ANNUAL REPORT ON GEOTRACES ACTIVITIES IN UNITED STATES

May 1st, 2022 to April 30th, 2023

New GEOTRACES or GEOTRACES relevant scientific results

With 54 peer-reviewed publications in the past year (see attached list) there are too many results to describe them all. Therefore, the approach here is to begin by listing the projects from U.S. GEOTRACES that were featured as GEOTRACES science highlights during the reporting period. See: < https://www.geotraces.org/category/science/newsflash/>. Following that we will report briefly on the status of GEOTRACES section GP17-OCE, completed in January 2023, and planning for GEOTRACES section GP17-ANT.

Science highlights, in reverse chronological order, with the name of the lead investigator, included:

Highlight Date	**Lead P.I.**	**Synopsis**
February 10, 2023	J. Fitzsimmons	Fitzsimmons and Conway (doi:10.1146/annurev-marine-032822-103431) present a complete review of iron and its isotope sources, internal cycling and sinks in the ocean, and summarize the end-member isotope signature of different iron sources (dust, sediments, hydrothermal venting). Their study contributes to improving our understanding of marine iron biogeochemistry and oceanic iron distributions by disentangling multiple iron sources, identifying the redox state of the sedimentary sources, distinguishing anthropogenic versus natural dust sources, and investigating different hydrothermal processes. Iron isotope fractionation might be used to understand the internal oceanic cycling of iron, including speciation changes, biological uptake, and particle scavenging. The authors propose an overview of future research needed to expand the utilization of this tracer and highlight the role that GEOTRACES has played in the development of this exciting oceanic tracer.
February 7, 2023	J.N. Smith	Smith and colleagues (doi:10.1029/2021JC018120) determined iodine-129 (^{129}I), chlorofluorocarbons (CFC-11) and sulfur hexafluoride (SF_6), in the Arctic Ocean in samples collected during two 2015 GEOTRACES cruises (GN01 and GN04). The resulting large, quasi-synoptic tracer data sets provide an opportunity to use these transient tracers to determine water mass mean ages and mixing rates in a highly stratified, arctic, marine system. Their calculated mean age sections conform to historical ideas of tracer ages while the mixing time is nearly constant in upper intermediate water, which reflects the influence of strong advective flow. The high mixing values found in the upper halocline are congruent with the nutrient maximum indicating that both are governed by winter shelf mixing processes.

October 17, 2022	S.J. John	John and co-authors (doi:10.1038/s41561-022-01045-7) test the lability and bioavailability of nickel (Ni) in the surface ocean using trace metal extraction from surface waters. They also test what controls the fluxes of Ni into the deeper ocean, with regards to the phosphate export and remineralization. A global Ni observation dataset was compiled to test Ni biogeochemical models (GEOTRACES Intermediate Data Product 2017) and data from samples collected during US GEOTRACES GP15. From the combined data-constrained global biogeochemical circulation modelling with culture experiments they find that Ni in oligotrophic gyres is both chemically and biologically labile and only minimally incorporated into diatom frustules. The authors suggest that slow depletion of Ni relative to macronutrients in upwelling regions can explain the residual Ni pool. They also propose that slower regeneration of Ni compared with macronutrients explains the strong Ni enrichment in deep waters.
September 15, 2022	A. Dastoor	Dastoor and co-authors (doi:10.1038/s43017-022-00269-w) revised the mercury (Hg) budget in the Arctic Ocean based on the recent Arctic Monitoring and Assessment Programme (www.amap.no) and new observations from 2015 GEOTRACES pan-Arctic transects. The revised Arctic Ocean mercury budget (~1,870 Mg) is lower than previous estimates (2,847–7,920 tons) and this implies a higher sensitivity to climate change and anthropogenic emissions. Particulate mercury settling (122 ± 55 tons per year) from surface waters to the shelf sediments is the largest mercury removal mechanism in the Arctic Ocean. The revised Arctic Ocean mass balance suggests that mercury burial in shelf sediments (42 ± 31 tons per year) may be underestimated by over 100% (52.2 ± 43.5 tons per year).
September 8, 2022	W.D. Gardner	Gardner and co-authors (doi: 10.1029/2021jc017970) presented an extensive description of particle concentrations and chlorophyll-a fluorescence (Chl-a) distribution along two GEOTRACES sections (GN01 and GN04) across the Arctic Ocean. The optical data acquired along the sections were paired with particle composition on filtered samples through the whole water column. Particle distributions in the Arctic are affected by currents, stratification, ice coverage and thickness, nutrient and light availability, and biological processes. The combination of cp (a proxy for particulate matter and particulate organic carbon) sections plotted with salinity, temperature, and Chl-a contours, adds a background and baseline across the entire Arctic Ocean that is useful in deciphering some of the particle dynamics of the Arctic.

July 6, 2022	S. Rahman	Rahman and co-authors (doi:10.1029/2022gb007330) using water mass mixing models along with the analysis of dissolved barium (dBa) from samples collected along GEOTRACES GA03 North Atlantic and GP16 Eastern Tropical Pacific sections, establish that most of dBa variations along those transects are controlled by conservative mixing. However, a close study of the non-conservative fractions, particulate excess Ba (pBa_{xs}), reveals that nonconservative processes are likely driving 30% of the supply/removal of dBa along both transects. Barite precipitation depletes dBa within oxygen minimum zones from concentrations predicted by water mass mixing, whereas inputs from continental margins, particle dissolution in the water column, and benthic diffusive flux raise dBa above predications. The authors also established that the global river dBa delivery (7 ± 4 Gmol year^{-1}; freshwater component) to the ocean is ∼50% lower than previous estimates. Associating radium isotopes to dBa distribution, they revealed that the western continental shelf of the North Atlantic supplies significant net new dBa to the ocean basin. This new addition of dBa is equal to or exceeds the combined dissolved plus desorbed particulate Ba global flux from rivers. They also present a re-evaluated residence time of dBa in the ocean, on the order of 3.5–5 kyr, ∼40%–60% lower than previously estimated.
June 21, 2022	Y. Huang	Huang and co-authors (doi: 10.3389/fmars.2022.837183) present the first data-driven surface to seafloor dissolved iron (dFe) climatology (1°×1° resolution) based on the compilation of published dFe observations with environmental predictors from contemporaneous satellite observations and reanalysis products. The exponential growth in dFe measurements in the last three decades mostly from the GEOTRACES program, provided the observational based distribution of dFe in the ocean; satellite observations and reanalysis products were used as the predictors in the machine learning (ML) algorithms. Based on the derived climatology and statistical tools, the authors confirmed that atmospheric iron input plays a major role in enriching the surface tropical waters. They also show that interplay between particle remineralization, scavenging, and current transport are controlling the deep-water Fe distribution. The climatology is used as a reference to evaluate the performance of 13 ocean biogeochemical models (OBM).
May 10, 2022	Y. Xiang	Xiang and co-authors (doi:10.1029/2021GB007292) compiled full ocean-depth size-fractionated (1–51 and >51 μm) particle concentration and composition of suspended particulate matter from three recent U.S.

		GEOTRACES cruises (GA03, GP16 and GN01) and combined these measurements with estimates of particle porosity to estimate particle sinking velocity and particle mass flux. The results show the importance of both particle characteristics and size distribution for mass fluxes, and similar methods can be applied to existing and future size-fractionated filtered particulate measurements to improve our understanding of the biological pump elsewhere.

U.S. GEOTRACES continues to promote synthesis of GEOTRACES findings, and here we highlight three papers taking a broad look at mercury in the environment that have benefited from GEOTRACES contributions:

- Dastoor, A., H. Angot, J. Bieser, J. H. Christensen, T. A. Douglas, L.-E. HeimbürgerBoavida, M. Jiskra, R. P. Mason, D. S. McLagan, D. Obrist, P. M. Outridge, M. V. Petrova, A. Ryjkov, K. A. St. Pierre, A. T. Schartup, A. L. Soerensen, K. Toyota, O. Travnikov, S. J. Wilson, and C. Zdanowicz (2022), Arctic mercury cycling, Nature Reviews Earth & Environment, 3(4), 270-286, doi:10.1038/s43017-022-00269-w.
- Fisher, J. A., L. Schneider, A.-H. Fostier, S. Guerrero, J. R. D. Guimarães, C. Labuschagne, J. J. Leaner, L. G. Martin, R. P. Mason, V. Somerset, and C. Walters (2023), A synthesis of mercury research in the Southern Hemisphere, part 2: Anthropogenic perturbations, Ambio, 52(5), 918-937, doi:10.1007/s13280-023-01840-5.
- Schneider, L., J. A. Fisher, M. C. Diéguez, A.-H. Fostier, J. R. D. Guimaraes, J. J. Leaner, and R. Mason (2023), A synthesis of mercury research in the Southern Hemisphere, part 1: Natural processes, Ambio, 52(5), 897-917, doi:10.1007/s13280-023-01832-5.

GEOTRACES or GEOTRACES relevant cruises

- The first leg of the U.S. GEOTRACES GP17 section (GP17-OCE) was completed earlier this year. The ship departed Papeete, Tahiti on 1 December 2022 and arrived in Punta Arenas, Chile on 25 January 2023. The chief scientist was Benjamin S. Twining of the Bigelow Laboratory for Ocean Sciences. Co-chief scientists were Jessica L. Fitzsimmons of Texas A&M University and Gregory A. Cutter of Old Dominion University. The cruise track is shown in Figure US-1.

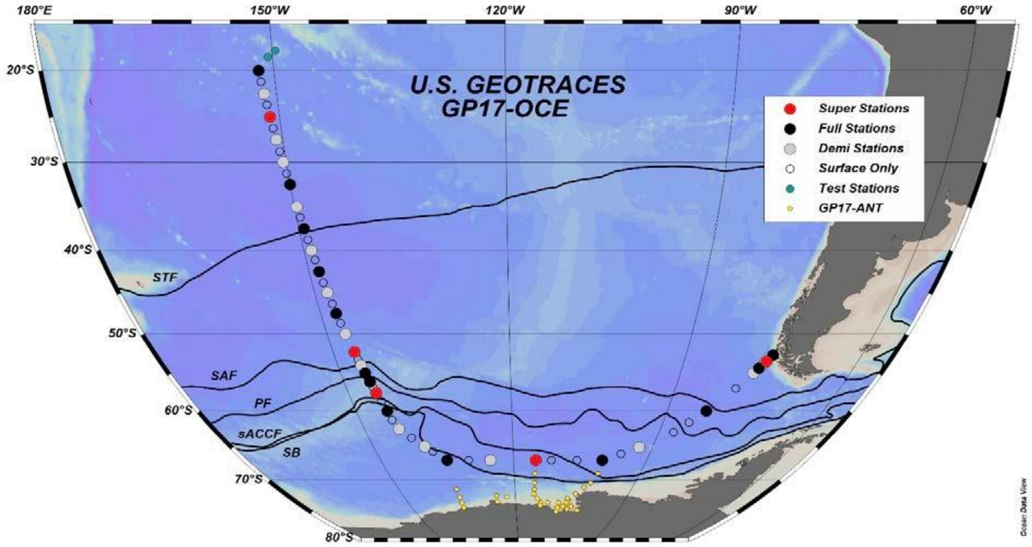

Figure US-1. *Track and station locations for GEOTRACES Section GP17-OCE.*

As illustrated in Figure US-1, sampling stations were compressed in the region of the Southern Ocean fronts during the southbound portion of the cruise in order to sample and characterize the trace element concentrations in each water mass as it surfaces in the Southern Ocean. Shipboard hydrographic data (Figure US-2) show that the stations (thin vertical lines) were well located to sample the various water masses, which are also identified in the figure.

Among the objectives of this section, scientists endeavored to determine the sources of iron to iron-limited ecosystems of the Southern Ocean, while also determining the biological uptake and internal cycling of iron and other trace elements. Shipboard measurement of dissolved iron concentrations (Peter Sedwick, Joseph Resing and Bettina Sohst) showed iron enrichment in Pacific Deep Water (PDW) and strong hydrothermal source of iron emitted by the Pacific Antarctic Ridge (Figure US-3, top). Dissolved iron along zonal portion of the GP17-OCE section (Figure US-3, bottom) shows enrichment in PDW as it moves around South America into the Southern Ocean. US GEOTRACES investigators will attempt to combine dFe data with concentrations of noble gases and modelling to determine the amount of dFe carried to the Southern Ocean in PDW that reaches the surface where is it can be used by marine ecosystems.

New projects and/or funding

- This report finds us in the middle of completing GEOTRACES Section GP17. It was decided that 2 expeditions were needed to achieve all of the scientific objectives of the section. The first cruise, GP17-OCE, is described above. Planning for the second cruise is described below. All of the projects for GP17 were funded prior to to the current reporting period.
- The only new funding for US GEOTRACES during the current reporting period is that the US GEOTRACES project office received a three-year renewal of its funding, beginning 1 October 2022.

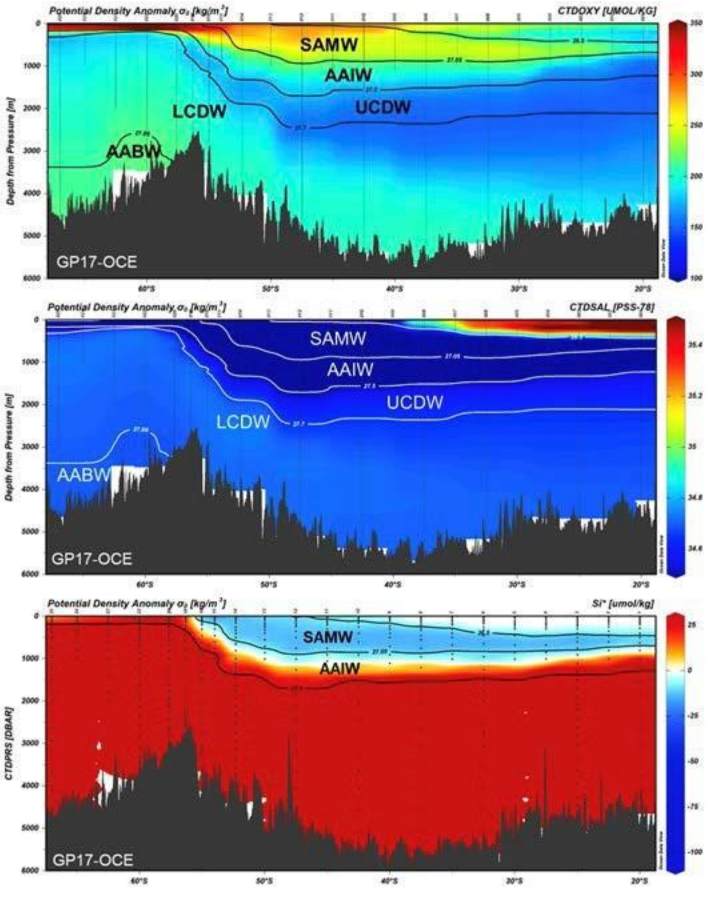

***Figure US-2.** Hydrographic data along the meridional portion of GP17-OCE: oxygen (top), salinity (middle) and Si* (concentration of Si minus the concentration of nitrate; bottom). The thin vertical lines in the top and middle panels show the station locations, while the dots in the bottom panel show the sample depths at each station. Water masses are labelled according to traditional definitions: SAMW = Subantarctic Mode Water; AAIW = Antarctic Intermediate Water; UCDW = Upper Circumpolar Deep Water; LCDW = Lower Circumpolar Deep Water; and AABW = Antarctic Bottom Water. The low oxygen water at mid depth also encompasses Pacific Deep Water (PDW).*

GEOTRACES workshops and meetings organized

- The U.S. GEOTRACES SSC met in person in Alexandria Virginia on 15 and 16 June 2022. After reviewing the status of existing and planned expeditions supporting GEOTRACES sections, the SSC decided that U.S. GEOTRACES would undertake no more section cruises. The SSC reached this policy decision by concluding that the GEOTRACES global survey is nearly complete, and that it is time to transition into studies that are focused on specific processes that supply, cycle or remove TEIs in the ocean. US GEOTRACES also plans to pursue synthesis of GEOTRACES findings.
- A U.S. GEOTRACES pre-cruise (GP17-ANT) logistics meeting was held on 13 and 14 March 2023 at Old Dominion University in Norfolk Virginia. About 60 participants attended in person and several more participated online. With 23 separately funded (by US NSF) projects participating in the GP17-ANT section, there were a large number of logistic issues to be resolved. GP17-ANT is the most logistically challenging cruise yet undertaken by U.S. GEOTRACES and the planning continues on a regular basis. The cruise is scheduled to depart Punta Arenas in late November 2023.

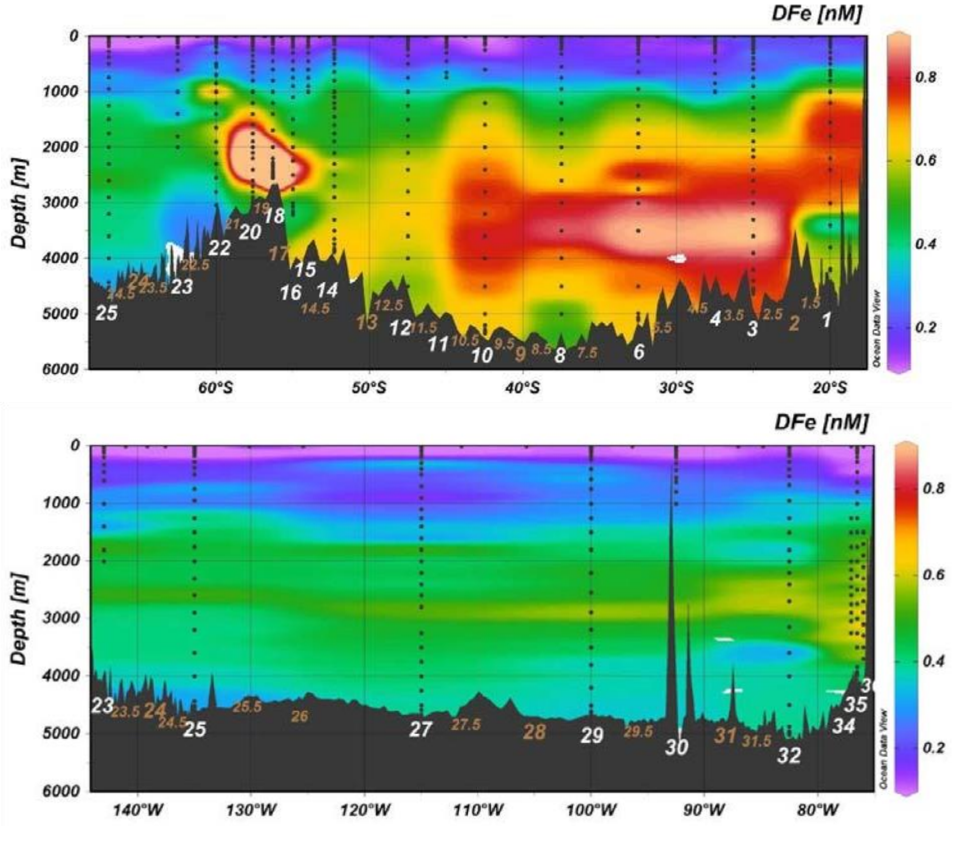

***Figure US-3.** <u>Top</u>: Shipboard dissolved iron concentration along meridional portion of the GP17OCE section. Dissolved iron is enriched in Pacific Deep Water from approximately 25° south to 45° south. High concentrations of dissolved iron are also observed around the crest of the Pacific-Antarctic Ridge. <u>Bottom</u>: Shipboard dissolved iron concentration along zonal portion of the GP17-OCE section.*

Dissolved iron is enriched in Pacific Deep Water as it moves around South America into the Southern Ocean. White numbers at the bottom show the cruise stations at which iron concentration were measured aboard the ship.

Outreach activities conducted

- For the first time, U.S. GEOTRACES attempted to create a virtual reality experience during GP17-OCE. Production of this virtual reality outreach product was under the direction of Christina Wiederwohl, at Texas A&M University, who presented a first look at the production during the 2023 Goldschmidt meeting in a presentation entitled "Reimagining oceanographic biogeochemistry: bringing the ocean to the community through virtual reality".
- The U.S. GEOTRACES website < https://usgeotraces.ldeo.columbia.edu> is currently being re-designed to accommodate educational and outreach materials that can be used by the US GEOTRACES Community.

Other GEOTRACES activities

- The U.S. GEOTRACES project office continues to offer small amounts of funding (<$5k) to support travel and/or publication costs related to synthesis papers. Currently, the project office is providing travel support for a synthesis group working on trace elements in the halocline of the Arctic Ocean. A draft of the paper produced by this group is currently under internal review.

New GEOTRACES or GEOTRACES-relevant publications (published or in press) *(If possible, please identify those publications acknowledging SCOR funding)*

- A list of publications is appended at the end of this report

Completed GEOTRACES PhD or Master theses (please include the URL link to the pdf file of the thesis, if available)

- A list of dissertations is included in the list of publications appended at the end of this report.

GEOTRACES presentations in international conferences

- The number of US GEOTRACES presentations at international meetings and conferences is too large to track.

Submitted by:

Bob Anderson < boba@ldeo.columbia.edu>

Claudia Giulivi < claudiag@ldeo.columbia.edu>

2022-2023 US GEOTRACES and GEOTRACES-related Publications

References 1 May 2022 – 30 April 2023 plus papers missed in previous reports

54 publications, 5 PhD Dissertations

US GEOTRACES and Related Publications

Related Publications include:

1) U.S. GEOTRACES PIs publishing results that support the GEOTRACES mission but the results are not from GEOTRACES cruises,
2) Papers that use data from U.S. GEOTRACES cruises but do not include U.S. GEOTRACES PIs as co-authors, and
3) Papers describing international collaboration on which U.S. GEOTRACES PIs appear as co-authors.

Publications

Bolster, K. M., M. I. Heller, M. R. Mulholland, and J. W. Moffett (2022), Iron and manganese accumulation within the Eastern Tropical North Pacific oxygen deficient zone, *Geochimica et Cosmochimica Acta*, *334*, 259-272, doi: 10.1016/j.gca.2022.07.013.

Bullock, E. J., L. Kipp, W. Moore, K. Brown, P. J. Mann, J. E. Vonk, N. Zimov, and M. A. Charette (2022), Radium Inputs into the Arctic Ocean from Rivers: A Basin-Wide Estimate, *Journal of Geophysical Research: Oceans*, *127*(9), e2022JC018964, doi: 10.1029/2022JC018964.

Chen, M., E. A. Boyle, S. Jiang, Q. Liu, J. Zhang, X. Wang, and K. Zhou (2023), Dissolved Lead (Pb) Concentrations and Pb Isotope Ratios Along the East China Sea and Kuroshio Transect—Evidence for Isopycnal Transport and Particle Exchange, *Journal of Geophysical Research: Oceans*, *128*(2), e2022JC019423, doi 10.1029/2022JC019423.

Dastoor, A., H. Angot, J. Bieser, J. H. Christensen, T. A. Douglas, L.-E. Heimbürger-Boavida, M. Jiskra, R. P. Mason, D. S. McLagan, D. Obrist, P. M. Outridge, M. V. Petrova, A. Ryjkov, K. A. St. Pierre, A. T. Schartup, A. L. Soerensen, K. Toyota, O. Travnikov, S. J. Wilson, and C. Zdanowicz (2022), Arctic mercury cycling, *Nature Reviews Earth & Environment*, *3*(4), 270-286, doi:10.1038/s43017-022-00269-w.

Eisenring, C., S. E. Oliver, S. Khatiwala, and G. F. de Souza (2022), Influence of GEOTRACES data distribution and misfit function choice on objective parameter retrieval in a marine zinc cycle model, *Biogeosciences*, *19*(21), 5079-5106, doi:10.5194/bg-19-5079-2022.

Fisher, J. A., L. Schneider, A.-H. Fostier, S. Guerrero, J. R. D. Guimarães, C. Labuschagne, J. J. Leaner, L. G. Martin, R. P. Mason, V. Somerset, and C. Walters (2023), A synthesis of mercury research in the Southern Hemisphere, part 2: Anthropogenic perturbations, *Ambio*, *52*(5), 918-937, doi:10.1007/s13280-023-01840-5.

Fitzsimmons, J. N., and T. M. Conway (2023), Novel Insights into Marine Iron Biogeochemistry from Iron Isotopes, *Annual Review of Marine Science*, *15*(1), 383-406, doi:10.1146/annurev-marine-032822-103431.

Gardner, W. D., M. J. Richardson, A. V. Mishonov, D. A. Bean, and J. C. Herguera (2022a), Nepheloid layers in the deep Gulf of Mexico, *Marine Geology*, *454*, 106950, doi: 10.1016/j.margeo.2022.106950.

Gardner, W. D., M. J. Richardson, A. V. Mishonov, P. J. Lam, and Y. Xiang (2022b), Distribution, Sources, and Dynamics of Particulate Matter Along Trans-Arctic Sections, *Journal of Geophysical Research: Oceans*, *127*(6), e2021JC017970, doi:10.1029/2021JC017970.

Gilbert, M., P. Ho, L. Whitmore, and A. Shiller (2023), Automated determination of gallium in seawater using seaFAST pre-concentration and high-resolution inductively-coupled plasma mass spectrometry, *Analytica Chimica Acta*, *1241*, 340799, doi: 10.1016/j.aca.2023.340799.

Gilbert, N. E., G. R. LeCleir, R. F. Strzepek, M. J. Ellwood, B. S. Twining, S. Roux, C. Pennacchio, P. W. Boyd, and S. W. Wilhelm (2022), Bioavailable iron titrations reveal oceanic Synechococcus ecotypes optimized for different iron availabilities, *ISME Communications*, *2*(1), 54, doi:10.1038/s43705-022-00132-5.

Grenier, M., P. van Beek, P. Lerner, V. Sanial, M. Souhaut, M. Lagarde, O. Marchal, and J. L. Reyss (2023), New insights on the 7Be cycle in the ocean, *Deep Sea Research Part I: Oceanographic Research Papers*, *194*, 103967, doi: 10.1016/j.dsr.2023.103967.

Hawco, N. J., A. Tagliabue, and B. S. Twining (2022), Manganese Limitation of Phytoplankton Physiology and Productivity in the Southern Ocean, *Global Biogeochemical Cycles*, *36*(11), e2022GB007382, doi: 10.1029/2022GB007382.

He, Y., and R. P. Mason (2021), Comparison of reactive gaseous mercury measured by KClcoated denuders and cation exchange membranes during the Pacific GEOTRACES GP15 expedition, *Atmospheric Environment*, *244*, 117973, doi: 10.1016/j.atmosenv.2020.117973.

He, Y., X. Shi, W. W. Huffman, C. H. Lamborg, and R. P. Mason (2022), Description of a Dimethylmercury Automatic Analyzer for the High-Resolution Measurement of Dissolved Gaseous Mercury Species in Surface Ocean Waters, *Environmental Science & Technology*, *56*(18), 13076-13084, doi: 10.1021/acs.est.2c02908.

Huang, Y., A. Tagliabue, and N. Cassar (2022), Data-Driven Modeling of Dissolved Iron in the Global Ocean, *Frontiers in Marine Science*, *9*.

Hunt, H. R., B. A. Summers, M. Sieber, S. Krisch, A. Al-Hashem, M. Hopwood, E. P. Achterberg, and T. M. Conway (2022), Distinguishing the influence of sediments, the Congo River, and water-mass mixing on the distribution of iron and its isotopes in the Southeast Atlantic Ocean, *Marine Chemistry*, *247*, 104181, doi: 10.1016/j.marchem.2022.104181.

Jenkins, W. J., S. C. Doney, A. M. Seltzer, C. R. German, D. E. Lott Iii, and K. L. Cahill (2023), A North Pacific Meridional Section (U.S. GEOTRACES GP15) of Helium Isotopes and Noble Gases I: Deep Water Distributions, *Global Biogeochemical Cycles*, *37*(5), e2022GB007667, doi: 10.1029/2022GB007667.

John, S. G., R. L. Kelly, X. Bian, F. Fu, M. I. Smith, N. T. Lanning, H. Liang, B. Pasquier, E. A. Seelen, M. Holzer, L. Wasylenki, T. M. Conway, J. N. Fitzsimmons, D. A. Hutchins, and S.-C. Yang (2022), The biogeochemical balance of oceanic nickel cycling, *Nature Geoscience*, *15*(11), 906-912, doi:10.1038/s41561-022-01045-7.

Jones, R., S. Nicholas, P. Northrup, B. Bostick, C. Hoffman, W. Hu, P. Lam, A. Leri, B. Toner, and B. Twining (2022), Characterization and Speciation of Marine Materials Using Synchrotron Probes: Guidelines for New Users, *Oceanography*, doi:10.5670/oceanog.2022.207.

Jonsson, S., M. G. Nerentorp Mastromonaco, K. Gårdfeldt, and R. P. Mason (2022), Distribution of total mercury and methylated mercury species in Central Arctic Ocean water and ice, *Marine Chemistry*, *242*, 104105, doi: 10.1016/j.marchem.2022.104105.

Joyce, E. E., S. J. Balint, and M. G. Hastings (2022), Isotopic Evidence That Alkyl Nitrates Are Important to Aerosol Nitrate Formation in the Equatorial Pacific, *Geophysical Research Letters*, *49*(16), e2022GL099960, doi:.1029/2022GL099960.

Kemnitz, N., D. E. Hammond, P. Henderson, E. Le Roy, M. Charette, W. Moore, R. F. Anderson, M. Q. Fleisher, A. Leal, E. Black, C. T. Hayes, J. Adkins, W. Berelson, and X. Bian (2023), Actinium and radium fluxes from the seabed in the northeast Pacific Basin, *Marine Chemistry*, *250*, 104180, doi: 10.1016/j.marchem.2022.104180.

Kipp, M. A., H. Li, M. J. Ellwood, S. G. John, R. Middag, J. F. Adkins, and F. L. H. Tissot (2022), 238U, 235U and 234U in seawater and deep-sea corals: A high-precision reappraisal, *Geochimica et Cosmochimica Acta*, *336*, 231-248, doi: 10.1016/j.gca.2022.09.018.

König, D., T. M. Conway, D. S. Hamilton, and A. Tagliabue (2022), Surface Ocean Biogeochemistry Regulates the Impact of Anthropogenic Aerosol Fe Deposition on the Cycling of Iron and Iron Isotopes in the North Pacific, *Geophysical Research Letters*, *49*(13), e2022GL098016, doi:10.1029/2022GL098016.

Lanning, N. T., S. Jiang, V. J. Amaral, K. Mateos, J. M. Steffen, P. J. Lam, E. A. Boyle, and J. N. Fitzsimmons (2023), Isotopes illustrate vertical transport of anthropogenic Pb by reversible scavenging within Pacific Ocean particle veils, *Proceedings of the National Academy of Sciences*, *120*(23), e2219688120, doi:10.1073/pnas.2219688120.

Marsay, C. M., W. M. Landing, D. Umstead, C. P. Till, R. Freiberger, J. N. Fitzsimmons, N. T. Lanning, A. M. Shiller, M. Hatta, R. Chmiel, M. Saito, and C. S. Buck (2022), Does Sea Spray Aerosol Contribute Significantly to Aerosol Trace Element Loading? A Case Study from the U.S. GEOTRACES Pacific Meridional Transect (GP15), *Global Biogeochemical Cycles*, *36*(8), e2022GB007416, doi:10.1029/2022GB007416.

Middag, R., R. Zitoun, and T. M. Conway (2023), Trace Metals, in *Marine Analytical Chemistry*, edited by J. Blasco and A. Tovar-Sánchez, pp. 103-198, Springer.

Middleton, J. T., A. Paytan, M. Auro, M. A. Saito, and T. J. Horner (2023), Barium isotope signatures of barite–fluid ion exchange in Equatorial Pacific sediments, *Earth and Planetary Science Letters*, *612*, 118150, doi: 10.1016/j.epsl.2023.118150.

Moriyasu, R., K. M. Bolster, D. S. Hardisty, D. C. Kadko, M. P. Stephens, and J. W. Moffett (2023), Meridional Survey of the Central Pacific Reveals Iodide Accumulation in Equatorial Surface Waters and Benthic Sources in the Abyssal Plain, *Global Biogeochemical Cycles*, *37*(3), e2021GB007300, doi:10.1029/2021GB007300.

Park, J., B. P. Durham, R. S. Key, R. D. Groussman, Z. Bartolek, P. Pinedo-Gonzalez, N. J. Hawco, S. G. John, M. C. G. Carlson, D. Lindell, L. W. Juranek, S. Ferrón, F. Ribalet, E. V. Armbrust, A. E. Ingalls, and R. M. Bundy (2023), Siderophore production and utilization by marine bacteria in the North Pacific Ocean, *Limnology and Oceanography*, *n/a*(n/a), doi:10.1002/lno.12373.

Rahman, S., A. M. Shiller, R. F. Anderson, M. A. Charette, C. T. Hayes, M. Gilbert, K. R. Grissom, P. J. Lam, D. C. Ohnemus, F. J. Pavia, B. S. Twining, and S. M. Vivancos (2022), Dissolved and Particulate Barium Distributions Along the US GEOTRACES North Atlantic and East Pacific Zonal Transects (GA03 and GP16): Global Implications for the Marine Barium Cycle, *Global Biogeochemical Cycles*, *36*(6), e2022GB007330, doi:10.1029/2022GB007330.

Schneider, L., J. A. Fisher, M. C. Diéguez, A.-H. Fostier, J. R. D. Guimaraes, J. J. Leaner, and R. Mason (2023), A synthesis of mercury research in the Southern Hemisphere, part 1: Natural processes, *Ambio*, *52*(5), 897-917, doi:10.1007/s13280-023-01832-5.

Sedwick, P. N., B. M. Sohst, K. N. Buck, S. Caprara, R. J. Johnson, D. C. Ohnemus, L. E. Sofen, A. Tagliabue, B. S. Twining, and T. E. Williams (2023), Atmospheric Input and Seasonal Inventory of Dissolved Iron in the Sargasso Sea: Implications for Iron Dynamics in Surface Waters of the Subtropical Ocean, *Geophysical Research Letters*, *50*(6), e2022GL102594, doi:1029/2022GL102594.

Sedwick, P. N., B. M. Sohst, C. O'Hara, S. E. Stammerjohn, B. Loose, M. S. Dinniman, N. J. Buck, J. A. Resing, and S. F. Ackley (2022), Seasonal Dynamics of Dissolved Iron on the Antarctic Continental Shelf: Late-Fall Observations from the Terra Nova Bay and Ross Ice Shelf Polynyas, *Journal of Geophysical Research: Oceans*, *127*(10), e2022JC018999, doi: 10.1029/2022JC018999.

Sieber, M., N. T. Lanning, X. Bian, S. C. Yang, S. Takano, Y. Sohrin, T. S. Weber, J. N. Fitzsimmons, S. G. John, and T. M. Conway (2023a), The Importance of Reversible Scavenging for the Marine Zn Cycle Evidenced by the Distribution of Zinc and Its Isotopes in the Pacific Ocean, *Journal of Geophysical Research: Oceans*, *128*(4), e2022JC019419, doi: 10.1029/2022JC019419.

Sieber, M., N. T. Lanning, Z. B. Bunnell, X. Bian, S.-C. Yang, C. M. Marsay, W. M. Landing, C. S. Buck, J. N. Fitzsimmons, S. G. John, and T. M. Conway (2023b), Biological, Physical, and Atmospheric Controls on the Distribution of Cadmium and Its Isotopes in the Pacific Ocean, *Global Biogeochemical Cycles*, *37*(2), e2022GB007441, doi: 10.1029/2022GB007441.

Smith, J. N., W. M. Smethie Jr, and N. Casacuberta (2022), Synoptic 129I and CFC–SF6 Transit Time Distribution (TTD) Sections Across the Central Arctic Ocean From the 2015 GEOTRACES Cruises, *Journal of Geophysical Research: Oceans*, *127*(9), e2021JC018120, doi: 10.1029/2021JC018120.

Sofen, L. E., O. A. Antipova, M. J. Ellwood, N. E. Gilbert, G. R. LeCleir, M. C. Lohan, C. Mahaffey, E. L. Mann, D. C. Ohnemus, S. W. Wilhelm, and B. S. Twining (2022), Trace metal contents of autotrophic flagellates from contrasting open-ocean ecosystems, *Limnology and Oceanography Letters*, *7*(4), 354-362, doi: 10.1002/lol2.10258.

Steiner, Z., W. M. Landing, M. S. Bohlin, M. Greaves, S. Prakash, P. N. Vinayachandran, and E. P. Achterberg (2022), Variability in the Concentration of Lithium in the Indo-Pacific Ocean, *Global Biogeochemical Cycles*, *36*(6), e2021GB007184, doi: 10.1029/2021GB007184.

Subhas, A. V., F. J. Pavia, S. Dong, and P. J. Lam (2023), Global Trends in the Distribution of Biogenic Minerals in the Ocean, *Journal of Geophysical Research: Oceans*, *128*(2), e2022JC019470, doi: 0.1029/2022JC019470.

Tagliabue, A., A. J. M. Lough, C. Vic, V. Roussenov, J. Gula, M. C. Lohan, J. A. Resing, and R. G. Williams (2022), Mechanisms Driving the Dispersal of Hydrothermal Iron from the Northern Mid Atlantic Ridge, *Geophysical Research Letters*, *49*(22), e2022GL100615, doi: 10.1029/2022GL100615.

Tian, H.-A., M. van Manen, F. Wille, J. Jung, S. Lee, T.-W. Kim, S. Aoki, C. Eich, C. P. D. Brussaard, G.-J. Reichart, T. M. Conway, and R. Middag (2023), The biogeochemistry of zinc and cadmium in the Amundsen Sea, coastal Antarctica, *Marine Chemistry*, *249*, 104223, doi: 10.1016/j.marchem.2023.104223.

Twining, B. S., and S. B. Baines (2022), Luxury iron uptake and storage in pennate diatoms from the equatorial Pacific Ocean, *Metallomics*, *14*(7), mfac035, doi:10.1093/mtomcs/mfac035.

van Manen, M., S. Aoki, C. P. D. Brussaard, T. M. Conway, C. Eich, L. J. A. Gerringa, J. Jung, T.-W. Kim, S. Lee, Y. Lee, G.-J. Reichart, H.-A. Tian, F. Wille, and R. Middag (2022), The role of the Dotson Ice Shelf and Circumpolar Deep Water as driver and source of dissolved and particulate iron and manganese in the Amundsen Sea polynya, Southern Ocean, *Marine Chemistry*, *246*, 104161, doi: 10.1016/j.marchem.2022.104161.

Wang, H., W. Wang, M. Liu, H. Zhou, M. J. Ellwood, D. A. Butterfield, N. J. Buck, and J. A. Resing (2022), Iron ligands and isotopes in hydrothermal plumes over backarc volcanoes in the Northeast Lau Basin, Southwest Pacific Ocean, *Geochimica et Cosmochimica Acta*, *336*, 341-352, doi: 10.1016/j.gca.2022.09.026.

Wei, Z., J. K. Cochran, E. Horowitz, P. Fitzgerald, C. Heilbrun, D. Kadko, M. Stephens, C. M. Marsay, C. S. Buck, and W. M. Landing (2022), 210Pb and 7Be as Coupled Flux and Source Tracers for Aerosols in the Pacific Ocean, *Global Biogeochemical Cycles*, *36*(8), e2022GB007378, doi: 10.1029/2022GB007378.

Williford, T., R. M. W. Amon, K. Kaiser, R. Benner, C. Stedmon, D. Bauch, J. N. Fitzsimmons, L. J. A. Gerringa, R. Newton, D. A. Hansell, M. A. Granskog, L. Jensen, L. M. Laglera, A. Pasqualini, B. Rabe, H. Reader, M. Rutgers van der Loeff, and G. Yan (2022), Spatial Complexity in Dissolved Organic Matter and Trace Elements Driven by Hydrography and Freshwater Input Across the Arctic Ocean During 2015 Arctic GEOTRACES Expeditions, *Journal of Geophysical Research: Oceans*, *127*(11), e2022JC018917, doi: 10.1029/2022JC018917.

Wiseman, N. A., J. K. Moore, B. S. Twining, D. S. Hamilton, and N. M. Mahowald (2023), Acclimation of Phytoplankton Fe:C Ratios Dampens the Biogeochemical Response to Varying Atmospheric Deposition of Soluble Iron, *Global Biogeochemical Cycles*, *37*(4), e2022GB007491, doi: 10.1029/2022GB007491.

Wu, F., J. D. Owens, C. R. German, R. A. Mills, and S. G. Nielsen (2022a), Vanadium isotope fractionation during hydrothermal sedimentation: Implications for the vanadium cycle in the oceans, *Geochimica et Cosmochimica Acta*, *328*, 168-184, doi: 10.1016/j.gca.2022.05.002.

Wu, Y., L. D. Pena, R. F. Anderson, A. E. Hartman, L. L. Bolge, C. Basak, J. Kim, M. J. A. Rijkenberg, H. J. W. de Baar, and S. L. Goldstein (2022b), Assessing neodymium isotopes as an ocean circulation tracer in the Southwest Atlantic, *Earth and Planetary Science Letters*, *599*, 117846, doi: 10.1016/j.epsl.2022.117846.

Xu, B., M. B. Cardenas, I. R. Santos, W. C. Burnett, M. A. Charette, V. Rodellas, S. Li, E. Lian, and Z. Yu (2022a), Closing the Global Marine 226Ra Budget Reveals the Biological Pump as a Dominant Removal Flux in the Upper Ocean, *Geophysical Research Letters*, *49*(12), e2022GL098087, doi: 10.1029/2022GL098087.

Xu, B., S. Li, W. C. Burnett, S. Zhao, I. R. Santos, E. Lian, X. Chen, and Z. Yu (2022b), Radium-226 in the global ocean as a tracer of thermohaline circulation: Synthesizing half a century of observations, *Earth-Science Reviews*, *226*, 103956, doi: 10.1016/j.earscirev.2022.103956.

Zhang, R., J. Ren, Z. Zhang, Z. Zhu, and S. John (2022), Distribution patterns of dissolved trace metals (Fe, Ni, Cu, Zn, Cd, and Pb) in China marginal seas during the GEOTRACES GP06-CN cruise, *Chemical Geology*, *604*, 120948, doi: 10.1016/j.chemgeo.2022.120948.

PhD theses

Bian, X. (2023), The marine biogeochemistry of nickel isotopes, PhD thesis, University of Southern California, Los Angeles.

He, Y. (2023), Air-sea exchange of mercury and its species in the coastal and open ocean, PhD thesis, University of Connecticut, Groton, Connecticut.

Michael, S. M. (2022), Trace metal (Al, Mn, Fe) sources and cycling at continental margin and hydrothermal interfaces in the Pacific Ocean, PhD thesis, University of Washington, Seattle, Washington.

Park, J. (2022), Characterization of organic iron and cobalt ligands in the subtropical North Pacific, PhD thesis, University of Washington, Seattle, Washington.

Redmond, N. (2023), The Mobility of Long-lived Radioisotopes and their Burial in the Marine Environment, PhD thesis, University of Southern Mississippi, Stennis Space Center, Mississippi.