**ANNUAL REPORT ON GEOTRACES ACTIVITIES IN CANADA**

**May 1, 2019 – April 1, 2020**

***Accomplishments***

Canadian PI's continue to work closely with US colleagues on Arctic GEOTRACES synthesis projects and a number of jointly authored manuscripts are planned, in progress or published at this point. The Canadian GEOTRACES community continues to support an ongoing process study making observations of bioactive trace elements and trace element-microbe interactions on time-series cruises completed along Line P in the northeast Pacific. The Canadian community is examining the impact of recent marine heatwaves on chemical and biological fields along Line P. Cullen is coordinating US colleagues to qualify the trace element sampling program for EXPORTS as a GEOTRACES compliant activity. Data from GN02 and GN03 are being submitted to the IDP2021.

Our new, GEOTRACES relevant scientific results, publications and presentations are summarized by Individual Investigator below.

Susan Allen, Earth, Ocean and Atmospheric Sciences, University of British Columbia

***New GEOTRACES or GEOTRACES relevant scientific results***

- Mn model for the Canadian Arctic Archipelago is showing good agreement with the Canadian 2015 GEOTRACES data.

***New GEOTRACES or GEOTRACES-relevant publications (published or in press)***


- ·Yu X, Allen S, Francois R, Grenier M, Myers P, Hu X. Modeling dissolved and particulate 230Th in the Canada Basin: Implications for recent changes in particle flux and intermediate circulation. Journal of Geophysical Research, Oceans 125: doi:10.1029/ 2019JC015640 (2020).
- ·Grenier M, Francois R, Soon M, Rutgers van der Loeff M, Yu X, Valk O, Not C, Morand S, Edwards R, LuY, Lepore K, Allen S. Changes in circulation and particle scavenging in the Amerasian Basin of the Arctic Ocean over the last three decades inferred from the water column distribution of geochemical tracers Journal of Geophysical Research, Oceans 124: 9338-9363, (2019).
- ·Colombo M, Rogalla B, Myers P, Allen S, Orians K. Tracing Dissolved Lead Sources in the Canadian Arctic: Insights from the Canadian GEOTRACES program. ACS Earth and Space Chemistry 3(7) 1302-1314. (2019).

Jay T. Cullen, University of Victoria

***New GEOTRACES or GEOTRACES relevant scientific results***

- Line P Time Series measurements of dissolved Fe and other bioactive trace elements and collaborations with Swiss, US, French and UK colleagues on metal isotope systems and organic matter-metal interaction.
- Nutrient Transports and living marine Resources Across the Inuit Nunangat (NTRAIN) ArcticNet funded project examining flux of bioactive trace elements from the Arctic to the North Atlantic.
- Hydrothermal flux of bioactive trace elements at Endeavour Ridge vent field in the subarctic northeast Pacific.

***New GEOTRACES or GEOTRACES-relevant publications (published or in press)*** (* denotes supervised personnel)


- Whitby, H., E. Bucciarelli, G. Sarthou, N. Cassar, C.L. Osburn, *D.J. Janssen, J.T. Cullen, A. Gonzalez, M. Tonnard and H. Planquette. (2020) A call for refining the role of humic-like substances in the oceanic iron cycle. Nature Scientific Reports. 10: 6144 https://doi.org/10.1038/s41598-020-62266-7
- Bundy, R.M., A. Tagliabue, N.J. Hawco, P.L. Morton, B.S. Twining, M. Hatta, A. Noble, M.R. Cape, S.G. John, J.T. Cullen and M.A. Saito. (in review). Elevated sources of cobalt in the Arctic Ocean. Biogeosciences. https://doi.org/10.5194/bg-2020-84
- Colombo, M., *S.L. Jackson, J.T. Cullen and K.O. Orians. (2020). Dissolved iron and manganese in the Canadian Arctic Ocean: On the biogeochemical processes controlling their distributions. Geochimica et Cosmochimica Acta. 277: 150-174. https://doi.org/10.1016/j.gca.2020.03.012
- Sedwick, P., A. Bowie, T. Church, J.T. Cullen, R. Johnson, M.C. Lohan, C. Marsay, D. McGillicuddy, B. Sohst, A. Tagliabue and S. Ussher. (2020). Dissolved iron in the Bermuda region of the subtropical North Atlantic Ocean: Seasonal dynamics, mesoscale variability, and physicochemical speciation. Marine Chemistry. 219 https://doi.org/10.1016/j.marchem.2019.103748
- Vance, D., G. de Souza, Y. Zhao, J.T. Cullen and M.C. Lohan. (2019). The relationship between zinc, its isotopes, and the major nutrients in the North-East Pacific. Earth and Planetary Science Letters. 525, https://doi.org/10.1016/j.epsl.2019.115748
- Nixon, R.L., *S.L. Jackson SL, J.T. Cullen and A.R.S. Ross. (2019). Distribution of copper-complexing ligands in the Canadian Arctic waters as determined by immobilized copper(II)-ion affinity chromatography. Marine Chemistry. 215, https://doi.org/10.1016/j.marchem.2019.103673
- Chen, J., M.W. Cooke, J-F. Mercier, M. Trudel, *J. Kellogg and J.T. Cullen. (2019). 210-Po in Pacific Salmon from the West Coast of Canada and its Contribution to the Dose by Ingestion. Health Physics Journal. 17(3): 248-253.
- *Janssen, D.J., W. Abouchami, S. Galer, **K.B. Purdon and J.T. Cullen. (2019). Particulate cadmium stable isotopes in the subarctic northeast Pacific reveal dynamic Cd cycling and a new isotopically light Cd sink. Earth and Planetary Science Letters. 515: 67-78.
- *Rosario Lorenzo, M., M. Segovia, J.T. Cullen, M.T. Maldonado. (2019). Particulate trace metal dynamics in response to increased CO2 and iron availability in a coastal mesocosm experiment. Biogeosciences, https://doi.org/10.5194/bg-2018-448

***GEOTRACES presentations in international conferences***

- Cullen J.T., *S.L. Jackson, M. Colombo, *D.J. Janssen and K.O. Orians. Mobility of nutrient and potentially toxic trace metals in a changing Arctic Ocean. ArcticNet ASM 2019, Dec. 4, Halifax NS Canada.
- Cullen J.T. Communicating risks from Fukushima to the public through scientific engagement from data collection to social media, Nov. 21, University of Portsmouth, School of the Environment, Geography and Geosciences, Portsmouth UK.
- Cullen J.T. Investigating enhanced hydrothermal inputs to near-ridge sediments during glacial terminations, Nov. 15, University of Oxford, Department of Earth Sciences, Oxford UK.
- Cullen J.T., L.A. Coogan. Investigating enhanced hydrothermal input to near-ridge sediments during glacial terminations. Oct. 28, University of Bern, Institut für Geologie, Bern Switzerland
- Cullen J.T., *J. Kellogg, K.O. Buesseler, J. Chen, J. Cornett, E. Frank, H. Gurney-Smith, M. Trudel. The integrated Fukushima ocean radionuclide monitoring (InFORM) project: Tracking Fukushima derived contamination in Canada. Jun. 4, 102nd Canadian Chemistry Conference and Exhibition, Quebec City Canada.
- Cullen J.T., M. Colombo, *S.L. Jackson and K.J. Orians. Contrasting the distributions of dissolved iron and manganese in seawater of the Canadian Arctic Ocean. Aug. 22, 2019 Goldschmidt Conference, Barcelona Spain.
- Cullen J.T., *S.L. Jackson and *D.J. Janssen. The distribution of dissolved cadmium and its utility as a water mass tracer in the Canadian Arctic Ocean. Aug. 21, 2019 Goldschmidt Conference, Barcelona Spain.
- Cullen J.T., *J. Kellogg, K.O. Buesseler, J. Chen, J. Cornett, E. Frank, H. Gurney-Smith, M. Trudel. InFORMing perceived risks from Fukushima through scientific engagement from data collection to social media. Aug. 19, 2019 Goldschmidt Conference, Barcelona Spain.

Alfonso Mucci, Department of Earth and Planetary Sciences, McGill University

***New GEOTRACES or GEOTRACES relevant scientific results***

- Re-initiated writing of a paper on brine-driven convection and evolution of mixed-layer properties in the Arctic Ocean

***Refereed Journal Publications***

- Beaupré-Laperrière A., Mucci A. and Thomas H. (2020) The recent state and variability of the carbonate system of the Canadian Arctic in the context of ocean acidification. Submitted to Biogeosciences (accepted with major revisions, in revision)
- Mears C., Thomas H., Henderson P.B., Charette M.A., MacIntyre H., Dehairs F., Monnin C., and Mucci A. (2020) Using 226Ra and 228Ra isotopes to distinguish water mass distribution in the Canadian Arctic Archipelago. Submitted to Biogeosciences (in review).

***Completed GEOTRACES PhD or Master theses***

- Beaupré-Laperrière A. (2019) The state and variability of the carbonate system of the Canadian Arctic in the context of ocean acidification. M.Sc. thesis, 101 pp., McGill University.

Dr. Kristin Orians, Chemistry and Earth, Ocean and Atmospheric Sciences, University of British Columbia

***New GEOTRACES or GEOTRACES-relevant publications (published or in press)***

- Colombo, M, Jackson, S.L., Cullen, J.T., Orians K.J. (2020) Dissolved iron and manganese in the Canadian Arctic Ocean: on the biogeochemical processes controlling their distributions. Geochimica et Cosmochimica Acta (Manuscript number: GCA-D-19-00913R3). DOI: 10.1016/j.gca.2020.03.012
- Sim, N. and Orians, K.J. (2019) Annual variability of dissolved manganese in Northeast Pacific along Line-P: 2010–2013, Marine Chemistry, 216, 103702. DOI: 10.1016/j.marchem.2019.103702
- Colombo, M., Brown, K.A., De Vera, J., Bergquist, B.A., Orians, K.J. (2019) Trace metal geochemistry of remote rivers in the Canadian Arctic Archipelago. Chemical Geology, 525, 479-491. DOI: 10.1016/j.chemgeo.2019.08.006
- Colombo, M., Rogalla, B., Myers, P.G., Allen, S.E., Orians, K.J. (2019) Tracing dissolved lead sources in the Canadian Arctic: insights from the Canadian GEOTRACES program. ACS Earth Space Chemistry, 3, 1302–1314. DOI: 10.1021/acsearthspacechem.9b00083

***Completed GEOTRACES PhD or Master theses***

- Colombo, M. On the biogeochemical processes controlling trace metal distributions in the Canadian Arctic Ocean and Arctic rivers. Ph.D. Thesis, Oceanography, UBC (Nov 2019). https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0386025

Dr. Andrew R.S. Ross, Research Scientist, Institute of Ocean Sciences, Fisheries and Oceans Canada (DFO), Assistant Adjunct Professor, Biochemistry and Microbiology, University of Victoria (UVic)

***New GEOTRACES or GEOTRACES relevant scientific results***

- Copper ligand concentrations in samples collected along Line P in 2016, 2017 and 2018 using GEOTRACES protocols have now been measured, compiled and analysed. These results are included in a Ph.D. thesis (Richard L. Nixon, University of Victoria) due to be defended in June 2020 and are currently being written up for publication.
- Copper ligand concentrations measured in samples collected across the Canadian Arctic in 2015 during GEOTRACES cruises GN02 and GN03 have been submitted via the DOor Portal to be considered for inclusion in IDP2021.

***GEOTRACES or GEOTRACES relevant cruises***

- Samples for copper ligand measurement were collected using GEOTRACES protocols during Line P cruise 2020-001 (February 7-25, 2020) as part of the Line P Iron Program, a GEOTRACES Process Study (GPpr07).

***New GEOTRACES or GEOTRACES-relevant publications (published or in press)***

- Copper ligand concentrations measured in samples collected across the Canadian Arctic in 2015 during GEOTRACES cruises GN02 and GN03 were published on June 27, 2019:

- Nixon, R.L, Jackson, S.L, Cullen, J.T., Ross, A.R.S. 2019. Distribution of copper-complexing ligands in the Canadian Arctic as determined using immobilized copper(II)-ion affinity chromatography. Marine Chemistry 215. doi 10.1016/j.marchem.2019.103673

***Completed GEOTRACES PhD or Master theses***

- University of Victoria Biochemistry and Microbiology graduate student Richard L. Nixon, whose thesis research was supported by the Canadian Arctic GEOTRACES program (CCAR-NSERC Grant RPGCC 433848-2012), will defend his PhD thesis on June 11, 2020.

***GEOTRACES presentations in international conferences***

- Copper ligand concentrations in samples collected across the Canadian Arctic in 2015 during GEOTRACES cruises GN02 and GN03 and along Line P in 2016, 2017 and 2018 as part of GEOTRACE Process Study GPpr07 were featured in the following presentations:
- Ross, A.R.S., Nixon, R.L., George, J., Jackson, S.L., Cullen, J.T. 2020. Evidence for the Production of Copper-complexing Ligands by Marine Phytoplankton in the Canadian Arctic and Subarctic NE Pacific. 20th Ocean Sciences Meeting, San Diego CA, 16-21 February.
- Ross, A.R.S., Nixon, R.L., George, J., Jackson, S.L., Cullen, J.T., Simpson, K.G, Robert, M. 2019. Evidence for the Production of Copper-complexing Ligands by Marine Phytoplankton in the Canadian Arctic and Subarctic NE Pacific. North Pacific Marine Science Organization (PICES) 2019 Annual Meeting, Victoria, Canada, 16-25 October.

Dr. John N. Smith, Head, Atlantic Environmental Radioactivity Section, Bedford Institute of Oceanography, Fisheries and Oceans Canada

***New GEOTRACES or GEOTRACES relevant scientific results***

Two papers ready for submission:

- Smith, J.N., M. Karcher, N. Casacuberta, W. Williams, T. Kenna and W.M. Smethie Jr., 2020, Measured and modelled 129I time series distributions in the Arctic Ocean reflect 1994-2015 changes in circulation and evolving climate indices, Global Biogeochemical Cycles.
- Smith, J.N., W.M. Smethie Jr., and Nuria Casacuberta, 2020, Synoptic 129I and CFC - SF6 transit time distribution (TTD) sections across the central Arctic Ocean from the 2015 GEOTRACES cruises, Journal of Geophysical Research.

***GEOTRACES or GEOTRACES relevant cruises***

- 2019 JOIS mission on Louis S. St. Laurent in Canada Basin

***GEOTRACES workshops and meetings organized***

- 2019 Goldschmidt Conference (Barcelona, Spain): Session 10c: Arctic and sub-Arctic Processes: Understanding Changing Ocean Circulation and Biogeochemistry: Conveners: Núria Casacuberta, Michael Karcher, John Smith, Lauren Kipp, Christian März, Robyn Tuerena: Keynote: Douglas Wallace

***New GEOTRACES or GEOTRACES-relevant publications (published or in press)***

- Smith J.N., and Edmonds H.N., Nuclear Fuel Reprocessing and Related Discharges, 2019. In Cochran, J. Kirk; Bokuniewicz, J. Henry; Yager, L. Patricia (eds.) Encyclopedia of Ocean Sciences, 3rd Edition, vol.[1], pp. 283-290. Oxford: Elsevier.

***GEOTRACES presentations in international conferences***

- Smith, J.N. and Casacuberta, N., Applications of Transit Time Distributions (TTDs) to tracer transport in the Arctic and North Atlantic Oceans, Session 10C, Goldschmidt Conference, Barcelona, Spain, 2019.
- Casacuberta, N., J.N. Smith et al., Understanding Circulation Processes in the Arctic and sub-Arctic Regions Using a Combination of Anthropogenic Chemical Tracers; Session CT24A-0891 - 2020 Ocean Sciences Meeting, San Diego, C.A.

Feiyue Wang, University of Manitoba

***New GEOTRACES or GEOTRACES relevant scientific results***

- Incubation studies as part of the Canadian Arctic GEOTRACES cast doubt on the validity of existing mercury methylation and demethylation rates determined by the seawater incubation approach, and call for the development of alternative methods to determine these crucially important rate constants in ambient seawater.

***GEOTRACES workshops and meetings organised***

- Attended the Asia GEOTRACES Workshop on Sources/sinks and internal cycling of mercury and other TEIs in the Northwest Pacific Ocean, Qingdao, China, December 8-10, 2019

***Other GEOTRACES activities***

- Participated in the interlaboratory calibration study on mercury and methylmercury in seawater as part of China's GEOTRACES GP09 in western Pacific.

***New GEOTRACES or GEOTRACES-relevant publications (published or in press)***

- Wang K., Munson K.M., Armstrong D., Macdonald R.W., and Wang F. 2020. Determining seawater mercury methylation and demethylation rates by the seawater incubation approach: a critique. Mar. Chem. 219, 103753

- Munson K.M., Latonas J., Xu W., Elliot A., Armstrong D.A., Stern, G.A, and Wang F. 2020. Elemental mercury in the marine boundary layer of North America: temporal and spatial patterns. Mar. Chem. 220, 103755

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

- Wang K., 2019. Methylmercury in Seawater and Its Bioaccumulation in Marine Food Webs of the Canadian Arctic. PhD Dissertation, Department of Environment and Geography, University of Manitoba, Winnipeg, MB, Canada. https://mspace.lib.umanitoba.ca/xmlui/handle/1993/33838

***GEOTRACES presentations in international conferences***

- Wang F., Outridge P., Feng X., Meng B., Heimburger-Boavida L.-E., and Mason R. 2019. How closely do mercury trends in fish and other aquatic wildlife track those in the atmosphere? - Implications for evaluating the effectiveness of the Minamata Convention. Oral presentation at the 14th International Conference on Mercury as a Global Pollutant, September 8-13, Krakow, Poland
- Wang K., Stief P., Glud R., and Wang F. Are micro-environments of Arctic copepods hotspots for mercury methylmercury? Oral presentation at the 14th International Conference on Mercury as a Global Pollutant, September 8-13, Krakow, Poland
- Munson K., James S., Gao Z., Samantha H.; Ciastek S., Chaudhuri P., Kuzyk Z.Z., Stern G., and Wang F. 2019. Mercury Cycling in the sub-Arctic Hudson Bay system. Oral presentation at the 14th International Conference on Mercury as a Global Pollutant, September 8-13, Krakow, Poland