Radium and thorium isotopes measured in the Western Arctic as part of the 2015 US GEOTRACES Arctic Cruise on the USCGC Healy (HLY1502) from August to October 2015

Website: https://www.bco-dmo.org/dataset/718440
Data Type: Cruise Results
Version: 3
Version Date: 2020-04-06

Project
» U.S. Arctic GEOTRACES Study (U.S. GEOTRACES Arctic)
» Collaborative Research: GEOTRACES Arctic Section: Radium and Thorium Isotopes as Natural Geochemical Tracers in the Arctic Ocean (Arctic GEOTRACES Ra Th)

Program
» U.S. GEOTRACES (U.S. GEOTRACES)

Contributors	Affiliation	Role
Charette, Matthew A.	Woods Hole Oceanographic Institution (WHOI)	Principal Investigator
Moore, Willard S	University of South Carolina	Co-Principal Investigator
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Radium and thorium isotopes measured in the Western Arctic as part of the 2015 US GEOTRACES Arctic Cruise on the USCGC Healy (HLY1502) from August to October 2015.

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Coverage

Spatial Extent: **N**:89.992 **E**:179.456 **S**:60.176 **W**:-180
Temporal Extent: 2015-08-12 - 2015-10-08

Dataset Description

Radium and thorium isotopes measured in the Western Arctic as part of the 2015 US GEOTRACES Arctic Cruise.

Please contact the PI and Co-PI (Charette and Moore) prior to use of these data in publications.

Acquisition Description

Water column sampling:
Radium and thorium isotopes were collected on manganese-coated cartridges filtered at depth using an adapted McLane in situ pump (WTS-LV). The pumps were programmed to filter 1500-2000L of seawater per deployment. Water (15-25 L) was also collected at the same depth using a 30L Niskin bottle; these samples were filtered (at <1L/min) through a manganese-coated acrylic fiber and used to calculate radium extraction efficiency of the pumped samples. The cartridges were rinsed with radium-free fresh water and excess moisture was removed using compressed air. Samples were analyzed three times using a delayed coincidence counter (RaDeCC) for 223Ra, 224Ra, 228Th, and 227Ac. The cartridge and fiber media were ashed at 820 degrees C and measured on gamma detectors for long lived radium (226Ra, 228Ra) and thorium isotopes. 226Ra was determined via alpha scintillation counting of the Niskin bottle Mn fiber samples.

Surface water sampling:
Surface water radium samples (280 L) were collected from approximately 2 m using a submersible surface pump and filtered through a manganese coated acrylic fiber, which quantitatively scavenges radium from the seawater. Fiber samples were then ashed in a muffle

furnace at 820 degrees C for 24 hours and the fiber ash was transferred to polystyrene vials, sealed with epoxy (to prevent 222Rn loss), and counted on high purity, well-type germanium detectors to measure 228Ra, using the lines of 228Ac (338 KeV and 911 KeV), and 226Ra, using the line for 214Pb (352 KeV). Detector efficiencies were determined by measuring ashed fiber standards prepared with a standard solution containing 226Ra and 232Th with daughters in equilibrium.

Processing Description

Data Processing:

The data were corrected for decay from the time of sampling. 223Raxs was corrected for 227Ac, 224Raxs was corrected for 228Th. When possible, total 228Th was used for the 224Raxs correction (total = dissolved + SSF particulate + LSF particulate); for samples collected using the surface pump, only dissolved 228Th was available. The radium activity of the water samples (cartridges) were corrected from the measured radium on acrylic fiber (<1L/min) using the emanation technique.

Data were flagged using the SeaDataNet quality flag scheme. For more information on SeaDataNet flags, see: https://www.geotraces.org/geotraces-quality-flag-policy/ and https://www.seadatanet.org/Standards/Data-Quality-Control

SeaDataNet quality flag definitions:

0 = No quality control;
1 = Good value;
2 = Probably good value;
3 = Probably bad value;
4 = Bad value;
5 = Changed value;
6 = Value below detection;
7 = Value in excess;
8 = Interpolated value;
9 = Missing value;
A = Value phenomenon uncertain.

Problem report:

Pump failures during sampling resulted in some gaps in data, these samples have been flagged as missing values (quality flag 9). In cases where low volumes (<600L) were filtered due to pump malfunctions, data has been flagged as questionable (quality flag 3). Samples with activities below detection limits have also been flagged (quality flag 6), and no value is reported for those samples.

BCO-DMO Processing:
- replaced blanks (missing data) with "nd"; replaced "ND" with "nd";
- added start and end date/times in ISO 8601 format;
- 02-July-2019: replaced version 1 of dataset with version 2 (additional data columns reported; additional columns for units in dpm/L and mBq/kg);
- 06-April-2020: replaced version 2 of dataset with version 3 (GEOTRACES IDP-formatted).

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Related Publications

Henderson, P. B., Morris, P. J., Moore, W. S., & Charette, M. A. (2012). Methodological advances for measuring low-level radium isotopes in seawater. Journal of Radioanalytical and Nuclear Chemistry, 296(1), 357–362. doi:10.1007/s10967-012-2047-9 [details]

Kipp, L. E., Charette, M. A., Moore, W. S., Henderson, P. B., & Rigor, I. G. (2018). Increased fluxes of shelf-derived materials to the central Arctic Ocean. Science Advances, 4(1), eaao1302. doi:10.1126/sciadv.aao1302 [details]

Kipp, L. E., Kadko, D. C., Pickart, R. S., Henderson, P. B., Moore, W. S., & Charette, M. A. (2019). Shelf-Basin Interactions and Water Mass Residence Times in the Western Arctic Ocean: Insights Provided by Radium Isotopes. Journal of Geophysical Research: Oceans, 124(5), 3279–3297. doi:10.1029/2019jc014988 https://doi.org/10.1029/2019JC014988 [details]

Maiti, K., Charette, M. A., Buesseler, K. O., Zhou, K., Henderson, P., Moore, W. S., … Kipp, L. (2015). Determination of particulate and dissolved 228Th in seawater using a delayed coincidence counter. Marine Chemistry, 177, 196–202. doi:10.1016/j.marchem.2014.12.001 [details]

Rutgers van der Loeff, M., Kipp, L., Charette, M. A., Moore, W. S., Black, E., Stimac, I., … Rember, R. (2018). Radium Isotopes Across the Arctic Ocean Show Time Scales of Water Mass Ventilation and Increasing Shelf Inputs. Journal of Geophysical Research: Oceans, 123(7), 4853–4873. doi:10.1029/2018jc013888 https://doi.org/10.1029/2018JC013888 [details]

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Parameters

Parameter	Description	Units
Cruise_ID	GEOTRACES cruise identifier	unitless
GEOTRC_CASTNO	Cast number	unitless

GEOTRC_INSTR	Sampling method	unitless
Station_ID	Station number	unitless
Start_Date_UTC	Date (UTC) at start of sample collection; format: yyyy-mm-dd	unitless
Start_Time_UTC	Time (UTC) at start of sample collection; format: HH:MM	unitless
Start_ISO_DateTime_UTC	Date and time (UTC) at start of sample collection; format: yyyy-mm-ddTHH:MMZ	unitless
End_Date_UTC	Date (UTC) at end of sample collection; format: yyyy-mm-dd	unitless
End_Time_UTC	Time (UTC) at end of sample collection; format: HH:MM	unitless
End_ISO_DateTime_UTC	Date and time (UTC) at end of sample collection; format: yyyy-mm-ddTHH:MMZ	unitless
Start_Latitude	Latitude at start of sample collection	degrees North
Start_Longitude	Longitude at start of sample collection	degrees East
End_Latitude	Latitude at end of sample collection	degrees North
End_Longitude	Longitude at end of sample collection	degrees East
Event_ID	Event number	unitless
Sample_ID	GEOTRACES sample number	unitless
Sample_Depth	Sample depth	meters (m)
Ra_226_D_CONC_PUMP_tmldld	Dissolved radium-226 activity	mBq/kg
SD1_Ra_226_D_CONC_PUMP_tmldld	One standard deviation of Ra_226_D_CONC_PUMP_tmldld	mBq/kg
Flag_Ra_226_D_CONC_PUMP_tmldld	SeaDataNet quality flag for Ra_226_D_CONC_PUMP_tmldld	unitless

Ra_228_D_CONC_PUMP_5i7kz7	Dissolved radium-228 activity	mBq/kg
SD1_Ra_228_D_CONC_PUMP_5i7kz7	One standard deviation of Ra_228_D_CONC_PUMP_5i7kz7	mBq/kg
Flag_Ra_228_D_CONC_PUMP_5i7kz7	SeaDataNet quality flag for Ra_228_D_CONC_PUMP_5i7kz7	unitless
Ra_224_D_CONC_PUMP_ryelyc	Dissolved radium-224 activity	mBq/kg
SD1_Ra_224_D_CONC_PUMP_ryelyc	One standard deviation of Ra_224_D_CONC_PUMP_ryelyc	mBq/kg
Flag_Ra_224_D_CONC_PUMP_ryelyc	SeaDataNet quality flag for Ra_224_D_CONC_PUMP_ryelyc	unitless
Ra_224xs_D_CONC_PUMP	Excess dissolved radium-224 activity	mBq/kg
Ra_224xs_D_CONC_PUMP_ERR	One standard deviation of Ra_224xs_D_CONC_PUMP	mBq/kg
Ra_224xs_D_CONC_PUMP_FLAG	SeaDataNet quality flag for Ra_224xs_D_CONC_PUMP	unitless
Ra_223_D_CONC_PUMP_8qp1jk	Dissolved radium-223 activity	mBq/kg
SD1_Ra_223_D_CONC_PUMP_8qp1jk	One standard deviation of Ra_223_D_CONC_PUMP_8qp1jk	mBq/kg
Flag_Ra_223_D_CONC_PUMP_8qp1jk	SeaDataNet quality flag for Ra_223_D_CONC_PUMP_8qp1jk	unitless
Ra_223xs_D_CONC_PUMP	Excess dissolved radium-223 actvitiy	mBq/kg
Ra_223xs_D_CONC_PUMP_ERR	One standard deviation of Ra_223xs_D_CONC_PUMP	mBq/kg
Ra_223xs_D_CONC_PUMP_FLAG	SeaDataNet quality flag for Ra_223xs_D_CONC_PUMP	unitless
Th_228_D_CONC_PUMP_fejwms	Dissolved thorium-228 activity	mBq/kg
SD1_Th_228_D_CONC_PUMP_fejwms	One standard deviation of Th_228_D_CONC_PUMP_fejwms	mBq/kg
Flag_Th_228_D_CONC_PUMP_fejwms	SeaDataNet quality flag for Th_228_D_CONC_PUMP_fejwms	unitless

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Instruments

Dataset-specific Instrument Name	30L Niskin bottles
Generic Instrument Name	Niskin bottle
Dataset-specific Description	In addition to water collected by pump, water (15-25 L) was also collected using a 30L Niskin bottles.
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24 or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

Dataset-specific Instrument Name	McLane WTS-LV
Generic Instrument Name	Large Volume Pumping System-WTS-LV
Dataset-specific Description	Water column samples were collected using McLane in situ pumps (McLane WTS-LV).
Generic Instrument Description	The Large Volume Pumping System-WTS-LV can be one of several different models of Water Transfer Systems (WTS) Large Volume (LV) pumping systems designed and manufactured by McLane Research Labs (Falmouth, MA, USA). The WTS-LV systems are large volume in-situ filtration systems designed to collect sinking particulates. WTS-LV systems are individual in situ, battery-powered, pumping/filtration units that can be deployed at multiple depths per cast to provide information on how particle flux changes with depth. The McLane WTS-LV series of oceanographic pumps draw ambient water through filters and can pump large volumes of seawater during a single cast. The WTS-LV pumps are designed for use from a hydro-wire and employ advanced control algorithms to dynamically optimize flow rates as material accumulates on a filter.

Dataset-specific Instrument Name	Radium Delayed Coincidence Counter
Generic Instrument Name	Radium Delayed Coincidence Counter
Dataset-specific Description	Samples were analyzed using Radium Delayed Coincidence (RaDeCC) counters and high-purity, well-type germanium detectors.
Generic Instrument Description	The RaDeCC is an alpha scintillation counter that distinguishes decay events of short-lived radium daughter products based on their contrasting half-lives. This system was pioneered by Giffin et al. (1963) and adapted for radium measurements by Moore and Arnold (1996). References: Giffin, C., A. Kaufman, W.S. Broecker (1963). Delayed coincidence counter for the assay of actinon and thoron. J. Geophys. Res., 68, pp. 1749-1757. Moore, W.S., R. Arnold (1996). Measurement of 223Ra and 224Ra in coastal waters using a delayed coincidence counter. J. Geophys. Res., 101 (1996), pp. 1321-1329. Charette, Matthew A.; Dulaiova, Henrieta; Gonneea, Meagan E.; Henderson, Paul B.; Moore, Willard S.; Scholten, Jan C.; Pham, M. K. (2012). GEOTRACES radium isotopes interlaboratory comparison experiment. Limnology and Oceanography - Methods, vol 10, pg 451.

Dataset-specific Instrument Name	Finish Thompson Magnetic Drive pump
Generic Instrument Name	Pump
Dataset-specific Description	Surface samples were collected using a Finish Thompson 1/2 HP Polypropylene 115V Magnetic Drive pump.
Generic Instrument Description	A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps

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Deployments

HLY1502

Website	https://www.bco-dmo.org/deployment/638807
Platform	USCGC Healy
Report	http://dmoserv3.whoi.edu/data_docs/GEOTRACES/Arctic/ARC01-report.pdf
Start Date	2015-08-09
End Date	2015-10-12
Description	US GEOTRACES Arctic cruise: The cruise began in Dutch Harbor, Alaska on 08 October 2015. After a station in the Bering Sea, Healy cruised to the North Pole on a westerly track before returning to the Canadian margin on an easterly track, returning to Dutch Harbor on 10 October 2015.

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Project Information

U.S. Arctic GEOTRACES Study (U.S. GEOTRACES Arctic)

Coverage: Arctic Ocean; Sailing from Dutch Harbor to Dutch Harbor

Description from NSF award abstract: In pursuit of its goal "to identify processes and quantify fluxes that control the distributions of key trace elements and isotopes in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions", in 2015 the International GEOTRACES Program will embark on several years of research in the Arctic Ocean. In a region where climate warming and general environmental change are occurring at amazing speed, research such as this is important for understanding the current state of Arctic Ocean geochemistry and for developing predictive capability as the regional ecosystem continues to warm and influence global oceanic and climatic conditions. The three investigators funded on this award, will manage a large team of U.S.scientists who will compete through the regular NSF proposal process to contribute their own unique expertise in marine trace metal, isotopic, and carbon cycle geochemistry to the U.S. effort. The three

managers will be responsible for arranging and overseeing at-sea technical services such as hydrographic measurements, nutrient analyses, and around-the-clock management of on-deck sampling activites upon which all participants depend, and for organizing all pre- and post-cruise technical support and scientific meetings. The management team will also lead educational outreach activities for the general public in Nome and Barrow, Alaska, to explain the significance of the study to these communities and to learn from residents' insights on observed changes in the marine system. The project itself will provide for the support and training of a number of pre-doctoral students and post-doctoral researchers. Inasmuch as the Arctic Ocean is an epicenter of global climate change, findings of this study are expected to advance present capability to forecast changes in regional and globlal ecosystem and climate system functioning. As the United States' contribution to the International GEOTRACES Arctic Ocean initiative, this project will be part of an ongoing multi-national effort to further scientific knowledge about trace elements and isotopes in the world ocean. This U.S. expedition will focus on the western Arctic Ocean in the boreal summer of 2015. The scientific team will consist of the management team funded through this award plus a team of scientists from U.S. academic institutions who will have successfully competed for and received NSF funds for specific science projects in time to participate in the final stages of cruise planning. The cruise track segments will include the Bering Strait, Chukchi shelf, and the deep Canada Basin. Several stations will be designated as so-called super stations for intense study of atmospheric aerosols, sea ice, and sediment chemistry as well as water-column processes. In total, the set of coordinated international expeditions will involve the deployment of ice-capable research ships from 6 nations (US, Canada, Germany, Sweden, UK, and Russia) across different parts of the Arctic Ocean, and application of state-of-the-art methods to unravel the complex dynamics of trace metals and isotopes that are important as oceanographic and biogeochemical tracers in the sea.

Collaborative Research: GEOTRACES Arctic Section: Radium and Thorium Isotopes as Natural Geochemical Tracers in the Arctic Ocean (Arctic GEOTRACES Ra Th)

Coverage: Western Arctic Ocean

NSF Award Abstract: In this project, investigators participating in the 2015 U.S. GEOTRACES Arctic expedition will measure radium and thorium isotopes in the western Arctic Ocean. In common with other national initiatives in the International GEOTRACES Program, the goals of the U.S. Arctic expedition are to identify processes and quantify fluxes that control the distributions of key trace elements and isotopes in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions. Some trace elements are essential to life, others are known biological toxins, and still others are important because they can be used as tracers of a variety of physical, chemical, and biological processes in the sea. The

radionuclides to be measured as part of this project are important because they are oceanographic tracers that provide information on rates of cycling of other trace elements. The project will involve training opportunities for graduate student researchers and for undergraduate students from under-represented groups. Results from the study will be shared publicly through the Woods Hole Oceanographic Institution's Center for Marine and Environmental Radioactivity. While other GEOTRACES projects will map the distribution of numerous trace elements and their isotopes (TEIs), their distribution cannot be properly interpreted without concurrent measurement of tracers capable of providing rates of internal TEI cycling processes and fluxes at boundaries and across interfaces. The isotopes to be measured in this project include a suite of uranium/thorium series radionuclides, including the shorter-lived 234-Th and 228-Th as well as the radium quartet (224-Ra, 223-Ra, 228-Ra, 226-Ra). These tracers have the appropriate half-lives and reactivities to allow for study of horizontal and vertical transport and mixing, as well as removal at ocean boundaries, supply via rivers and submarine groundwater discharge, surface scavenging and export and subsurface remineralization. The researchers have considerable experience developing and implementing the most efficient methods to sample and quantify this suite of tracers, which includes use of battery powered in-situ pumps for large volume sampling. Hence, in addition to the proposed work on uranium/thorium series radionuclides, the team will also provide a service to other GEOTRACES researchers by coordinating pump use and sampling for many essential particulate TEIs.

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Program Information

U.S. GEOTRACES (U.S. GEOTRACES)

Website: http://www.geotraces.org/

Coverage: Global

GEOTRACES is a SCOR sponsored program; and funding for program infrastructure development is provided by the U.S. National Science Foundation. GEOTRACES gained momentum following a special symposium, S02: Biogeochemical cycling of trace elements and isotopes in the ocean and applications to constrain contemporary marine processes (GEOSECS II), at a 2003 Goldschmidt meeting convened in Japan. The GEOSECS II acronym referred to the Geochemical Ocean Section Studies To determine full water column distributions of selected trace elements and isotopes, including their concentration, chemical

speciation, and physical form, along a sufficient number of sections in each ocean basin to establish the principal relationships between these distributions and with more traditional hydrographic parameters; * To evaluate the sources, sinks, and internal cycling of these species and thereby characterize more completely the physical, chemical and biological processes regulating their distributions, and the sensitivity of these processes to global change; and * To understand the processes that control the concentrations of geochemical species used for proxies of the past environment, both in the water column and in the substrates that reflect the water column. GEOTRACES will be global in scope, consisting of ocean sections complemented by regional process studies. Sections and process studies will combine fieldwork, laboratory experiments and modelling. Beyond realizing the scientific objectives identified above, a natural outcome of this work will be to build a community of marine scientists who understand the processes regulating trace element cycles sufficiently well to exploit this knowledge reliably in future interdisciplinary studies. Expand "Projects" below for information about and data resulting from individual US GEOTRACES research projects.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1458305
NSF Division of Ocean Sciences (NSF OCE)	OCE-1458424

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