

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN UNITED STATES

May 1st, 2016 to April 30th, 2017

Principal activities of the U.S. GEOTRACES program include:

- 1) Preparing manuscripts from Pacific section (GP16),
- 2) Analyzing samples from the Arctic (GN01),
- 3) Submitting a management proposal for a Pacific Meridional Section (GP15), and 4) Hosting a synthesis workshop on the internal cycling of TEIs in the ocean.

Cruise-related Activities

North Atlantic Papers from Atlantic section GA03 continue to be published (see Publications below). New data sets have been submitted for IDP2017.

Eastern Tropical Pacific The deadline to submit manuscripts for a special issue of Marine Chemistry with results from GP16 has been extended until Spring 2017. An absolute deadline has not been announced, but several additional manuscripts have been added to the volume as a result of the deadline extension.

Meanwhile, other papers from GP16 have been published already. Among the novel and exciting results from GP16 that we highlight here is the work from the PhD dissertation of Rene Boiteau at the Woods Hole Oceanographic Institution (see publication list). He has isolated and identified the molecular structures of organic ligands that bind Fe, Cu and Ni in seawater. In a paper in PNAS he showed that marine microbes produce different sets of ligands to bind Fe depending on (a) the availability of Fe and (b) the availability of macro nutrients. In a paper in Frontiers in Marine Science he presented structures of ligands that bind Cu and Ni.

Arctic Ocean US investigators continue to analyze samples collected aboard the U.S. Coast Guard Cutter Healy (HLY1502, 9 August to 12 October, 2015, sailing out of and returning to Dutch Harbor, Alaska; Chief Scientist: David Kadko, Co-Chief Scientist: Bill Landing, Logistics Coordinator: Greg Cutter). Many preliminary results from this cruise, as well as from other arctic sections, were presented during a special session at the 2017 meeting of the Associated Sciences of Limnology and Oceanography held in Honolulu, Hawaii (28 February – 3 March 2017). Investigators involved in GN01 plan to hold a data workshop to be hosted by David Kadko in Miami, Florida, USA from 23 to 26 October, 2017.

Pacific Meridional Section The US GEOTRACES SSC has designated GP15 to be the next section to be carried out by the U.S. program, conditional on funding. A team led by Greg Cutter (Chief Scientist) as well as Phoebe Lam and Karen Casciotti (co-Chief Scientists) submitted a proposal to the US NSF Chemical Oceanography program for its 15 August 2016 proposal deadline to secure ship time and cover major logistics costs (e.g., operation of the trace metal clean sampling system and operation of the in situ pumps) of the expedition. The proposal was recommended for funding. However, funding for science in the U.S. is uncertain at this time. Major cuts to funding have been threatened by the new administration. At the time this report was written, a federal budget for the next fiscal year has not been proposed.

If funding materializes, then the dates of the cruise have been delayed from the proposed target of July – September until later in the year, September – November, 2018. This is later than desired, but the delay was obligated by competing demands for ship time.

Research objectives for GP15 include:

- 1) Boundary exchange with volcanic margin waters; TEI supply to Subarctic HNLC region
- 2) TEI distribution within the ocean's oldest water mass
- 3) TEI distributions within distal portions of hydrothermal plumes of Juan de Fuca Ridge and East Pacific Rise
- 4) TEI distributions within distal portions of oxygen deficient zones
- 5) TEI distributions in equatorial zonal jets and upwelling regime
- 6) Ultra-oligotrophic waters of the southern subtropical gyre
- 7) Baseline TEIs in western sector of planned sea-bed mining.

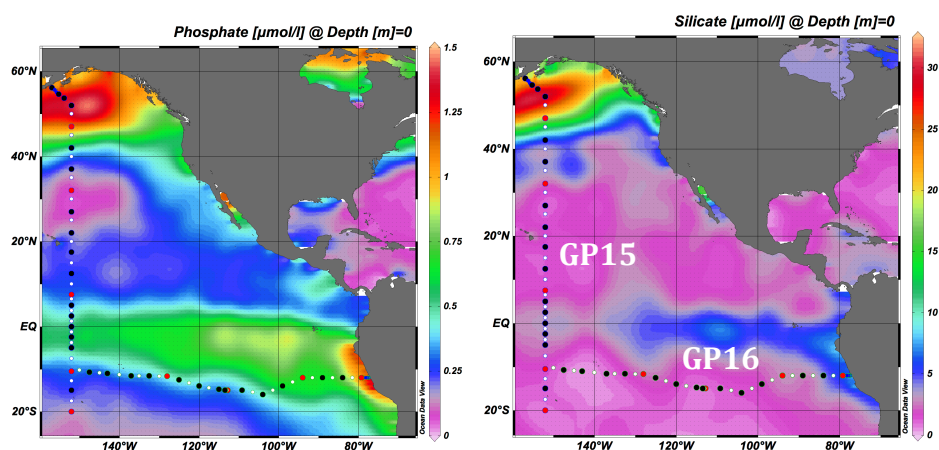


Figure 19. Station locations proposed for GP15 (along 152°W) and previously occupied on GP16 (along ~12°S) with climatological surface phosphate and silicic acid concentrations (World Ocean Atlas, figures in Ocean Data View).

Although funding for GP15 is by no means guaranteed, the U.S. GEOTRACES community met 5 - 7 October, 2016, in La Jolla, California, to refine the goals laid out in the U.S. GEOTRACES Pacific Plan (2008) and set scientific priorities for the section. The workshop allowed individual investigators to coordinate their planned research for GP16 well in advance of the 15 February 2017 proposal deadline.

Hoping for a positive outcome of federal budget negotiations, individual investigators submitted proposals to the US NSF Chemical Oceanography program on 15 February, 2017, requesting support for investigation of specific TEIs and groups of TEIs along GP15. Decisions on these proposals should be released in June or July.

Compliant data A cruise aboard the U.S. research ice breaker Nathaniel B Palmer (NBP1702) was carried out between Antarctica and New Zealand during January through March 2017. Station work was concentrated within the Antarctic Circumpolar Current, along 170°W, following the track of the U.S. JGOFS Antarctic Environment and Southern Ocean Process Study (AESOPS) in the late 1990's. Chief Scientist Rebecca Robinson (University of Rhode Island) sampled for nitrogen isotopes to study nitrogen isotope fractionation during biological utilization of upwelled nitrate. Mark Brzezinski (University of California Santa Barbara) collected samples to study silicon isotope fractionation during biological utilization of silicic acid. The group of Robert Anderson (Lamont-Doherty Earth Observatory) sampled

for dissolved ^{230}Th , ^{232}Th and ^{231}Pa . Paulina Pinedo-Gonzalez, a post doc working with Seth John at the University of Southern California, sampled for concentrations and isotopic compositions of dissolved Fe, Zn and Cd. Sampling for N, Si and U-series radionuclides was confined to the upper 1500 m of the water column. Sampling for Fe, Zn and their isotopes was limited to surface waters. Station locations are shown in Figure 2. A cruise report will be provided to the IPO when it is available.

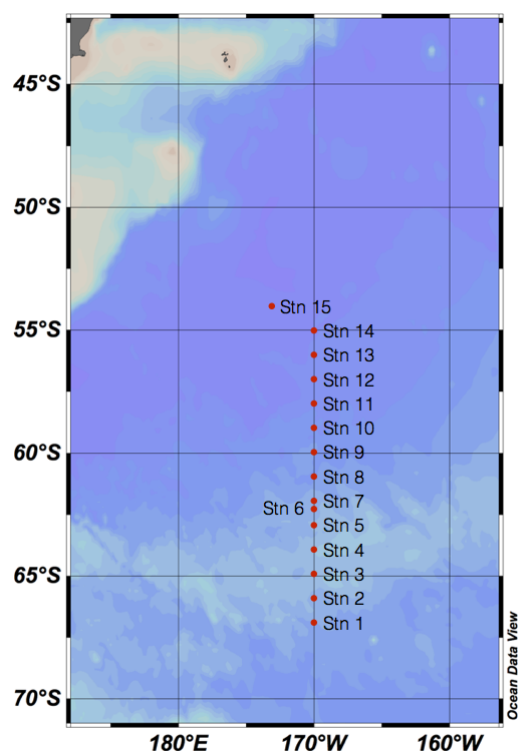


Figure 20. Station locations proposed for cruise NBP1702 along 170°W crossing the Antarctic Circumpolar Current between Antarctica and New Zealand.

New Funding

Although no new funding was secured during the past year, as noted above, the management proposal for GP15 was recommended for funding by the US NSF Chemical Oceanography program. The management proposal will support cruise logistics, such as nutrient analyses and hydrography as well as the sampling systems to be shared by all investigators (Niskin rosette, trace metal clean rosette, in situ pumps). Funding decisions on the proposals to support research on TEIs, which were submitted 15 February 2017, are anticipated in June or July of 2017.

Presentation of results

A large number of presentations based on results from the GN01 section were made at the 2017 meeting of the Associated Sciences of Limnology and Oceanography, Honolulu, Hawaii, USA, as described above. The session, number 17 in the program, was entitled “Biogeochemical Cycling of Trace Elements and Isotopes in the Arctic Ocean.”

Additional GEOTRACES presentations were given in Session 25 “Linking Atmospheric Deposition to the Biogeochemistry of Aquatic and Marine Systems” and in session 29 “REE Marine Geochemistry in the 21st Century- A Tribute to the Pioneering Research of Henry Elderfield (1943 – 2016).”

U.S. GEOTRACES Meetings

As noted above, 62 investigators from the US GEOTRACES community with an interest in participating in GP15 assembled for a cruise planning workshop held in La Jolla, California from 5 - 7 October 2016. Plenary speakers were invited to discuss hydrography and circulation in the North Pacific as well as primary productivity, nutrient dynamics and particle dynamics, all of which are thought to influence the distributions of trace elements and their isotopes along the GP15 section.

Members of the US GEOTRACES SSC also attended the workshop, and held a closed meeting during the afternoon of 7 October to finalize priorities for the GP15 section. These priorities were announced to the US GEOTRACES community and posted, along with other information to aid in preparing proposals, on the US GEOTRACES web site:

http://usgeotraces.org/USGEOTRACES_website/documents/pacificDOC/WSPac2016/WSPAC%202016Proposal_Prep_Docs.html

Synthesis Meetings

The second foundational workshop in support of international GEOTRACES synthesis activities was held at the Lamont-Doherty Earth Observatory, Palisades, New York, USA from 1-4 August, 2016. The workshop, entitled “Biogeochemical cycling of trace elements within the ocean: A synthesis workshop” was sponsored jointly by US GEOTRACES and by the Ocean Carbon and Biogeochemistry Program. More than 100 investigators from 12 nations participated in the workshop.

Plenary talks were streamed live on the web, and videos are available on the workshop web site along with the slides from the plenary presentations and from the working group summaries: <http://web.whoi.edu/geotraces-synthesis/>

The workshop was organized around three themes related to the internal cycling of trace elements and their isotopes within the ocean:

- Biological uptake and trace element bioavailability
- Abiotic cycling and scavenging, including particulate and dissolved speciation
- Export, recycling and regeneration

Working groups formed around specific topics related to each of the themes above and developed recommendations for future work on each topic. From these recommendations, 12 specific topics were identified for further development as synthesis papers. Workshop participants then reformed new working groups to establish a strategy for preparation and publication of these synthesis papers.

As of the time this report is written, several manuscripts are in progress, but none are ready for submission. The internal cycling workshop will provide an empirical comparison of two fundamentally different approaches to synthesis. The first GEOTRACES synthesis workshop, on the supply and removal of trace elements at ocean boundaries (December, 2015, London UK), required invited speakers to prepare manuscripts for publication in a special volume of the *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 374: DOI: 10.1098/rsta.2015.0300). The internal cycling workshop, with its bottom-up approach to the selection of synthesis papers, will provide an

interesting contrast to the first workshop. We look forward to compiling the lessons learned from these experiences.

A summary of the anticipated products of the internal cycling workshop is provided in Appendix I of this report.

Outreach Activities

The most noteworthy outreach activity of the past year was the successful publication of a children's book illustrating the experiences of US GEOTRACES Scientists in the Arctic Ocean aboard HLY1502 (GN01).

The book, by Katlin Bowman and Elizabeth Saito, entitled "To the Top of the World" is featured on the GEOTRACES web site: <http://www.geotraces.org/outreach/other-outreach-materials/educational-initiatives/1293-geotraces-expedition-children-book-2>

Although it is scheduled after the nominal annual cycle covered by this report, we note that Chris Measures and Mariko Hatta of the University of Hawaii will share a public presentation entitled "Oceanography in the Arctic and the Disappearing Sea Ice" on 16 May 2017. See <http://hi-sci.org/Meetings/May2017.shtml>

Data Management

A summary of GEOTRACES data management at the Biological and Chemical Oceanography – Data Management Office (BCO-DMO) is provided in Appendix II.

Publications (GEOTRACES, GEOTRACES Compliant and GEOTRACES-related)

During the past year US GEOTRACES investigators published a total of 30 peer-reviewed journal articles, including papers published by lead authors in other nations for which U.S. GEOTRACES investigators serve as co-authors.

- Anderson, R.F., Cheng, H., Edwards, R.L., Fleisher, M.Q., Hayes, C.T., Huang, K.F., Kadko, D., Lam, P.J., Landing, W.M., Lao, Y., Lu, Y., Measures, C.I., Moran, S.B., Morton, P.L., Ohnemus, D.C., Robinson, L.F., Shelley, R.U., 2016. How well can we quantify dust deposition to the ocean? *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374, DOI: 10.1098/rsta.2015.0285.
- Baker, A.R., Landing, W.M., Bucciarelli, E., Cheize, M., Fietz, S., Hayes, C.T., Kadko, D., Morton, P.L., Rogan, N., Sarthou, G., Shelley, R.U., Shi, Z., Shiller, A., van Hulten, M.M.P., 2016. Trace element and isotope deposition across the air–sea interface: progress and research needs. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374, DOI: 10.1098/rsta.2016.0190.
- Bates, S.L., Hendry, K.R., Pryer, H.V., Kinsley, C.W., Pyle, K.M., Woodward, E.M.S., Horner, T.J., 2017. Barium isotopes reveal role of ocean circulation on barium cycling in the Atlantic. *Geochimica et Cosmochimica Acta*, 204, 286-299.
- Behrens, M.K., Muratli, J., Pradoux, C., Wu, Y., Böning, P., Brumsack, H.-J., Goldstein, S.L., Haley, B., Jeandel, C., Paffrath, R., Pena, L.D., Schnetger, B., Pahnke, K., 2016. Rapid and precise analysis of rare earth elements in small volumes of seawater - Method and intercomparison. *Marine Chemistry*, 186, 110-120.

- Boiteau, R.M., Mende, D.R., Hawco, N.J., McIlvin, M.R., Fitzsimmons, J.N., Saito, M.A., Sedwick, P.N., DeLong, E.F., Repeta, D.J., 2016a. Siderophore-based microbial adaptations to iron scarcity across the eastern Pacific Ocean. *Proceedings of the National Academy of Sciences*, 113, 14237-14242.
- Boiteau, R.M., Till, C.P., Ruacho, A., Bundy, R.M., Hawco, N.J., McKenna, A.M., Barbeau, K.A., Bruland, K.W., Saito, M.A., Repeta, D.J., 2016b. Structural Characterization of Natural Nickel and Copper Binding Ligands along the US GEOTRACES Eastern Pacific Zonal Transect. *Frontiers in Marine Science*, 3, 10.3389/fmars.2016.00243.
- Bowman, K.L., Hammerschmidt, C.R., Lamborg, C.H., Swarr, G.J., Agather, A.M., 2016. Distribution of mercury species across a zonal section of the eastern tropical South Pacific Ocean (U.S. GEOTRACES GP16). *Marine Chemistry*, 186, 156-166.
- Boyd, P.W., Ellwood, M.J., Tagliabue, A., Twining, B.S., 2017. Biotic and abiotic retention, recycling and remineralization of metals in the ocean. *Nature Geosci*, 10, 167-173.
- Casciotti, K.L., 2016. Nitrite isotopes as tracers of marine N cycle processes. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374, DOI: 10.1098/rsta.2015.0295.
- Charette, M.A., Lam, P.J., Lohan, M.C., Kwon, E.Y., Hatje, V., Jeandel, C., Shiller, A.M., Cutter, G.A., Thomas, A., Boyd, P.W., Homoky, W.B., Milne, A., Thomas, H., Andersson, P.S., Porcelli, D., Tanaka, T., Geibert, W., Dehairs, F., Garcia-Orellana, J., 2016. Coastal ocean and shelf-sea biogeochemical cycling of trace elements and isotopes: lessons learned from GEOTRACES. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374, DOI: 10.1098/rsta.2016.0076.
- Chen, M., Boyle, E.A., Lee, J.-M., Nurhati, I., Zurbrick, C., Switzer, A.D., Carrasco, G., 2016. Lead isotope exchange between dissolved and fluvial particulate matter: a laboratory study from the Johor River estuary. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374, DOI: 10.1098/rsta.2016.0054.
- Conway, T.M., John, S.G., Lacan, F., 2016. Intercomparison of dissolved iron isotope profiles from reoccupation of three GEOTRACES stations in the Atlantic Ocean. *Marine Chemistry*, 183, 50-61.
- Fitzsimmons, J.N., John, S.G., Marsay, C.M., Hoffman, C.L., Nicholas, S.L., Toner, B.M., German, C.R., Sherrell, R.M., 2017. Iron persistence in a distal hydrothermal plume supported by dissolved-particulate exchange. *Nature Geosci*, 10, 195-201.
- German, C.R., Casciotti, K.A., Dutay, J.C., Heimbürger, L.E., Jenkins, W.J., Measures, C.I., Mills, R.A., Obata, H., Schlitzer, R., Tagliabue, A., Turner, D.R., Whitby, H., 2016. Hydrothermal impacts on trace element and isotope ocean biogeochemistry. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374, DOI: 10.1098/rsta.2016.0035.
- Grand, M.M., Chocholouš, P., Růžicka, J., Solich, P., Measures, C.I., 2016. Determination of trace zinc in seawater by coupling solid phase extraction and fluorescence detection in the Lab-On-Valve format. *Analytica Chimica Acta*, 923, 45-54.
- Grasse, P., Brzezinski, M.A., Cardinal, D., de Souza, G.F., Andersson, P., Closset, I., Cao, Z., Dai, M., Ehlert, C., Estrade, N., Francois, R., Frank, M., Jiang, G., Jones, J.L., Kooijman, E., Liu, Q., Lu, D., Pahnke, K., Ponzevera, E., Schmitt, M., Sun, X., Sutton,

- J.N., Thil, F., Weis, D., Wetzel, F., Zhang, A., Zhang, J., Zhang, Z., 2017. GEOTRACES inter-calibration of the stable silicon isotope composition of dissolved silicic acid in seawater. *Journal of Analytical Atomic Spectrometry*, 32, 562-578.
- Hawco, N.J., Ohnemus, D.C., Resing, J.A., Twining, B.S., Saito, M.A., 2016. A dissolved cobalt plume in the oxygen minimum zone of the eastern tropical South Pacific. *Biogeosciences*, 13, 5697-5717.
 - Hayes, C.T., Rosen, J., McGee, D., Boyle, E.A., 2017. Thorium distributions in high- and low-dust regions and the significance for iron supply. *Global Biogeochemical Cycles*, 31, 328-347.
 - Homoky, W.B., Weber, T., Berelson, W.M., Conway, T.M., Henderson, G.M., van Hulten, M., Jeandel, C., Severmann, S., Tagliabue, A., 2016. Quantifying trace element and isotope fluxes at the ocean–sediment boundary: a review. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374, DOI: 10.1098/rsta.2016.0246.
 - John, S.G., Kunzmann, M., Townsend, E.J., Rosenberg, A.D., 2017. Zinc and cadmium stable isotopes in the geological record: A case study from the post-snowball Earth Nuccaleena cap dolostone. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 466, 202-208.
 - Kadko, D., 2017. Upwelling and primary production during the U.S. GEOTRACES East Pacific Zonal Transect. *Global Biogeochemical Cycles*, 31, 218-232.
 - Kim, J.-M., Baars, O., Morel, F.M.M., 2016. The effect of acidification on the bioavailability and electrochemical lability of zinc in seawater. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374, DOI: 10.1098/rsta.2015.0296.
 - Lamborg, C.H., Hammerschmidt, C.R., Bowman, K.L., 2016. An examination of the role of particles in oceanic mercury cycling. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374, DOI: 10.1098/rsta.2015.0297.
 - Mason, R.P., Hammerschmidt, C.R., Lamborg, C.H., Bowman, K.L., Swarr, G.J., Shelley, R.U., 2017. The air-sea exchange of mercury in the low latitude Pacific and Atlantic Oceans. *Deep Sea Research Part I: Oceanographic Research Papers*, 122, 17 - 28.
 - Ohnemus, D.C., Rauschenberg, S., Cutter, G.A., Fitzsimmons, J.N., Sherrell, R.M., Twining, B.S., 2017. Elevated trace metal content of prokaryotic communities associated with marine oxygen deficient zones. *Limnology and Oceanography*, 62, 3-25.
 - Roshan, S., Wu, J., Jenkins, W.J., 2016. Long-range transport of hydrothermal dissolved Zn in the tropical South Pacific. *Marine Chemistry*, 183, 25-32.
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 - Tagliabue, A., Aumont, O., DeAth, R., Dunne, J.P., Dutkiewicz, S., Galbraith, E., Misumi, K., Moore, J.K., Ridgwell, A., Sherman, E., Stock, C., Vichi, M., Völker, C., Yool, A., 2016. How well do global ocean biogeochemistry models simulate dissolved iron distributions? *Global Biogeochemical Cycles*, 30, 149-174.
 - Tagliabue, A., Bowie, A.R., Boyd, P.W., Buck, K.N., Johnson, K.S., Saito, M.A., 2017. The integral role of iron in ocean biogeochemistry. *Nature*, 543, 51-59.

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Books and Book Chapters

- Radon: A Tracer for Geological, Geophysical and Geochemical Studies – Springer, M. Baskaran – August 2016 (Book DOI: 10.1007/978-3-319-21329-3; ISBN: 978-3-319-21328-6; ISBN 978-3-319-213329-3 eBook).
- Baskaran, M., 2017a. Applications of Radon Progeny in Atmospheric studies. In: “Radon: A Tracer for Geological, Geophysical and Geochemical Studies” pp. 85-117, Book DOI: 10.1007/978-3-319-21329-3.
- Baskaran, M., 2017b. Radon: A Geochemical and Geophysical Tracer in Marine System. In: “Radon: A Tracer for Geological, Geophysical and Geochemical Studies” pp. 119-144, Book DOI: 10.1007/978-3-319-21329-3.

Dissertations

- Boiteau, R., 2016. Molecular determination of marine iron ligands by mass spectrometry. Vol. PhD (p. 230): Massachusetts Institute of Technology - Woods Hole Oceanographic Institution.
- DiMento, B., 2017. An investigation of the major transformations and loss mechanisms of mercury and selenium in the surface ocean. Vol. PhD (p. 181): University of Connecticut.
- Hawco, N.J., 2017. The Cobalt Cycle in the Tropical Pacific Ocean. Vol. PhD (p. 217): Massachusetts Institute of Technology - Woods Hole Oceanographic Institution.
- Peters, B., 2016. Stable isotope measurements from a cold polar desert and marine oxygen deficient zone reveal clues about the global nitrogen cycle. *Earth System Science*, Vol. PhD Dissertation (p. 261): Stanford University.

Submitted by Bob Anderson (boba@ldeo.columbia.edu).

APPENDIX I. US GEOTRACES

SUMMARY OF ANTICIPATED PRODUCTS

Synthesis workshop: Biogeochemical Cycling of Trace Elements within the Ocean

Lamont-Doherty Earth Observatory in Palisades New York, USA, 1 – 4 August 2016

Jointly sponsored by GEOTRACES and by the Ocean Carbon and Biochemistry program

Workshop themes:

- 1) Biological uptake and trace element bioavailability,
- 2) Abiotic cycling and scavenging, including particulate and dissolved speciation,
- 3) Export, recycling and regeneration

Recommendations and anticipated products (TEI = trace element and isotope):

Micronutrient group

1) *Estimate Bioavailability of Fe with oceanographic data using the “bioavailability envelope” concept of Lis et al., (ISME Journal, 2015) using GEOTRACES data sets [dissolved Fe from GEOVIDE, KEOPS, NEOPS, (Geraldine), FeCYCLE (Andrew Bowie), and HOT and BATS; as well as single cell Fe quotas (SXRF) and cell surface area data (Ben Twining)]*

Heroes: Yeala Shaked, Maite Maldonado (Ben Twining, Mark Moore, Dan Repeta, Seth John, Adrian Marchetti, Mak Saito, Alessandro Tagliabue, Bill Sunda, Geraldine Sarthou, Bethany Jenkins)

2) *Estimate bioavailability of Fe in natural systems by examining phytoplankton single cell Fe quotas across concentration gradients of dissolved and (labile) particulate TEIs, using data from NAZT, GeoMICS, EPZT, IRONBRU cruises on SXRF, dissolved Fe, soluble and colloidal Fe, Fe voltammetry/speciation, total particulate and labile particulate Fe.*

Heroes: Ben Twining (Kristen Buck, Randie Bundy, Mark Moore, Jessica Fitzsimmons, Claire Till, Jim Moffett, Mak Saito, Jingfeng Wu, Kathy Barbeau, Maite Maldonado)

3) *Test the hypothesis for light and Fe co-limitation in deep chlorophyll maxima (DCM) using GEOTRACES dissolved Fe data sets. Explore also TARA molecular data sets (and possibly those from GEOMICS & Malaspina-2010 Expedition) to look for iron stress metagenomics markers in the world's DCMs*

Heroes: Bill Sunda (Dreux Chappell, Pete Sedwick, Mak Saito, Kathy Barbeau, Alexandra Bausch, Adrian Marchetti, Jessica Fitzsimmons, Seth John, Dan Ohnemus, Bethany Jenkins).

4) *Explore Redfieldian concepts of elemental stoichiometry using dissolved and particulate GEOTRACES TE data and ocean models*

Heroes: Mak Saito, Ben Twining (Dan Ohnemus, Mark Moore, Clare Davis, Amber Annett, Alyson Santoro, Bill Sunda, Alessandro Tagliabue, Alexandra Bausch, Maite Maldonado)

5) *Organismal quota approach to calculate community trace metal demand and compare to trace metal inventories and relative resource supply (linking TEs data sets to hydrography, aeolian deposition information...). This aims to ultimately address controls on biogeography. The derived organismal trace metal quotas are based on biochemistry concepts of cell metabolism (Raven's estimates of trace metal quotas based on proteins trace metal content and metabolic rates)*

Heroes: Maite Maldonado, Al Tagliabue (Ben Twining, Mark Moore, Mak Saito, Adrian Marchetti, Alyson Santoro, Tung-Yuan Ho, Clare Davis, Susanna Fitz, Amber Annett, Mark Brzezinski)

NOTE: To achieve 5 and 3, and maybe 1, it would be nice, but not required, to find oceanic transect where there are GEOTRACES TE data and complementary “omics data” (e.g., from TARA Ocean Expeditions (to contact Colomban de Vargas), GEOMICS, or Malaspina-2010 Expedition (to contact Mart Estrada). We will then have to mine through the massive sequence databases to link metrics from sequences (e.g, taxonomic composition, presence/absence or gene expression of particular genes or pathways, etc.) with the GEOTRACES data. The *molecular jockeys* helping with this are Adrian Marchetti, Alyson Santoro, Bethany Jenkins, Dreux Chappell, Mak Saito, Geraldine Sarthou, and Dan Repeta

Abiotic cycling and scavenging (including particulate and dissolved speciation group)

6) *A Synthesis Paper on “Paradigms of ligand composition and cycling and the degree of confidence in them” will be produced*

Heroes: Kristen Buck, Randie Bundy (John Dunne, Geraldine Sarthou, Jessica Fitzsimmons, Maeve Lohan, Alessandro Tagliabue, Tim Conway, Julia Gauglitz, Dan Repeta, Elliot Sherman and Kazuhiro Misumi)

Export, recycling and regeneration group

7) *Compare radionuclide-based methods ($^{234}\text{Th}/^{238}\text{U}$; $^{228}\text{Th}/^{228}\text{Ra}$; $^{230}\text{Th}/^{234}\text{U}$; $^{210}\text{Po}/^{210}\text{Pb}$; Pu/Np) to estimate the downward flux of particulate C, N, P, ^{232}Th , Al, Cd, Fe, Co, Cu, and Mn from the surface mixed layer to the sea bed.*

Heroes: Chris Hayes, Erin Black (Gideon Henderson, Ken Buesseler, Frank Pavia, Bob Anderson, Mark Baskaran, Tim Kenna, Patrick Fitzgerald, Kirk Cochran)

8) *Modes of regeneration: desorption/dissolution vs. biotic respiration. Combine measured TEI distributions with calculated AOU, depth-dependent OURs, and preformed TEI concentrations to discriminate among effects of abiotic scavenging, biotic uptake and regeneration, and physical transport.*

Heroes: Bill Jenkins (Greg Cutter, Nick Hawko, Bob Anderson, Keith Moore, Bill Smethie, Yi Tang, Rana Fine, Francois Primeau, Tom Weber, Molly Martin, Susan Little, Xin-Yuan Zheng, Yves Plancherel, Ed Boyle, Maureen Conte, Max Grand, Alan Shiller, Mariko Hatta, Ken Buesseler, Erin Black, Maeve Lohan, Dave Kadko)

Corollary: Greater attention needs to be afforded to defining end-member TEI concentrations of major water masses.

Hybrid products derived from the abiotic cycling and scavenging and the export and regeneration groups

9) *Improve simple models for particle aggregation and disaggregation by adding 2nd order rate kinetics for aggregation, and by including the aggregation of small and large particles.*

Heroes: Adrian Burd (Rob Sherrell, Paul Lerner, Francois Primeau, Phoebe Lam)

10) *Kd for the spectrum of elements. Estimate relative scavenging of an element for which we can derive an absolute Kd, like Th, when their concentrations are measured concurrently with ^{230}Th and ^{232}Th .*

Heroes: Chris Hayes (Seth John, Xin-Yuan Zheng)

11) *Compare beam transmission measured concurrently with abundance and composition of particles measured on GEOTRACES will lead to new algorithms to interpret beam transmission in terms of particle distributions that affect TEI scavenging as well as the optical properties of nepheloid layers.*

Heroes: Chris Hayes (Rob Sherrell, Dan Ohnemus, Wilf Gardner, Mary Jo Richardson, Phoebe Lam, Jessica Fitzsimmons, Frankie Pavia, Bob Anderson)

12) *Prepare a synthesis paper on the distribution of nepheloid layers, the abundance and composition of particles within them, differences in the scavenging intensity, sorption coefficients of particle-reactive radionuclides, and their impact on dissolved TEI distributions.*

Heroes: Rob Sherrell (Chris Hayes, Dan Ohnemus, Wilf Gardner, Mary Jo Richardson, Phoebe Lam, Jessica Fitzsimmons, Frankie Pavia, Bob Anderson, Mark Baskaran)

APPENDIX II. US GEOTRACES
DATA MANAGEMENT ACTIVITIES AT BCO-DMO



website: <http://www.bco-dmo.org>

email: info@bco-dmo.org

U.S. GEOTRACES: <http://www.bco-dmo.org/program/2022>

Overview

The Biological and Chemical Oceanography Data Management Office (BCO-DMO), based at Woods Hole Oceanographic Institution, manages GEOTRACES data from U.S. investigators. Serving as the U.S. GEOTRACES Data Assembly Center (DAC), BCO-DMO provides data management services at no cost to NSF-funded investigators. The BCO-DMO data managers work closely with contributing investigators to ensure the quality and completeness of data and metadata. Additionally, BCO-DMO is responsible for transferring the U.S. data to the GEOTRACES International Data Assembly Centre (GDAC). GDAC staff archive the data long-term, and they help prepare data for inclusion in the GEOTRACES Intermediate Data Product (IDP).

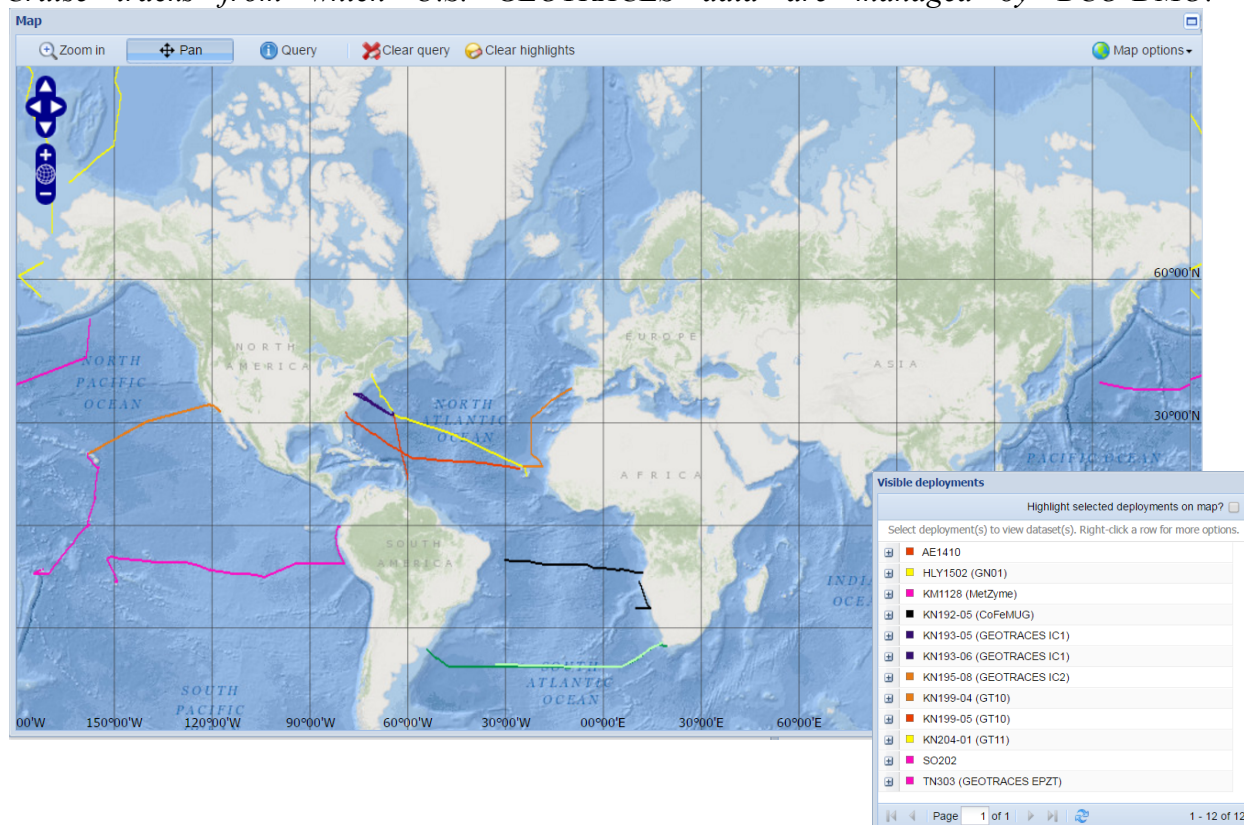
Available Data

Summary of U.S. GEOTRACES Data Available from BCO-DMO as of April 2017.

Cruise ID	Chief Sci	Dates	# of Datasets
GEOTRACES-Compliant			
KN192-05 (CoFeMUG, GAc01)	Mak Saito	2007-11-16 to 2007-12-13	10
SO202-INOPEX (GPc01, INOPEX)	Rainer Gersonde	2009-07-08 to 2009-08-28	1
KM1128 (MetZyme)	Carl Lamborg	2011-10-01 to 2011-10-25	4
AE1410 (GAc02)	Maureen Conte	2014-05-31 to 2014-06-08	1
Intercalibration Cruises			
KN193-05 (InterCal 1 Leg 1)	Greg Cutter	2008-06-08 to 2008-06-27	3
KN193-06 (InterCal 1 Leg 2)	Greg Cutter	2008-06-29 to 2008-07-12	6
KN195-08	Greg Cutter	2009-05-06 to 2009-05-29	3
International GEOTRACES Cruises from which U.S. PIs have contributed data			

RRS Discovery D357 (GA10)	Gideon Henderson	2010-10-18 to 2010-11-22	1
RRS James Cook JC068 (GA10)	Gideon Henderson	2011-12-24 to 2012-01-27	1
North Atlantic Transect (NAT)			
KN199-04 (GA03 Leg 1)	William Jenkins	2010-10-15 to 2010-11-04	72
KN199-05 (GA03 Leg 2)	William Jenkins	2010-11-08 to 2010-11-26	6
KN204 (GA03)	Ed Boyle	2011-11-06 to 2011-12-11	67
East Pacific Zonal Transect (EPZT)			
TN303 (EPZT, GP16)	Jim Moffett	2013-10-25 to 2013-12-20	65
Arctic			
CGC Healy HLY1502 (GN01)	David Kadko	2015-08-09 to 2015-10-12	8

Cruise tracks from which U.S. GEOTRACES data are managed by BCO-DMO.



Current Status

Most of the data submitted to BCO-DMO since the last IDP was released has been from the East Pacific Zonal Transect (EPZT) cruise, along with some data from the North Atlantic Transect (NAT) and Arctic cruises. Data that were submitted to BCO-DMO by the IDP

deadlines have been contributed to GDAC for inclusion in the 2017 IDP, due to be released in August. BCO-DMO data managers have been in frequent communication with GDAC as part of this process to ensure that U.S. data are included in the IDP.

We expect to see more Arctic data coming in as samples are processed, and we're also ready to provide data management support for the upcoming Pacific Meridional Transect cruise. We encourage PIs to contact us (info@bco-dmo.org) with questions or concerns about their data. When contributing datasets, we strongly suggest including complete sample metadata with each record (sample ID number, event number, station number, cast number, bottle number, depth, latitude, longitude, and date-time). PIs may opt to restrict their data for a specified time period, though we encourage open sharing of data as early as possible to foster collaboration and data re-use.

The BCO-DMO Team includes: Hannah Ake, Nancy Copley, Cyndy Chandler, David Glover, Bob Groman, Danie Kinkade, Shannon Rauch, Adam Shepherd, Amber York, and Peter Wiebe.

Questions/comments should be directed to info@bco-dmo.org and/or the main point of contact at BCO-DMO for U.S. GEOTRACES, Shannon Rauch (srauch@whoi.edu).