the Kerguelen Plateau.

Citation: Holmes, T., Wuttig, M.K., Chase, Z., Van Der Merwe, P., Townsend, A.T., Schallenberg, C., Tonnard, M., and Bowie, A.R. 2019. Iron Availability Influences Nutrient Drawdown in the Heard and McDonald Islands Region, Southern Ocean. *Marine Chemistry*, doi:10.1016/j.marchem.2019.03.002.

Cruises

- Completion of “Constraining external iron inputs and cycling in the southern extension of the East Australian Current.” IN2018_V04. GEOTRACES PIs: Ellwood, Boyd, Chase, Bowie. This voyage took place in September 2018 in the Tasman Sea and the Subantarctic Southern Ocean south of Tasmania with the aim of assessing the relationships between production and nutrient supply across the southern extent of the East Australian Current (EAC) and the northern subantarctic zone.
- Completion of SOTS time series “Surface and subsurface subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site”. GEOTRACES PIs: Boyd, Ellwood, Bowie. This voyage took place in March 2019 in the Subantarctic Southern Ocean south of Tasmania and follows up similar voyages in March 2016 and 2018.
- Completion of the ENRICH (Euphausiids and Nutrient Recycling in Cetacean Hotspots) voyage in the Southern Ocean. Collection of samples for Trace elements, macro-nutrients, iron binding organic ligands and biological indicators in Feb-March 2019 in the marginal ice zone of East Antarctica. The aim of the voyage was to assess the role of whales and krill in fertilising surface waters with trace elements. Several incubations and solubility experiments were carried out onboard to identify the main trace metal sources and their bio-availability.

New projects and/or funding

- ARC Discovery Grant, PIs Z. Chase, A. Bowie and P. Strutton. Dust to the ocean: Does it really increase productivity?
- UTAS-IMAS Capital Expenditure, A. Bowie, Z. Chase, P. Boyd, D. Lannuzel, New equipment for the trace element oceanography laboratory.

GEOTRACES workshops and meetings

- Water Mass Transformation for Ocean Physics and Biogeochemistry, 4 – 6 February 2019, UNSW.
- Biogeochemical-Argo float Workshop, Hobart, 5-8 November 2018, co-convenors Philip Boyd, Peter Strutton, Tom Trull.

Outreach activities conducted

- Delphine Lannuzel: Beer Aquatic, June 2018: 90 min public lecture at the Hobart Brewing Co entitled “Role of sea ice and glaciers as ocean fertilisers” (<http://whysci.org.au/event/beer-aquatic-ice/>)
- Delphine Lannuzel: Television interview SkyNews “Researchers discover green-coloured icebergs linked to ocean iron levels” 02/03/2019 https://www.skynews.com.au/details/_6009244572001

New GEOTRACES publications (published or in press)

- Bowie, A., and Tagliabue, A. 2018. Geotraces Data Products: Standardising and Linking Ocean Trace Element and Isotope Data at a Global Scale. *Elements* 14, no. 6: 436–37.
- Castrillejo, M., Casacuberta, N., Christl, M., Vockenhuber, C., Synal, H.-A., García-Ibáñez, M. I., ... Masqué, P. (2018). Tracing water masses with 129I and 236U in the subpolar North Atlantic along the GEOTRACES GA01 section. *Biogeosciences*, 15(18), 5545–5564. <https://doi.org/10.5194/bg-15-5545-2018>
- Chase, Z., Ellwood, M.J., and van de Flierdt, T. 2018. Discovering the Ocean’s Past Through Geochemistry. *Elements* 14, no. 6: 397–402. doi:10.2138/gselements.14.6.397.
- Ellwood, M.J., Bowie, A.R., Baker, A., Gault-Ringold, M., Hassler, C., Law, C.S., Maher, W.A., Marriner, A., Nodder, S., Sander, S., Stevens, C., Townsend, A., van der Merwe, P., Woodward, E.M.S., Wuttig, K., Boyd, P.W., 2018. Insights into the Biogeochemical Cycling of Iron, Nitrate, and Phosphate Across a 5,300 km South Pacific Zonal Section (153°E–150°W). *Global Biogeochemical Cycles*, 2017GB005736.
- Gdaniec, S., Roy-Barman, M., Foliot, L., Thil, F., Dapoigny, A., Burckel, P., Garcia-Orellana, J., Masque, P., Mörtz, C.-M., Andersson, P.S., 2018. Thorium and protactinium isotopes as tracers of marine particle fluxes and deep water circulation in the Mediterranean Sea. *Mar. Chem.* 199, 12–23. doi:10.1016/j.marchem.2017.12.002
- George, E., Stirling, C.H., Gault-Ringold, M., Ellwood, M.J., Middag, R., 2019. Marine biogeochemical cycling of cadmium and cadmium isotopes in the extreme nutrient-depleted subtropical gyre of the South West Pacific Ocean. *Earth and Planetary Science Letters* 514, 84–95.
- Grand M.M., Laes-Huon A., Fietz S., Resing J.A., Obata H., Luther G.W. III, Tagliabue A., Achterberg E.P., Middag R., Tovar-Sánchez A. and Bowie A.R. 2019 Developing Autonomous Observing Systems for Micronutrient Trace Metals. *Front. Mar. Sci.* 6:35. doi: 10.3389/fmars.2019.00035
- Holmes, T., Wuttig, M.K., Chase, Z., Van Der Merwe, P., Townsend, A.T., Schallenberg, C., Tonnard, M., and Bowie, A.R. 2019. Iron Availability Influences Nutrient Drawdown in the Heard and McDonald Islands Region, Southern Ocean. *Marine Chemistry*, 1–0. doi:10.1016/j.marchem.2019.03.002.
- Lambelet, M., van de Flierdt, T., Butler, E.C.V., Bowie, A.R., Rintoul, S.R., Watson, R.J., Remenyi, T., Lannuzel, D., Warner, M., Robinson, L.F., Bostock, H.C., Bradtmiller, L.I., 2018. The Neodymium Isotope Fingerprint of Adélie Coast Bottom Water. *Geophys. Res. Lett.* 45, 11,247–11,256. doi:10.1029/2018GL080074
- Pérez-Tribouillier, H., Noble, T.L., Townsend, A.T., Bowie, A.R. and Chase, Z. (In Press 2019), Pre-concentration of thorium and neodymium isotopes using Nobias chelating

resin: Method development and application to chromatographic separation, *Talanta* doi: <https://doi.org/10.1016/j.talanta.2019.03.08>

- Moreau S., Lannuzel D., Janssens J. et al. Sea-ice meltwater and circumpolar deep water drive contrasting productivity in three Antarctic polynyas. *Journal of Geophysical Research - Oceans*, accepted March 2019
- Myriokefalitakis, S., Ito, A., Kanakidou, M., Nenes, A., Krol, M. C., Mahowald, N. M., Scanza, R. A., Hamilton, D. S., Johnson, M. S., Meskhidze, N., Kok, J. F., Guieu, C., Baker, A. R., Jickells, T. D., Sarin, M. M., Bikkina, S., Shelley, R., Bowie, A., Perron, M. M. G., and Duce, R. A., 2018. Reviews and syntheses: the GESAMP atmospheric iron deposition model intercomparison study, *Biogeosciences*, 15, 6659-6684, <https://doi.org/10.5194/bg-15-6659-2018>.
- Roy-Barman, M., Pons-Branchu, E., Levier, M., Bordier, L., Foliot, L., Gdaniec, S., Ayrault, S., Garcia-Orellana, J., Masque, P., Castrillejo, M., 2019. Barium during the GEOTRACES GA-04S MedSeA cruise: The Mediterranean Sea Ba budget revisited. *Chemical Geology* 511, 431–440.
- Schallenberg, C., Bestley, S., Klocker, A., Trull, T. W., Davies, D. M., Gault-Ringold, M., et al. 2018. Sustained upwelling of subsurface iron supplies seasonally persistent phytoplankton blooms around the southern Kerguelen plateau, Southern Ocean. *Journal of Geophysical Research: Oceans*, 123, 5986–6003, <https://doi.org/10.1029/2018JC013932>.
- Schlitzer, R., et al. 2018. The GEOTRACES Intermediate Data Product 2017. *Chemical Geology*, 210-223.
- Sutton, J.N., André, L., Cardinal, D., Conley, D.J., de Souza, G.F., Dean, J., Dodd, J., Ehlert, C., Ellwood, M.J., Frings, P.J., Grasse, P., Hendry, K., Leng, M.J., Michalopoulos, P., Panizzo, V.N., Swann, G.E.A., 2018. A Review of the Stable Isotope Biogeochemistry of the Global Silicon Cycle and Its Associated Trace Elements. *Frontiers in Earth Science* 5.
- Tang, Y., Lemaitre, N., Castrillejo, M., Roca-Martí, M., Masqué, P., & Stewart, G. (2019). The export flux of particulate organic carbon derived from $^{210}\text{Po}/^{210}\text{Pb}$ disequilibria along the North Atlantic GEOTRACES GA01 transect: GEOVIDE cruise. *Biogeosciences*, 16(2), 309–327. <https://doi.org/10.5194/bg-16-309-2019>
- Tang, Y., Castrillejo, M., Roca-Martí, M., Masqué, P., Lemaitre, N., & Stewart, G. (2018). Distributions of total and size-fractionated particulate ^{210}Po and ^{210}Pb activities along the North Atlantic GEOTRACES GA01 transect: GEOVIDE cruise. *Biogeosciences*, 15(17), 5437–5453. <https://doi.org/10.5194/bg-15-5437-2018>
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- Yang, L., Nadeau, K., Meija, J., Grinberg, P., Pagliano, E., Ardini, F., Grotti, M., Schlosser, C., Streu, P., Achterberg, E.P., Sohrin, Y., Minami, T., Zheng, L., Wu, J., Chen, G., Ellwood, M.J., Turetta, C., Aguilar-Islas, A., Rember, R., Sarthou, G., Tonnard, M., Planquette, H., Matoušek, T., Crum, S., Mester, Z., 2018. Inter-laboratory study for the certification of trace elements in seawater certified reference materials NASS-7 and CASS-6. *Analytical and Bioanalytical Chemistry* 410, 4469-4479.
- Wang, R.M., Archer, C., Bowie, A.R. and Vance, D. Zinc and nickel isotopes in seawater from the Indian Sector of the Southern Ocean: the impact of natural iron fertilization

versus Southern Ocean hydrography and biogeochemistry. *Chemical Geology*, 511, 452-464, <https://doi.org/10.1016/j.chemgeo.2018.09.010>

Completed GEOTRACES PhD or Master theses

- Manon Tonnard, UTAS-UBO cotutelle joint student, “Biogeochemical cycle of iron: distribution and speciation in the North Atlantic Ocean (GA01) and the Southern Ocean (GIpr05) (GEOTRACES)”. Supervisors: Andrew Bowie, Geraldine Sarthou, Pier van der Merwe, Helene Planquette

GEOTRACES presentations in international conferences

- Pérez-Tribouillier, H., Chase, Z., Noble, T.L., Townsend, A.T. and Bowie, A.R. 2018. Simultaneous Pre-Concentration of Thorium and Neodymium from Seawater: Method Development and Application to the Kerguelen Plateau. *Goldschmidt Abstracts*.
- Adhitya Sutresna, Bence Paul, Estephany Marillo-Sialer, Peter Rayner, Robyn Schofield, Maximilien Desservettaz, Andrew Bowie, Michal Strzelec, 2018. Characterisation of LA-ICP-MS to measure, speciate and source apportion PM2.5 in Garden Island, Western Australia. *Atmospheric Composition & Chemistry Observations & Modelling Conference incorporating the Cape Grim Annual Science Meeting 2018*, Aspendale VIC Dec 4-6, 2018
- Pier van der Merwe, Tom Trull, Trevor Goodwin, Peter Jansen, Andrew Bowie, 2018. Autonomous, trace metal clean, seawater sampler: AUV integration and 12 month mooring deployment. *Antarctic and Southern Ocean Forum, 2. Observation Technologies*. 14-17 August 2018, CSIRO Hobart. <https://asof2018.ieee.org/>
- Alessandro Tagliabue, Andrew Bowie, Michael Ellwood, William Landing, Angela Milne, Daniel Ohnemus, Benjamin Twining, Philip Boyd, 2018. Revealing the mechanisms shaping the internal cycling of dissolved iron across the Pacific Basin. *Challenger Conference 2018*, 10th to 14th September 2018. The 18th Biennial Conference of the Challenger Society for Marine Science. Newcastle University, UK
- A. Ito, S. Myriokefalitakis, M. Kanakidou, N. Mahowald, R. A. Scanza, A. Baker, T. Jickells, M. Sarin, S. Bikkina, Y. Gao, R. Shelley, C. Buck, W. Landing, A. Bowie, M. Perron, N. Meskhidze, M. Johnson, Y. Feng, R. Duce, 2018. The GESAMP global model intercomparison: Evaluation of labile iron in aerosols. *EGU General Assembly 2018 AS4.1/BG1.14/OS3.3 – Air-sea exchanges: Impacts on Biogeochemistry and Climate*, 13 April
- A. Ito, S. Myriokefalitakis, M. Kanakidou, N. Mahowald, R. A. Scanza, A. Baker, T. Jickells, M. Sarin, S. Bikkina, Y. Gao, R. Shelley, C. Buck, W. Landing, A. Bowie, M. Perron, N. Meskhidze, M. Johnson, Y. Feng, R. Duce, 2018. The GESAMP global model intercomparison: Evaluation of labile iron in aerosols *Japanese Geophysical Union annual meeting 2018*, Chiba, Japan, May 20-24, http://www.jpogu.org/meeting_e2018/
- Ratnarajah, L, Blain, S, Bowie, AR, Catala, P, Friedlaender, AS, Holmes, TM, Lannuzel D, Obernosterer, I, Tonnard, M, van der Merwe, P, Wuttig, K, 2018. Nutrient recycling influences microbial communities in the Southern Ocean. *Polar 2018, SCAR Open Science conference 2018*, Davos, 15-26 June 2018
- Pier van der Merwe, Kathrin Wuttig, Thomas Holmes, Zanna Chase, Tom Trull, Andrew Bowie, 2018. High Fe lability of particles sourced from glacial erosion, Heard Island.

Session: Biogeochemical cycling in the Polar Regions: Terrestrial and Ocean interactions.
Polar 2018, SCAR Open Science conference 2018, Davos, 15-26 June 2018

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