

Shipboard FIA dissolved Al, Fe, and Mn from samples collected from ice floes using a pump during USCGC Healy cruise HLY1502 (GN01) in the Canada and Makarov Basins of the Arctic Ocean from August to October 2015

Website: <https://www.bco-dmo.org/dataset/825648>

Data Type: Cruise Results

Version: 2

Version Date: 2021-07-09

Project

» [U.S. Arctic GEOTRACES Study \(GN01\)](#) (U.S. GEOTRACES Arctic)

» [GEOTRACES Arctic Section: Shipboard determination of key trace elements](#) (GEOTRACES Arctic Al Fe Mn)

Program

» [U.S. GEOTRACES](#) (U.S. GEOTRACES)

Contributors	Affiliation	Role
Measures, Christopher I.	University of Hawai'i (UH)	Principal Investigator
Hatta, Mariko	University of Hawai'i (UH)	Co-Principal Investigator, Contact
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract

Shipboard FIA dissolved Al, Fe, and Mn from samples collected from ice floes using a pump during USCGC Healy cruise HLY1502 (GN01) in the Canada and Makarov Basins of the Arctic Ocean from August to October 2015.

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Coverage

Spatial Extent: N:90 E:-150 S:75 W:-150.2

Temporal Extent: 2015-09-04 - 2015-09-19

Methods & Sampling

Water samples (water column, surface water, water under sea-ice, sea-ice, snow, and melt pond) were collected at 28 stations from the USCG Healy during the GEOTRACES Western Arctic research expedition, which took place during the US GEOTRACES Arctic cruise aboard USCGC Healy (HLY1502) from August 9 to

October 11, 2015 in the Arctic Ocean. This dataset contains data resulting from SUBICE PUMP samples (samples collected from ice floes using a pump).

Surface water samples were collected from a surface pump when sea ice conditions permitted. Surface pump samples were collected by zodiac, and a trace metal clean peristaltic pump following the GEOTRACES Program Cookbook sampling recommendations, and in accordance with previous collection protocols (Bruland et al. 2005). The pump system consisted of: a Teflon coated Tygon tubing and a rotary pump with plastic wetted parts (IWAKI magnetic drive pump, model WMD-30LFY-115) deployed from one of the USCGC Healy Rigid Hull Inflatable Boats (26 ft (7.9 m)). Samples were collected into a pre-acid cleaned 20L carboy jug and they were filtered through 0.2µM Polycarbonate (PCTE) cartridge filters in the clean container on the ship.

Additional seawater samples were collected at nominal depths of 1, 5, and 20m from under the sea ice at 6 stations, using a portable pumping system (same as described above) deployed through a hole at the station's sea ice floe. The hole was made with an ice corer (Kovacs 9 cm diameter Mak II corer), and allowed to sit undisturbed for ~ 1hr under a canvas tent prior to sampling. At these same stations, samples of melted snow (6 samples), sea-ice (5 samples), and where available melt pond (5 samples) were also obtained. These latter samples were also filtered through the 0.2 µM Acropak filter.

Samples were drawn into pre-numbered 125 ml PMP bottles after three rinses and were stored in plastic bags in the dark at room temperature before determination which was usually within 12-36 hours of collection.

Samples were analyzed shipboard for dissolved Al, Fe & Mn using flow injection analysis methods (Resing and Measures, 1994; Measures et al., 1995, Resing and Mottl, 1992 respectively). Prior to determination samples were acidified by the addition of 125 µl sub-boiling distilled 6N HCl and were microwaved in groups of 4 for 3 minutes in a 900 W microwave oven to achieve a temperature of 60 +/- 10 °C. Samples were allowed to cool for at least 1 hour prior to determination. Samples were determined in groups of 8.

For preparation for standard solutions: Shipboard mixed standards (Al and Fe, Mn) were prepared in the shore-based laboratory by serial dilution of commercial Al, Fe, and Mn standards (BDH Aristar) into distilled water which was acidified with the equivalent of 4 ml sub-boiled 6N HCl. Standards for instrument calibration were prepared daily from filtered seawater by acidifying 1 L of low Fe seawater from a previous cast with 1 ml of 6N HCl and microwaving for 5 minutes to reach a temperature of 60 +/- 10°C. After 1 hour, 200 +/- 2 ml of the cooled seawater was added to each of three 250 ml PMP bottles each of which had been rinsed three times with the microwaved seawater and shaken dry. Working standards were prepared by adding 0, +100µL, +200µL spikes of the shipboard mixed standard to these bottles, to yield a standard curve of +10.58nM and +21.16nM for Al, +0.528nM and +1.057nM for Fe, +1.45nM and +2.90nM for Mn. The system blank from the addition of the acid and buffer to samples was determined by double spiking a replicate sample i.e. by adding 2 x 125 µl 6N HCl and 5 ml of sample buffer to the replicate bottle and comparing the resulting signal to the original sample.

For dissolved Al analysis: Dissolved Al was determined using a Flow Injection Analysis scheme with fluorometric detection. Major components were a Rabbit peristaltic pump, a Dynamax FL-1 fluorometer, a Rainin A/D board and a Macintosh G3 computer running Rainin MacIntegrator v 1.4.3 to log and reduce data. The analytical scheme produces a complex between lumogallion and dissolved Al which when excited at 484 nm produces fluorescence at 552 nm. Detailed description of the methodology is published in Resing and Measures (1994). A 3-minute pre-concentration of sample (~9 ml) onto an 8-hydroxyquinoline (8-HQ) resin column yielded a detection limit of 0.27 and a precision of 2.1% at 12.8 nM.

For dissolved Fe analysis: Dissolved Fe was determined using a Flow Injection Analysis scheme with spectrophotometric detection (Rainin Dynamax UV-C). Major components were a Rabbit peristaltic pump, a Rainin Dynamax UV-C, a Rainin A/D board and a Macintosh G3 computer running Rainin MacIntegrator v 1.4.3 to log and reduce data. The spectrophotometric detection of the iron eluted from the column is achieved through its catalytic effect on the oxidation of N,N-dimethylp-phenylenediamine dihydrochloride (DPD) the oxidized product is measured at 514 nm. Detailed description of the methodology is published in Measures et al (1995). A 3-minute pre-concentration of sample (~9 ml) onto an 8-hydroxyquinoline (8-HQ) resin column yielded a detection limit of 0.090 nM and a precision of 0.67% at 2.96nM.

For dissolved Mn analysis: Dissolved Mn was determined using a Flow Injection Analysis scheme with spectrophotometric detection (Rainin Dynamax UV-C). Major components were a Rabbit peristaltic pump, a Rainin Dynamax UV-C, a Rainin A/D board and a Macintosh G3 computer running Rainin MacIntegrator v 1.4.3 to log and reduce data. The spectrophotometric detection of the manganese eluted from the column is achieved through its catalytic effect on the formation of malachite green which is measured at 620 nm. Detailed description of the methodology is published in Resing and Mottl (1992). A 3-minute pre-concentration of sample (~9 ml) onto an 8-hydroxyquinoline (8-HQ) resin column yielded a detection limit of 0.55 nM and a

precision of 1.16% at 2.7 nM.

Calculation of each dissolved trace element concentrations: Calculation of sample concentrations was by dividing the peak height derived from sample using the A/D software by the calculated slope of the standard curve. Variations in the slope of the standard curve during a day's run were corrected by the following procedure.

The change in the value of the slope of the standard curve between each run of standards was divided by the number of samples run between those standards to provide a calculated value for the slope of the standard curve at the point each sample was run. The value of the peak height for each sample was then recalculated by the estimated ratio of the standard curve slope at the point that sample was run. The estimate of the slope at each sample run is calculated by: (Initial slope + (incremental change per sample X # of samples run since initial standard was run)). The sample concentration is then calculated from the initial standard curve slope.

The analytical blanks of dissolved Fe and Mn were determined by the shore-based ICPMS data that was measured by co-PI Dr. J. Fitzsimmons (Texas A&M University). The ICPMS data and its metadata will be submitted separately. The blank corrected FIA data was obtained from the intercept of the correlation plot between the ICPMS data and FIA data on each of the days the FIA was run.

Intercalibration for dissolved Al: GEOTRACES standard seawater and internal standard seawater were analyzed periodically. A large batch of seawater was acidified prior to the cruise and used as a primary standard during measurements. This standard seawater was run along with each sample analysis. Our laboratory has participated the GEOTRACES intercalibration effort using this flow injection method.

We report our laboratory values for the GEOTRACES GS standard analyses using this flow injection method to be: GEOTRACES GS = 29.63 ± 1.15 nM (n=2). Using $1L=1.027$ kg, our Al value is calculated as 28.85 ± 1.12 nmol/kg and it is within the error of the consensus value (27.5 ± 0.2 nmol/kg).

These results are in good agreement with this from the GEOTRACES intercalibration effort for Al and demonstrate that the methodologies employed to produce this dataset detect concentrations within the standard deviation of current consensus values.

The Al data from the GEOTRACES Arctic Ocean cruise were compared with several published data set in the various basins in the Arctic Ocean (Makarov Basin, Middag et al., 2009), the Amundsen Basin (Middag et al., 2009), and the Canada Basin (Giesbrecht et al 2013) which all show very similar results throughout the water column.

Data Processing Description

Quality flags for dissolved Al, Fe, and Mn:

- 1 = Below detection limit (Measurement was determined but was found to be below the detection limit);
- 2 = Good;
- 3 = Questionable/suspect;
- 4 = Bad;
- 9 = Missing data (no sample).

BCO-DMO Processing:

- modified parameter names;
- replaced "n/a" with "nd" ("no data");
- added longitude values in -180 to 180.

Version history:

- 2021-07-09 (v2; current) - removed rows for GT_Sample_IDs 11334, 11452, 11498, 11624, and 11724 (which are meltpond samples, not subice samples).
- 2020-09-29 (v1) - version 1 published.

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Data Files

File
AlFeMn_Subice.csv (Comma Separated Values (.csv), 1.35 KB) MD5:90c8f79e77bfb2933ce7a4da2104bbc8 Primary data file for dataset ID 825648

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Related Publications

Bruland, K. W., Rue, E. L., Smith, G. J., & DiTullio, G. R. (2005). Iron, macronutrients and diatom blooms in the Peru upwelling regime: brown and blue waters of Peru. *Marine Chemistry*, 93(2-4), 81-103.

doi:[10.1016/j.marchem.2004.06.011](https://doi.org/10.1016/j.marchem.2004.06.011)

Methods

Giesbrecht, T., Sim, N., Orians, K. J., & Cullen, J. T. (2013). The distribution of dissolved and total dissolvable aluminum in the Beaufort Sea and Canada Basin region of the Arctic Ocean. *Journal of Geophysical Research: Oceans*, 118(12), 6824-6837. doi:10.1002/2013jc009202 <https://doi.org/10.1002/2013JC009202>

Related Research

Measures, C. I., Yuan, J., & Resing, J. A. (1995). Determination of iron in seawater by flow injection analysis using in-line preconcentration and spectrophotometric detection. *Marine Chemistry*, 50(1-4), 3-12.

doi:[10.1016/0304-4203\(95\)00022-j](https://doi.org/10.1016/0304-4203(95)00022-j)

Methods

Middag, R., de Baar, H. J. W., Laan, P., & Bakker, K. (2009). Dissolved aluminium and the silicon cycle in the Arctic Ocean. *Marine Chemistry*, 115(3-4), 176-195. doi:[10.1016/j.marchem.2009.08.002](https://doi.org/10.1016/j.marchem.2009.08.002)

Related Research

Resing, J. A., & Measures, C. I. (1994). Fluorometric Determination of Al in Seawater by Flow Injection Analysis with In-Line Preconcentration. *Analytical Chemistry*, 66(22), 4105-4111. doi:[10.1021/ac00094a039](https://doi.org/10.1021/ac00094a039)

Methods

Resing, J. A., & Mottl, M. J. (1992). Determination of manganese in seawater using flow injection analysis with on-line preconcentration and spectrophotometric detection. *Analytical Chemistry*, 64(22), 2682-2687.

doi:[10.1021/ac00046a006](https://doi.org/10.1021/ac00046a006)

Methods

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Parameters

Parameter	Description	Units
Station	Station number	unitless
LONGITUDE	Longitude; -180-180. Positive values = East.	degrees East
LATITUDE	Latitude North; 0-90. Positive values = North.	degrees North
LONGITUDE_360	Longitude from 0 to 360 degrees East.	degrees East
Depth	Sample depth	meters (m)
GT_Sample_ID	GEOTRACES sample number	unitless
Al_D_CONC_SUBICE_PUMP_qnmcbu	Dissolved Aluminum concentration	nanomoles per liter (nmol/L)
Flag_Al_D_CONC_SUBICE_PUMP_qnmcbu	Quality flag for Al_D_CONC_SUBICE_PUMP_qnmcbu. Definitions: 1 = Below detection limit (Measurement was determined but was found to be below the detection limit); 2 = Good; 3 = Questionable/suspect; 4 = Bad; 9 = Missing data (no sample).	unitless
Fe_D_CONC_PUMP	Dissolved Iron concentration	nanomoles per liter (nmol/L)
Fe_D_CONC_PUMP_QF	Quality flag for Fe_D_CONC_PUMP. Definitions: 1 = Below detection limit (Measurement was determined but was found to be below the detection limit); 2 = Good; 3 = Questionable/suspect; 4 = Bad; 9 = Missing data (no sample).	unitless
Mn_D_CONC_PUMP	Dissolved Manganese concentration	nanomoles per liter (nmol/L)
Mn_D_CONC_PUMP_QF	Quality flag for Mn_D_CONC_PUMP. Definitions: 1 = Below detection limit (Measurement was determined but was found to be below the detection limit); 2 = Good; 3 = Questionable/suspect; 4 = Bad; 9 = Missing data (no sample).	unitless

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Instruments

Dataset-specific Instrument Name	FIA
Generic Instrument Name	Flow Injection Analyzer
Dataset-specific Description	Dissolved Fe was determined using a Flow Injection Analysis scheme with spectrophotometric detection (Rainin Dynamax UV-C). Major components of the scheme include a Rabbit peristaltic pump, a Dynamax FL-1 fluorometer, a Rainin A/D board, and a Macintosh G3 computer running Rainin MacIntegrator v 1.4.3 to log and reduce data.
Generic Instrument Description	An instrument that performs flow injection analysis. Flow injection analysis (FIA) is an approach to chemical analysis that is accomplished by injecting a plug of sample into a flowing carrier stream. FIA is an automated method in which a sample is injected into a continuous flow of a carrier solution that mixes with other continuously flowing solutions before reaching a detector. Precision is dramatically increased when FIA is used instead of manual injections and as a result very specific FIA systems have been developed for a wide array of analytical techniques.

Dataset-specific Instrument Name	Flow injection for dFe DPD system with Rainin Dynamax Absorbance detector UV-C
Generic Instrument Name	Flow Injection Analyzer
Dataset-specific Description	Dissolved Fe was determined using a Flow Injection Analysis scheme with spectrophotometric detection (Rainin Dynamax UV-C). Major components were a Rabbit peristaltic pump, a Rainin Dynamax UV-C, a Rainin A/D board and a Macintosh G3 computer running Rainin MacIntegrator v 1.4.3 to log and reduce data. The spectrophotometric detection of the iron eluted from the column is achieved through its catalytic effect on the oxidation of N,N-dimethylp-phenylenediamine dihydrochloride (DPD) the oxidized product is measured at 514 nm.
Generic Instrument Description	An instrument that performs flow injection analysis. Flow injection analysis (FIA) is an approach to chemical analysis that is accomplished by injecting a plug of sample into a flowing carrier stream. FIA is an automated method in which a sample is injected into a continuous flow of a carrier solution that mixes with other continuously flowing solutions before reaching a detector. Precision is dramatically increased when FIA is used instead of manual injections and as a result very specific FIA systems have been developed for a wide array of analytical techniques.

Dataset-specific Instrument Name	Flow injection for dMn system with Rainin Dynamax Absorbance detector UV-C
Generic Instrument Name	Flow Injection Analyzer
Dataset-specific Description	Dissolved Mn was determined using a Flow Injection Analysis scheme with spectrophotometric detection (Rainin Dynamax UV-C). Major components were a Rabbit peristaltic pump, a Rainin Dynamax UV-C, a Rainin A/D board and a Macintosh G3 computer running Rainin MacIntegrator v 1.4.3 to log and reduce data.
Generic Instrument Description	An instrument that performs flow injection analysis. Flow injection analysis (FIA) is an approach to chemical analysis that is accomplished by injecting a plug of sample into a flowing carrier stream. FIA is an automated method in which a sample is injected into a continuous flow of a carrier solution that mixes with other continuously flowing solutions before reaching a detector. Precision is dramatically increased when FIA is used instead of manual injections and as a result very specific FIA systems have been developed for a wide array of analytical techniques.

Dataset-specific Instrument Name	Flow injection for dAl lumogallion system with Rainin Dynamax FL-1 fluorometer
Generic Instrument Name	Flow injection lumogallion system with fluorometer
Dataset-specific Description	Dissolved Al was determined using a Flow Injection Analysis scheme with fluorometric detection. The scheme produces a complex between lumogallion and dissolved Al. Major components of the scheme include a Rabbit peristaltic pump, a Dynamax FL-1 fluorometer, a Rainin A/D board, and a Macintosh G3 computer running Rainin MacIntegrator v 1.4.3 to log and reduce data.
Generic Instrument Description	An analytical system used to determine concentrations of chemical species in a sample based on the fluorescence from the reaction between lumogallion and the species of interest. The system typically comprises individual components typically including pumps, injection and autosampler valves, preconcentration columns and a fluorometer. The system is normally uniquely assembled for each analysis. (From SeaDataNet)

Dataset-specific Instrument Name	IWAKI magnetic drive pump
Generic Instrument Name	Pump
Dataset-specific Description	Seawater was collected using Teflon coated Tygon tubing and a rotary pump with plastic wetted parts (IWAKI magnetic drive pump, model WMD-30LFY-115).
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	https://datadocs.bco-dmo.org/docs/302/geotraces/GEOTRACES_ARCTIC/data_docs/cruise_reports/healy1502.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 in the GO-SHIP Cruise Report (PDF) and 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 (GN01) (U.S. GEOTRACES Arctic)

Website: <https://www.geotraces.org/>

Coverage: Arctic Ocean; Sailing from Dutch Harbor to Dutch Harbor (GN01)

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 activities 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 global 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: Shipboard determination of key trace elements (GEOTRACES Arctic Al Fe Mn)

NSF Award Abstract:

In this project, investigators participating in the 2015 U.S. GEOTRACES Arctic expedition will make shipboard measurements of dissolved aluminum, iron, and manganese in seawater, ice, snow, and melt pond samples collected during the cruise. 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. This project will be of particular importance to the success of the overall Arctic expedition because measurements of trace metals in seawater require highly-specialized clean sampling techniques to prevent contamination. Accordingly, the shipboard measurements made by this scientific team will allow for the early detection and rectification of any sample contamination problems while still

at sea. In terms of broader impacts, education and training of the next generation of marine trace element scientists, including undergraduate and graduate students, as well as public outreach will be key aspects of this project.

The shipboard determinations of dissolved aluminum, iron, and manganese in this study will provide near real-time insights into the distribution of these parameters, which can be used to potentially modify sampling strategies and can also be used to identify any systemic sampling contamination issues during the GEOTRACES Arctic expedition. Definitive data for dissolved iron and manganese will be produced by shore-based ICP MS, a type of mass spectrometry capable of detecting metals at very low concentrations. However, since dissolved aluminum data cannot be determined by shore-based ICP MS, the shipboard data set collected as part of this project will provide the definitive data set for this key GEOTRACES parameter. In addition, the researchers will undertake high resolution water sampling in the upper 10 m of the water column to characterize the trace metal distribution in this highly stratified region, which cannot be sampled by a conventional rosette. This sampling will be conducted from the edge of ice-floes or a small boat, away from the disturbing effects of the research vessel.

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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-1439253

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