Dissolved Ba, Cd, Cu, Ga, Mn, Ni, and V concentrations and Ba isotope concentrations from the US GEOTRACES Arctic Expedition (GN01, HLY1502) from August to October 2015

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Project
» U.S. Arctic GEOTRACES Study (U.S. GEOTRACES Arctic)
» GEOTRACES Arctic Section: Methane, vanadium, barium, and gallium as process indicators in the Arctic Ocean (GEOTRACES Arctic Methane V Ba Ga)

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

Contributors	Affiliation	Role
Shiller, Alan M.	University of Southern Mississippi (USM)	Principal Investigator
Horner, Tristan J.	Woods Hole Oceanographic Institution (WHOI)	Co-Principal Investigator
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Abstract
Dissolved Ba, Cd, Cu, Ga, Mn, Ni, and V concentration data from the US GEOTRACES Arctic Expedition (GN01, HLY1502) from August to October 2015. Clean seawater samples were collected using a GEOTRACES CTD referred to as GT-C/12L GoFlo. Additional near surface samples were collected using either a small boat or through the ice using Teflon coated Tygon tubing and a trace metal clean pump (IWAKI, model WMD-30LFY-115). This dataset also includes selected stable Ba isotope analyses.

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Coverage

Spatial Extent: **N**:89.995 **E**:179.5926 **S**:60.165 **W**:-179.8082
Temporal Extent: 2015-08-12 - 2015-10-08

Dataset Description

This dataset includes dissolved Ba, Cd, Cu, Ga, Mn, Ni, and V concentration data from the US GEOTRACES Arctic Expedition (GN01, HLY1502)/ This dataset also includes selected stable Ba isotope analyses. Note Co-PI Tristan Horner and related award, OCE-1736949, supported the Ba isotope analyses only.

Acquisition Description

Clean seawater samples were collected using a GEOTRACES CTD referred to as GT-C/12L GoFlo. For more information, see the cruise report. Additional near surface samples were collected using either a small boat or through the ice using Teflon coated Tygon tubing and a trace metal clean pump (IWAKI, model WMD-30LFY-115).

Water samples were filtered through pre-cleaned, 0.2 µm Pall Acropak Supor filter capsules as described elsewhere (e.g., Cutter et al., 2012; Hatta et al., 2015). Filtered water was collected in 125 mL HDPE bottles (Nalgene) that had been precleaned by soaking in hot 1.2 M HCl (reagent grade) for at least 8 h with subsequent thorough rinsing with ultrapure distilled deionized water (Barnstead E-pure). Small boat and under-ice samples were first collected into large acid-washed carboys and subsampled into 125 mL bottles.

Dissolved Ga was determined by isotope dilution ICP-MS using a ThermoFisher Element 2 operated in low resolution. Samples were concentrated using $Mg(OH)_2$ co-precipitation (e.g., Shiller & Bairamadgi, 2006; Zurbrick et al., 2012). Briefly, in this technique, a small addition (~70 µL) of clean aqueous ammonia is added to the acidified seawater sample (~7.5 mL) which precipitates a fraction of the dissolved magnesium as the hydroxide, which in turn, scavenges the gallium from solution. An enriched isotope spike of known concentration was prepared using purified enriched ^{71}Ga (99.8%), obtained from Oak Ridge National Laboratories.

Because there is a significant interference of doubly charged ^{138}Ba with ^{69}Ga, the precipitate was washed three times with a solution of high purity 0.1% NH_4OH to minimize residual Ba. The precipitate was then dissolved in 550 mL ultrapure 3% HNO3 (Seastar Chemicals, Baseline) and analyzed in low resolution using a ThermoFinnigan Element 2 High Resolution Inductively Coupled Plasma Mass Spectrometer (HR-ICP-MS). Isotopes monitored on the ICP-MS were ^{69}Ga, ^{71}Ga, and ^{138}Ba. A slight correction for residual Ba was made based on the ratio of responses at masses 69 and 138 to a Ba standard solution. Because the residual salt content varied from sample to sample, it was not possible to matrix-match the Ba correction standard. However, typically, this correction affected the final result by < 2.5 pmol/kg; where higher Ba corrections were noted, the sample was reprecipitated and re-analyzed because of concerns about the accuracy of applying the Ba standard correction to samples of high salt content.

The reagent blank contribution to the dissolved Ga analysis is typically 0.6 pmol/kg and the detection limit (based on 3 times the standard deviation of the blank) is 0.3 pmol/kg. Repeated runs of US GEOTRACES intercalibration samples (GS and GD), in-house reference solutions, and cast overlap samples suggest a precision of ± 4%; the limit of detection for Ga was 1.5 pmol/kg. Recovery of the method, as determined by repeated analysis of a spiked and unspiked seawater sample was 100 ± 7%.

Dissolved Ba was measured using a ThermoFisher Element 2 Inductively Coupled Plasma Mass Spectrometer (ICP-MS) and the isotope dilution method as described by Jacquet et al. (2005). Aliquots (50 µL) of each sample were spiked with 25 µL of a ^{135}Ba-enriched solution (~170 nM) and then diluted 30-fold with 0.2 µm ultrapure filtered water. A sample of ~93% enriched ^{135}Ba was obtained from Oak Ridge National Laboratories for use as the enriched isotope spike. The ICP-MS was operated in low resolution and both ^{135}Ba and ^{138}Ba were determined. The samples were bracketed every 10 samples with a blank and the spike ^{135}Ba solution. The volumes of the spikes, samples and dilution water were accurately assessed by calibrating each pipette by weight. The reproducibility error of this method was estimated by comparing samples collected at the same depths on different casts at the same station. For 12 pairs of these replicate samples, the average absolute deviation of 0.7 nmol/kg or typically 1.5%. Repeated runs of runs of US GEOTRACES intercalibration samples and in-house reference solutions suggest a similar precision; the limit of detection for barium was 0.7 nmol/kg. Our precision is similar to that reported by other labs for Ba (e.g., Jacquet et al., 2005).

Dissolved δ138Ba (Ba isotopes) were measured at WHOI (Woods Hole Oceanographic Institution) using a ThermoFinnigan Neptune multicollector ICP-MS. Five mL aliquots were prepared by first spiking with a known quantity of 135Ba–136Ba double spike to achieve a spike:sample ratio of between 1-2. Following equilibration with the spike, samples were co-precipitated with $CaCO_3$ by dropwise addition of 350 µL of 1 M Na_2CO_3 solution. The precipitate was dissolved and reconstituted in 2 M HCl for ion-exchange chromatography. Chromatography protocols are detailed in Horner et al. (2015). Following purification, samples were again reconstituted in 2 % nitric acid and analyzed for δ138Ba at the WHOI Plasma Facility. Samples were aspirated at 140 µL/min, desolvated using an Aridus II, and introduced into the instrument using 1 L/min Ar carrier gas containing 2-5 mL/min admixed nitrogen. Samples are measured in low-resolution mode relative to concentration- and spike:sample-matched aliquots of NIST SRM 3108 (≡0 ‰), measured after every fourth sample. Samples are themselves analyzed between 2-4 times, and Ba-isotopic compositions calculated using an iterative, geometric-based deconvolution of spike-sample mixtures.

Dissolved V, Ni, Cu, Cd, and Mn were determined using 14 mL of sample that was spiked with a mixture of isotopically-enriched Ni-62, Cu-65, Cd-111, and V-50 (Oak Ridge Nat'l. Labs). Each spike was >90% enriched in the listed isotopes, except for V-50 (0.25% natural abundance) which was 44.3% enriched. The sample/spike ratio was chosen so as to have the analytical isotope ratios approximately the geometric mean of the natural and enriched spike isotope ratios. Samples were then extracted/pre-concentrated using a SeaFAST system (Elemental Scientific, Inc.) operated in offline mode. A 10-mL sample loop was employed and the elution volume was 750 µL. A similar online SeaFAST extraction procedure is described by Hathorne et al. (2012) for rare earth elements. The extracted samples were subsequently analyzed using a Thermo-Fisher high resolution ICP-MS with an Apex-FAST high efficiency sample introduction system with Spiro desolvator (Elemental Scientific, Inc.). All elements were determined in medium resolution, except Cd which was determined in low resolution. For Mn-55 the V, Ni, and Cu spikes served as internal standards. Calibration was checked by analysis of a large-volume composite North Atlantic surface seawater sample. Spiked (with a natural isotopic abundance elemental spike) and unspiked aliquots of this sample were analyzed twice in each analytical run. Ti-47 and Cr-52 were monitored to correct for any Ti-50 or Cr-50 isobaric interference on V-50; the correction was generally <1%. Likewise, Mo-98 was monitored to correct for MoO^+ interference on Cd isotopes.

The reproducibility error of this method was estimated by comparing samples collected at the same depths on different casts at the same station as well as by repeated measurement of GEOTRACES reference waters and an in-house standard. Recovery of the method was determined by repeated analysis of a spiked and unspiked seawater. The recoveries, precisions, and comparisons to reference waters are shown in Table 1 (see Supplemental Files).

Processing Description

Quality control:
Data are flagged using the WOCE Hydrographic Program (WHP) bottle parameter data quality codes, as follows:
1 = Sample for this measurement was drawn from water bottle but analysis not received. Note that if water is drawn for any measurement from a water bottle, the quality flag for that parameter must be set equal to 1 initially to ensure that all water samples are accounted for.
2 =Acceptable measurement.
3 = Questionable measurement.
4 = Bad measurement.
5 = Not reported.
6 = Mean of replicate measurements (Number of replicates should be specified in the -.DOC file and replicate data tabulated).
7 = Manual chromatographic peak measurement.
8 = Irregular digital chromatographic peak integration.
9 = Sample not drawn for this measurement from this bottle.

For intercalibration procedures, refer to the dataset's GEOTRACES Intercalibration Report (PDF).

BCO-DMO Processing:
- modified parameter names;
- added ISO8601 date-time field;
- 2020-12-15: replaced v1 with v2 (DOoR-formatted names and addition of Ba isotope data).

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Related Publications

Charette, M. A., Kipp, L. E., Jensen, L. T., Dabrowski, J. S., Whitmore, L. M., Fitzsimmons, J. N., … Bundy, R. M. (2020). The Transpolar Drift as a Source of Riverine and Shelf-Derived Trace Elements to the Central Arctic Ocean. Journal of Geophysical Research: Oceans, 125(5). doi:10.1029/2019jc015920 https://doi.org/10.1029/2019JC015920
Results

Cutter, G. A., & Bruland, K. W. (2012). Rapid and noncontaminating sampling system for trace elements in global ocean surveys. Limnology and Oceanography: Methods, 10(6), 425–436. doi:10.4319/lom.2012.10.425
Methods

Hathorne, E. C., Haley, B., Stichel, T., Grasse, P., Zieringer, M., & Frank, M. (2012). Online preconcentration ICP-MS analysis of rare earth elements in seawater. Geochemistry, Geophysics, Geosystems, 13(1), n/a–n/a. doi:10.1029/2011gc003907 https://doi.org/10.1029/2011GC003907
Methods

Hatta, M., Measures, C. I., Wu, J., Roshan, S., Fitzsimmons, J. N., Sedwick, P., & Morton, P. (2015). An overview of dissolved Fe and Mn distributions during the 2010–2011 U.S. GEOTRACES north Atlantic cruises: GEOTRACES GA03. Deep Sea Research Part II: Topical Studies in Oceanography, 116, 117–129. doi:10.1016/j.dsr2.2014.07.005
Methods

Horner, T. J., Kinsley, C. W., & Nielsen, S. G. (2015). Barium-isotopic fractionation in seawater mediated by barite cycling and oceanic circulation. Earth and Planetary Science Letters, 430, 511–522. doi:10.1016/j.epsl.2015.07.027
Methods

Jacquet, S. H. M., Dehairs, F., Cardinal, D., Navez, J., & Delille, B. (2005). Barium distribution across the Southern Ocean frontal system in the Crozet–Kerguelen Basin. Marine Chemistry, 95(3-4), 149–162. doi:10.1016/j.marchem.2004.09.002
Methods

Kadko, D., Aguilar-Islas, A., Bolt, C., Buck, C. S., Fitzsimmons, J. N., Jensen, L. T., … Anderson, R. F. (2019). The residence times of trace elements determined in the surface Arctic Ocean during the 2015 US Arctic GEOTRACES expedition. Marine Chemistry, 208, 56–69. doi:10.1016/j.marchem.2018.10.011
Results

Shiller, A. M., & Bairamadgi, G. R. (2006). Dissolved gallium in the northwest Pacific and the south and central Atlantic Oceans: Implications for aeolian Fe input and a reconsideration of profiles. Geochemistry, Geophysics, Geosystems, 7(8), n/a–n/a. doi:10.1029/2005gc001118 https://doi.org/10.1029/2005GC001118
Methods

Whitmore, L. M., Morton, P. L., Twining, B. S., & Shiller, A. M. (2019). Vanadium cycling in the Western Arctic Ocean is influenced by shelf-basin connectivity. Marine Chemistry, 216, 103701. doi:10.1016/j.marchem.2019.103701
Results

Whitmore, L. M., Pasqualini, A., Newton, R., & Shiller, A. M. (2020). Gallium: A New Tracer of Pacific Water in the Arctic Ocean. Journal of Geophysical Research: Oceans, 125(7). doi:10.1029/2019jc015842 https://doi.org/10.1029/2019JC015842
Results

Zurbrick, C. M., Morton, P. L., Gallon, C., Shiller, A. M., Landing, W. M., & Flegal, A. R. (2012). Intercalibration of Cd and Pb concentration measurements in the northwest Pacific Ocean. Limnology and Oceanography: Methods, 10(4), 270–277. doi:10.4319/lom.2012.10.270
Methods

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Parameters

Parameter	Description	Units
Station_ID	Station number	unitless

Start_Date_UTC	Start date (UTC); format: DD/MM/YYYY	unitless
Start_Time_UTC	Start time (UTC); format: hhmm	unitless
Start_ISO_DateTime_UTC	Date and time (UTC) at start of event; format: YYYY-MM-DDThh:mmZ	unitless
End_Date_UTC	End date (UTC); format: DD/MM/YYYY	unitless
End_Time_UTC	End time (UTC); format: hhmm	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
CAST_NO	Cast number	unitless
Sample_ID	GEOTRACES sample number	unitless
Sample_Depth	Sample depth	meters (m)
Ba_138_134_D_DELTA_BOTTLE_gorel8	Atom ratio of dissolved Ba isotopes expressed in conventional DELTA notation referenced to {NIST 3104a}; from bottle samples	per mil
SD1_Ba_138_134_D_DELTA_BOTTLE_gorel8	One standard deviaton of Ba_138_134_D_DELTA_BOTTLE_gorel8	per mil
Flag_Ba_138_134_D_DELTA_BOTTLE_gorel8	Quality flag for Ba_138_134_D_DELTA_BOTTLE_gorel8	unitless
Ba_138_134_D_DELTA_BOAT_PUMP_qgmo1e	Atom ratio of dissolved Ba isotopes expressed in conventional DELTA notation referenced to {NIST 3104a}; from boat pump samples	per mil
SD1_Ba_138_134_D_DELTA_BOAT_PUMP_qgmo1e	One standard deviaton of Ba_138_134_D_DELTA_BOAT_PUMP_qgmo1e	per mil
Flag_Ba_138_134_D_DELTA_BOAT_PUMP_qgmo1e	Quality flag for Ba_138_134_D_DELTA_BOAT_PUMP_qgmo1e	unitless
Ba_138_134_D_DELTA_SUBICE_PUMP_xjmpgx	Atom ratio of dissolved Ba isotopes expressed in conventional DELTA notation referenced to {NIST 3104a}; from sub-ice pump samples	per mil
SD1_Ba_138_134_D_DELTA_SUBICE_PUMP_xjmpgx	One standard deviaton of Ba_138_134_D_DELTA_SUBICE_PUMP_xjmpgx	per mil
Flag_Ba_138_134_D_DELTA_SUBICE_PUMP_xjmpgx	Quality flag for Ba_138_134_D_DELTA_SUBICE_PUMP_xjmpgx	unitless
Ba_D_CONC_BOTTLE_gaggba	Dissolved barium concentration from bottle samples	nanomoles per kilogram (nmol/kg)
SD1_Ba_D_CONC_BOTTLE_gaggba	One standard deviaton of Ba_D_CONC_BOTTLE_gaggba	nanomoles per kilogram (nmol/kg)

Flag_Ba_D_CONC_BOTTLE_gaggba	Quality flag for Ba_D_CONC_BOTTLE_gaggba	unitless
Ba_D_CONC_BOAT_PUMP_s9e7xv	Dissolved barium concentration from boat pump samples	nanomoles per kilogram (nmol/kg)
SD1_Ba_D_CONC_BOAT_PUMP_s9e7xv	One standard deviaton of Ba_D_CONC_BOAT_PUMP_s9e7xv	nanomoles per kilogram (nmol/kg)
Flag_Ba_D_CONC_BOAT_PUMP_s9e7xv	Quality flag for Ba_D_CONC_BOAT_PUMP_s9e7xv	unitless
Ba_D_CONC_SUBICE_PUMP_d6phfd	Dissolved barium concentration from sub-ice pump samples	nanomoles per kilogram (nmol/kg)
SD1_Ba_D_CONC_SUBICE_PUMP_d6phfd	One standard deviaton of Ba_D_CONC_SUBICE_PUMP_d6phfd	nanomoles per kilogram (nmol/kg)
Flag_Ba_D_CONC_SUBICE_PUMP_d6phfd	Quality flag for Ba_D_CONC_SUBICE_PUMP_d6phfd	unitless
Cd_D_CONC_BOTTLE_wikkhy	Dissolved cadmium from bottle samples	nanomoles per kilogram (nmol/kg)
SD1_Cd_D_CONC_BOTTLE_wikkhy	One standard deviaton of Cd_D_CONC_BOTTLE_wikkhy	nanomoles per kilogram (nmol/kg)
Flag_Cd_D_CONC_BOTTLE_wikkhy	Quality flag for Cd_D_CONC_BOTTLE_wikkhy	unitless
Cd_D_CONC_BOAT_PUMP_jz0rob	Dissolved cadmium from boat pump samples	nanomoles per kilogram (nmol/kg)
SD1_Cd_D_CONC_BOAT_PUMP_jz0rob	One standard deviaton of Cd_D_CONC_BOAT_PUMP_jz0rob	nanomoles per kilogram (nmol/kg)
Flag_Cd_D_CONC_BOAT_PUMP_jz0rob	Quality flag for Cd_D_CONC_BOAT_PUMP_jz0rob	unitless
Cd_D_CONC_SUBICE_PUMP_gorkxq	Dissolved cadmium from sub-ice pump samples	nanomoles per kilogram (nmol/kg)
SD1_Cd_D_CONC_SUBICE_PUMP_gorkxq	One standard deviaton of Cd_D_CONC_SUBICE_PUMP_gorkxq	nanomoles per kilogram (nmol/kg)
Flag_Cd_D_CONC_SUBICE_PUMP_gorkxq	Quality flag for Cd_D_CONC_SUBICE_PUMP_gorkxq	unitless

Cu_D_CONC_BOTTLE_tq3sck	Dissolved copper from bottle samples	nanomoles per kilogram (nmol/kg)
SD1_Cu_D_CONC_BOTTLE_tq3sck	One standard deviaton of Cu_D_CONC_BOTTLE_tq3sck	nanomoles per kilogram (nmol/kg)
Flag_Cu_D_CONC_BOTTLE_tq3sck	Quality flag for Cu_D_CONC_BOTTLE_tq3sck	unitless
Cu_D_CONC_SUBICE_PUMP_detas0	Dissolved copper from sub-ice pump samples	nanomoles per kilogram (nmol/kg)
Cu_D_CONC_BOAT_PUMP_6crw16	Dissolved copper from boat pump samples	nanomoles per kilogram (nmol/kg)
SD1_Cu_D_CONC_SUBICE_PUMP_detas0	One standard deviation of Cu_D_CONC_SUBICE_PUMP_detas0	nanomoles per kilogram (nmol/kg)
SD1_Cu_D_CONC_BOAT_PUMP_6crw16	One standard deviation of Cu_D_CONC_BOAT_PUMP_6crw16	nanomoles per kilogram (nmol/kg)
Flag_Cu_D_CONC_SUBICE_PUMP_detas0	Quality flag for Cu_D_CONC_SUBICE_PUMP_detas0	unitless
Flag_Cu_D_CONC_BOAT_PUMP_6crw16	Quality flag for Cu_D_CONC_BOAT_PUMP_6crw16	unitless
Ga_D_CONC_BOTTLE_1mgxwx	Dissolved gallium concentration from bottle samples	picomoles per kilogram (pmol/kg)
SD1_Ga_D_CONC_BOTTLE_1mgxwx	One standard deviaton of Ga_D_CONC_BOTTLE_1mgxwx	picomoles per kilogram (pmol/kg)
Flag_Ga_D_CONC_BOTTLE_1mgxwx	Quality flag for Ga_D_CONC_BOTTLE_1mgxwx	unitless
Ga_D_CONC_BOAT_PUMP_yl8lnv	Dissolved gallium concentration from boat pump samples	picomoles per kilogram (pmol/kg)
SD1_Ga_D_CONC_BOAT_PUMP_yl8lnv	One standard deviaton of Ga_D_CONC_BOAT_PUMP_yl8lnv	picomoles per kilogram (pmol/kg)
Flag_Ga_D_CONC_BOAT_PUMP_yl8lnv	Quality flag for Ga_D_CONC_BOAT_PUMP_yl8lnv	unitless

Ga_D_CONC_SUBICE_PUMP_xsfaz3	Dissolved gallium concentration from sub-ice pump samples	picomoles per kilogram (pmol/kg)
SD1_Ga_D_CONC_SUBICE_PUMP_xsfaz3	One standard deviaton of Ga_D_CONC_SUBICE_PUMP_xsfaz3	picomoles per kilogram (pmol/kg)
Flag_Ga_D_CONC_SUBICE_PUMP_xsfaz3	Quality flag for Ga_D_CONC_SUBICE_PUMP_xsfaz3	unitless
Mn_D_CONC_BOTTLE_itu1qi	Dissolved manganese from bottle samples	nanomoles per kilogram (nmol/kg)
SD1_Mn_D_CONC_BOTTLE_itu1qi	One standard deviaton of Mn_D_CONC_BOTTLE_itu1qi	nanomoles per kilogram (nmol/kg)
Flag_Mn_D_CONC_BOTTLE_itu1qi	Quality flag for Mn_D_CONC_BOTTLE_itu1qi	unitless
Mn_D_CONC_BOAT_PUMP_tdgkvz	Dissolved manganese from boat pump samples	nanomoles per kilogram (nmol/kg)
SD1_Mn_D_CONC_BOAT_PUMP_tdgkvz	One standard deviaton of Mn_D_CONC_BOAT_PUMP_tdgkvz	nanomoles per kilogram (nmol/kg)
Flag_Mn_D_CONC_BOAT_PUMP_tdgkvz	Quality flag for Mn_D_CONC_BOAT_PUMP_tdgkvz	unitless
Mn_D_CONC_SUBICE_PUMP_md5sbr	Dissolved manganese from sub-ice pump samples	nanomoles per kilogram (nmol/kg)
SD1_Mn_D_CONC_SUBICE_PUMP_md5sbr	One standard deviaton of Mn_D_CONC_SUBICE_PUMP_md5sbr	nanomoles per kilogram (nmol/kg)
Flag_Mn_D_CONC_SUBICE_PUMP_md5sbr	Quality flag for Mn_D_CONC_SUBICE_PUMP_md5sbr	unitless
Ni_D_CONC_BOTTLE_tpaocv	Dissolved nickel from bottle samples	nanomoles per kilogram (nmol/kg)
SD1_Ni_D_CONC_BOTTLE_tpaocv	One standard deviaton of Ni_D_CONC_BOTTLE_tpaocv	nanomoles per kilogram (nmol/kg)
Flag_Ni_D_CONC_BOTTLE_tpaocv	Quality flag for Ni_D_CONC_BOTTLE_tpaocv	unitless

Ni_D_CONC_BOAT_PUMP_jxf39e	Dissolved nickel from boat pump samples	nanomoles per kilogram (nmol/kg)
SD1_Ni_D_CONC_BOAT_PUMP_jxf39e	One standard deviaton of Ni_D_CONC_BOAT_PUMP_jxf39e	nanomoles per kilogram (nmol/kg)
Flag_Ni_D_CONC_BOAT_PUMP_jxf39e	Quality flag for Ni_D_CONC_BOAT_PUMP_jxf39e	unitless
Ni_D_CONC_SUBICE_PUMP_vmo4mu	Dissolved nickel from sub-ice pump samples	nanomoles per kilogram (nmol/kg)
SD1_Ni_D_CONC_SUBICE_PUMP_vmo4mu	One standard deviaton of Ni_D_CONC_SUBICE_PUMP_vmo4mu	nanomoles per kilogram (nmol/kg)
Flag_Ni_D_CONC_SUBICE_PUMP_vmo4mu	Quality flag for Ni_D_CONC_SUBICE_PUMP_vmo4mu	unitless
V_D_CONC_BOTTLE_y54tnw	Dissolved vanadium from bottle samples	nanomoles per kilogram (nmol/kg)
SD1_V_D_CONC_BOTTLE_y54tnw	One standard deviaton of V_D_CONC_BOTTLE_y54tnw	nanomoles per kilogram (nmol/kg)
Flag_V_D_CONC_BOTTLE_y54tnw	Quality flag for V_D_CONC_BOTTLE_y54tnw	unitless
V_D_CONC_BOAT_PUMP_6ejtax	Dissolved vanadium from boat pump samples	nanomoles per kilogram (nmol/kg)
SD1_V_D_CONC_BOAT_PUMP_6ejtax	One standard deviaton of V_D_CONC_BOAT_PUMP_6ejtax	nanomoles per kilogram (nmol/kg)
Flag_V_D_CONC_BOAT_PUMP_6ejtax	Quality flag for V_D_CONC_BOAT_PUMP_6ejtax	unitless
V_D_CONC_SUBICE_PUMP_o0swtf	Dissolved vanadium from sub-ice pump samples	nanomoles per kilogram (nmol/kg)
SD1_V_D_CONC_SUBICE_PUMP_o0swtf	One standard deviaton of V_D_CONC_SUBICE_PUMP_o0swtf	nanomoles per kilogram (nmol/kg)
Flag_V_D_CONC_SUBICE_PUMP_o0swtf	Quality flag for V_D_CONC_SUBICE_PUMP_o0swtf	unitless

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Instruments

Dataset-specific Instrument Name	ThermoFisher Element 2 ICP-MS
Generic Instrument Name	Inductively Coupled Plasma Mass Spectrometer
Generic Instrument Description	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

Dataset-specific Instrument Name	ThermoFinnigan Element 2 High Resolution Inductively Coupled Plasma Mass Spectrometer (HR-ICP-MS)
Generic Instrument Name	Inductively Coupled Plasma Mass Spectrometer
Generic Instrument Description	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

Dataset-specific Instrument Name	ThermoFinnigan Neptune multicollector ICP-MS
Generic Instrument Name	Inductively Coupled Plasma Mass Spectrometer
Generic Instrument Description	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

Dataset-specific Instrument Name	Thermo-Fisher high resolution ICP-MS with an Apex-FAST high efficiency sample introduction system with Spiro desolvator (Elemental Scientific, Inc.)
Generic Instrument Name	Inductively Coupled Plasma Mass Spectrometer
Generic Instrument Description	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

Dataset-specific Instrument Name	GT-C/12L GoFlo
Generic Instrument Name	GO-FLO Teflon Trace Metal Bottle
Generic Instrument Description	GO-FLO Teflon-lined Trace Metal free sampling bottles are used for collecting water samples for trace metal, nutrient and pigment analysis. The GO-FLO sampling bottle is designed specifically to avoid sample contamination at the surface, internal spring contamination, loss of sample on deck (internal seals), and exchange of water from different depths.

Dataset-specific Instrument Name	Teflon coated Tygon tubing and a trace metal clean pump (IWAKI, model WMD-30LFY-115)
Generic Instrument Name	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

Dataset-specific Instrument Name	
Generic Instrument Name	SeaFAST Automated Preconcentration System
Generic Instrument Description	The seaFAST is an automated sample introduction system for analysis of seawater and other high matrix samples for analyses by ICPMS (Inductively Coupled Plasma Mass Spectrometry).

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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	Arctic transect encompassing Bering and Chukchi Shelves and the Canadian, Makarov and Amundsen sub-basins of the Arctic Ocean. The transect started in the Bering Sea (60°N) and traveled northward across the Bering Shelf, through the Bering Strait and across the Chukchi shelf, then traversing along 170-180°W across the Alpha-Mendeleev and Lomonosov Ridges to the North Pole (Amundsen basin, 90°N), and then back southward along ~150°W to terminate on the Chukchi Shelf (72°N). Additional cruise information is available from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/HLY1502

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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.

GEOTRACES Arctic Section: Methane, vanadium, barium, and gallium as process indicators in the Arctic Ocean (GEOTRACES Arctic Methane V Ba Ga)

Coverage: Arctic Circle

NSF Award Abstract:
In this project, an investigator participating in the 2015 U.S. GEOTRACES Arctic expedition will make measurements of methane, a dissolved trace gas, as well as the dissolved trace elements of gallium, barium, and vanadium in the Arctic Ocean. In common with other multinational 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 trace elements and gas measured as part of this project will be used as tracers for a variety of processes such as river and atmospheric inputs to the Arctic Ocean, as well as circulation in the region. The knowledge and experience gained from this project will be incorporated into courses in oceanography and marine chemistry, as well as be shared through public outreach activities. The project will support the scientific training of a graduate student.

The tracers to be measured as part of this study, methane, gallium, barium, and vanadium, will provide important information about oceanic circulation and water inputs to the Arctic. Gallium is likely to prove a sensitive tracer for Atlantic versus Pacific water components in the western Arctic Ocean, an issue of interest in circulation studies and also relevant to projections of the stability of methane hydrates on the Arctic shelves. Barium is of interest because it has been shown to be an indicator of fluvial inputs and contributions to the halocline. This is pertinent to understanding upper ocean circulation in the Arctic as well as to freshwater contributions to the Atlantic Meridional Overturning Circulation. For vanadium, the large proportion of shelf area in the Arctic makes this an ideal region to examine whether shelf sediment uptake determines surface ocean vanadium depletion. For methane, Arctic waters are a significant source of this Greenhouse Gas to the atmosphere and global change is likely exacerbating its release. Determination of the methane distribution will therefore be of interest in and of itself, although it is also a potentially valuable indicator of interactions with the shelf as well as of river inputs. Overall, results from this study will lead to an increased understanding of key ocean biogeochemical and physical processes including cross margin exchange of materials, sources of water in the Arctic Ocean, and fluxes of methane to the atmosphere.

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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-1736949
NSF Division of Ocean Sciences (NSF OCE)	OCE-1436312

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