Concentrations of dissolved and particulate mercury species collected on the US GEOTRACES Arctic cruise (HLY1502, GN01) from August to October 2015

Website: https://www.bco-dmo.org/dataset/827530
Data Type: Cruise Results
Version: 2
Version Date: 2021-02-03

Project
» U.S. Arctic GEOTRACES Study (GN01) (U.S. GEOTRACES Arctic)
» Collaborative Research: GEOTRACES Arctic Section: Mercury Speciation and Cycling in the Arctic Ocean (GEOTRACES Arctic Mercury)

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

Contributors	Affiliation	Role
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Abstract
Concentrations of dissolved and particulate mercury species, including elemental, total, monomethyl- and dimethylmercury, collected on GN01 (HLY1502) from August to October 2015 as part of the U.S. GEOTRACES Arctic project.

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Coverage

Spatial Extent: **N**:89.997 **E**:178.927 **S**:60.224 **W**:-180
Temporal Extent: 2015-08-12 - 2015-10-08

Dataset Description

Concentrations of dissolved and particulate mercury species collected on GN01 (HLY1502, US GEOTRACES Arctic cruise), including elemental, total, monomethyl- and dimethylmercury.

Methods & Sampling

Dissolved Mercury Species:
Samples were collected according to Cutter and Bruland 2012, utilizing a trace metal clean rosette (GT-C rosette). Samples above 20 m were pumped from a hole drilled in the ice far away from the ship, using clean sampling techniques.

Sample bottles were cleaned according to Hammerschmidt et al. 2012.

Dissolved mercury analyses were performed at sea, with the exception of monomethylmercury. The full methodology may be found in the Hg Cook Book, and more detailed method descriptions can be found in Lamborg et al. 2012, Hammerschmidt and Bowman 2012, Bowman et al. 2015, Bowman et al. 2016.

Dissolved species of mercury were measured with a Tekran Model 2500 CVAFS Mercury Detector. Analysis of total mercury (HgT; Fitzgerald and Gill 1979, Bloom and Fitzgerald 1988, Bloom 1989) has a method detection limit of 0.10 pM, and procedural duplicates varied by 11 ± 5% (n = 17).

Elemental mercury (Hg0) was analyzed according to Fitzgerald and Gill (1979), Bloom and Fitzgerald (1988) and Bloom (1989). The method detection limit was 0.04 pM and procedural duplicates varied by 11 ± 14% (n = 8).

Monomethylmercury (MMHg) was analyzed according to Bowman and Hammerschmdit (2011), Tseng et al. (2004) and Munson et al. (2014). The method detection limit was 0.020 pM, and procedural duplicates averaged 11 ± 8% (n =5).

Dimethylmercury (DMHg) was analyzed according to Bowman and Hammerschmidt (2011), Tseng et al. (2004) and Baya et al. (2013). The method detection limit was 0.012 pM.

Particulate Mercury Species:
Sample collection with in-situ pumps is outlined in Bishop et al. 2012.

Particulate samples were frozen and transported to Wright State University (Dayton, OH) where they were analyzed within 6 months of collection. Filter punches were digested in acid-cleaned polypropylene containers with 8 mL of 2N HNO3 (Baker Instra-Analyzed). After analysis of MMHg, an aliquot of digestate was oxidized with BrCl solution for total Hg determination, according to Hammerschmidt & Fitzgerald (2006). All analyzes were performed on Tekran Model 2500 CVAFS Mercury Detector.

Particulate HgT analysis was done according to Fitzgerald & Gill (1979), Bloom & Fitzgerald (1988), and Bloom (1989). The method detection limit was 0.75 pmol/kg, and procedural duplicates averaged 7 ± 6 RPD (n = 16).

Particulate MMHg was analyzed according to Tseng et al. (2004). The detection limit for the method was 0.075 pmol/kg.

While at sea, variable gas pressure in the gas chromatograph caused irregular MMHg peak retention times, making it indecipherable from the inorganic Hg peak. Accordingly, seawater samples ranging from 0.25 to 2 L, were acidified to 1% with sulfuric acid and shipped frozen to Wright State University for analysis.

Data Processing Description

The following **WOCE Quality Flags** were used:
2 – Ok,
3 – Questionable,
4 – Bad Analysis,
5 – Sample lost,
6 – Mean of replicates,
9 – Sample was not collected for Hg analysis.
"nd" indicates no data.
"bdl" indicates below detection limit.

BCO-DMO Processing:
- replaced "-999", "-999.000", and "NaN" with "nd" as missing data identifier;
- replaced Hg_0_D_CONC_BOTTLE_jo6zdp value for sample 11947 with "nd" as requested by PI;
- renamed fields to conform with BCO-DMO naming conventions;
- replaced dates 08/12/2015 with 12/08/2015 to match DD/MM/YYYY format used throughout dataset;
- added ISO8601 format date-time fields;

- 2021-02-03: replaced dataset with version 2, which removes the duplicate, incorrect row for Sample_ID 10840.

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Data Files

File
Hg.csv(Comma Separated Values (.csv), 103.34 KB) MD5:a203dc3c0794518f48a1da3135aaf39d Primary data file for dataset ID 827530

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Related Publications

Agather, A. M., Bowman, K. L., Lamborg, C. H., & Hammerschmidt, C. R. (2019). Distribution of mercury species in the Western Arctic Ocean (U.S. GEOTRACES GN01). Marine Chemistry, 216, 103686. doi:10.1016/j.marchem.2019.103686
Results

Baya, P. A., Hollinsworth, J. L., & Hintelmann, H. (2013). Evaluation and optimization of solid adsorbents for the sampling of gaseous methylated mercury species. Analytica Chimica Acta, 786, 61–69. doi:10.1016/j.aca.2013.05.019
Methods

Bishop, J. K. B., Lam, P. J., & Wood, T. J. (2012). Getting good particles: Accurate sampling of particles by large volume in-situ filtration. Limnology and Oceanography: Methods, 10(9), 681–710. doi:10.4319/lom.2012.10.681
Methods

Bloom, N. (1989). Determination of Picogram Levels of Methylmercury by Aqueous Phase Ethylation, Followed by Cryogenic Gas Chromatography with Cold Vapour Atomic Fluorescence Detection. Canadian Journal of Fisheries and Aquatic Sciences, 46(7), 1131–1140. doi:10.1139/f89-147
Methods

Bloom, N., & Fitzgerald, W. F. (1988). Determination of volatile mercury species at the picogram level by low-temperature gas chromatography with cold-vapour atomic fluorescence detection. Analytica Chimica Acta, 208, 151–161. doi:10.1016/s0003-2670(00)80743-6 https://doi.org/10.1016/S0003-2670(00)80743-6
Methods

Bowman, K. L., & Hammerschmidt, C. R. (2011). Extraction of monomethylmercury from seawater for low-femtomolar determination. Limnology and Oceanography: Methods, 9(4), 121–128. doi:10.4319/lom.2011.9.121
Methods

Bowman, K. L., Collins, R. E., Agather, A. M., Lamborg, C. H., Hammerschmidt, C. R., Kaul, D., … Elias, D. A. (2020). Distribution of mercury-cycling genes in the Arctic and equatorial Pacific Oceans and their relationship to mercury speciation. Limnology and Oceanography, 65(S1). doi:10.1002/lno.11310
Results

Bowman, K. L., Hammerschmidt, C. R., Lamborg, C. H., & Swarr, G. (2015). Mercury in the North Atlantic Ocean: The U.S. GEOTRACES zonal and meridional sections. Deep Sea Research Part II: Topical Studies in Oceanography, 116, 251–261. doi:10.1016/j.dsr2.2014.07.004
Methods

Bowman, K. L., Hammerschmidt, C. R., Lamborg, C. H., Swarr, G. J., & Agather, A. M. (2016). Distribution of mercury species across a zonal section of the eastern tropical South Pacific Ocean (U.S. GEOTRACES GP16). Marine Chemistry, 186, 156–166. doi:10.1016/j.marchem.2016.09.005
Methods

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

Fitzgerald, W. F., & Gill, G. A. (1979). Subnanogram determination of mercury by two-stage gold amalgamation and gas phase detection applied to atmospheric analysis. Analytical Chemistry, 51(11), 1714–1720. doi:10.1021/ac50047a030
Methods

Hammerschmidt, C. R., & Bowman, K. L. (2012). Vertical methylmercury distribution in the subtropical North Pacific Ocean. Marine Chemistry, 132-133, 77–82. doi:10.1016/j.marchem.2012.02.005
Methods

Hammerschmidt, C. R., & Fitzgerald, W. F. (2006). Bioaccumulation and Trophic Transfer of Methylmercury in Long Island Sound. Archives of Environmental Contamination and Toxicology, 51(3), 416–424. doi:10.1007/s00244-005-0265-7
Methods

Hammerschmidt, C. R., Bowman, K. L., Tabatchnick, M. D., & Lamborg, C. H. (2011). Storage bottle material and cleaning for determination of total mercury in seawater. Limnology and Oceanography: Methods, 9(10), 426–431. doi:10.4319/lom.2011.9.426 https://doi.org/10.4319/lom.2011.9.426
Methods

Lamborg, C. H., Hammerschmidt, C. R., Gill, G. A., Mason, R. P., & Gichuki, S. (2012). An intercomparison of procedures for the determination of total mercury in seawater and recommendations regarding mercury speciation during GEOTRACES cruises. Limnology and Oceanography: Methods, 10(2), 90–100. doi:10.4319/lom.2012.10.90
Methods

Munson, K. M., Babi, D., & Lamborg, C. H. (2014). Determination of monomethylmercury from seawater with ascorbic acid-assisted direct ethylation. Limnology and Oceanography: Methods, 12(1), 1–9. doi:10.4319/lom.2014.12.1
Methods

Tesán Onrubia, J. A., Petrova, M. V., Puigcorbé, V., Black, E. E., Valk, O., Dufour, A., … Heimbürger-Boavida, L.-E. (2020). Mercury Export Flux in the Arctic Ocean Estimated from 234Th/238U Disequilibria. ACS Earth and Space Chemistry, 4(5), 795–801. doi:10.1021/acsearthspacechem.0c00055
Results

Tseng, C.-M., Hammerschmidt, C. R., & Fitzgerald, W. F. (2004). Determination of Methylmercury in Environmental Matrixes by On-Line Flow Injection and Atomic Fluorescence Spectrometry. Analytical Chemistry, 76(23), 7131–7136. doi:10.1021/ac049118e
Methods

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Related Datasets

Replaces Old Versions

Lamborg, C., Hammerschmidt, C. (2018) **[DEPRECATED] Dissolved mercury measurements from the Western Arctic Ocean, which were sampled as part of the 2015 US GEOTRACES Cruise (GN01; HLY1502).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 2) Version Date 2018-06-22 http://lod.bco-dmo.org/id/dataset/738136 [view at BCO-DMO]
Relationship Description: "GN01 Particulate Mercury" and "GN01 Dissolved Mercury Species" have been updated and replaced by a single dataset containing both particulate and dissolved mercury species.

Lamborg, C., Hammerschmidt, C. (2018) **[DEPRECATED] Particulate total mercury and particulate monomethylmercury concentrations from the Western Arctic Ocean, which were sampled by McLane pumps during he 2015 US GEOTRACES Cruise (GN01; HLY1502).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2018-07-10 http://lod.bco-dmo.org/id/dataset/738307 [view at BCO-DMO]
Relationship Description: "GN01 Particulate Mercury" and "GN01 Dissolved Mercury Species" have been updated and replaced by a single dataset containing both particulate and dissolved mercury species.

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Parameters

Parameter	Description	Units
Station_ID	Station number	unitless
Start_Date_UTC	Date and time at the start of the sampling event, according to the event log. Format: DD/MM/YYYY	unitless
Start_Time_UTC	Date and time at the start of the sampling event, according to the event log. Format: hh:mm	unitless
Start_ISO_DateTime_UTC	Date and time (UTC) at start of the sampling event; formatted to ISO8601 standard: YYYY-MM-DDThh:mmZ	unitless
End_Date_UTC	Date and time at the end of the sampling event, according to the event log. Format: DD/MM/YYYY	unitless
End_Time_UTC	Date and time at the end of the sampling event, according to the event log. Format: hh:mm	unitless
End_ISO_DateTime_UTC	Date and time (UTC) at end of the sampling event; formatted to ISO8601 standard: YYYY-MM-DDThh:mmZ	unitless
Start_Latitude	Latitude of sample collection	degrees North
Start_Longitude	Longitude of sample collection	degrees East
End_Latitude	Latitude of sample collection	degrees North
End_Longitude	Longitude of sample collection	degrees East
Event_ID	GEOTRACES event number	unitless
Sample_ID	GEOTRACES unique sample ID number	unitless
Sample_Depth	Depth of sample collection	meters (m)
Hg_0_D_CONC_BOTTLE_jo6zdp	Elemental mercury measurement	picomoles per kilogram (pmol/kg)
SD1_Hg_0_D_CONC_BOTTLE_jo6zdp	One standard deviation of Hg_0_D_CONC_BOTTLE_jo6zdp	picomoles per kilogram (pmol/kg)
Flag_Hg_0_D_CONC_BOTTLE_jo6zdp	Elemental mercury quality flag (WOCE)	unitless
Hg_D_CONC_BOTTLE_ntd14w	Total dissolved mercury measurement	picomoles per kilogram (pmol/kg)
SD1_Hg_D_CONC_BOTTLE_ntd14w	One standard deviation of Hg_D_CONC_BOTTLE_ntd14w	picomoles per kilogram (pmol/kg)
Flag_Hg_D_CONC_BOTTLE_ntd14w	Total mercury quality flag (WOCE)	unitless
Hg_DM_D_CONC_BOTTLE_9fiz3v	Dimethylmercury measurement	picomoles per kilogram (pmol/kg)
SD1_Hg_DM_D_CONC_BOTTLE_9fiz3v	One standard deviation of Hg_DM_D_CONC_BOTTLE_9fiz3v	picomoles per kilogram (pmol/kg)
Flag_Hg_DM_D_CONC_BOTTLE_9fiz3v	Dimethylmercury quality flag (WOCE)	unitless
Hg_MM_D_CONC_BOTTLE_ny980n	Monomethylmercury measurement	picomoles per kilogram (pmol/kg)

SD1_Hg_MM_D_CONC_BOTTLE_ny980n	One standard deviation of Hg_MM_D_CONC_BOTTLE_ny980n	picomoles per kilogram (pmol/kg)
Flag_Hg_MM_D_CONC_BOTTLE_ny980n	Monomethylmercury quality flag (WOCE)	unitless
Hg_SPT_CONC_PUMP_bf7clc	Total particulate mercury measurement	picomoles per kilogram (pmol/kg)
SD1_Hg_SPT_CONC_PUMP_bf7clc	One standard deviation of Hg_SPT_CONC_PUMP_bf7clc	picomoles per kilogram (pmol/kg)
Flag_Hg_SPT_CONC_PUMP_bf7clc	Total particulate monomethylmercury quality flag (WOCE)	unitless
Hg_MM_SPT_CONC_PUMP_58nleq	Particulate monomethylmercury measurement	picomoles per kilogram (pmol/kg)
SD1_Hg_MM_SPT_CONC_PUMP_58nleq	One standard deviation of Hg_MM_SPT_CONC_PUMP_58nleq	picomoles per kilogram (pmol/kg)
Flag_Hg_MM_SPT_CONC_PUMP_58nleq	Particulate monomethylmercury quality flag (WOCE)	unitless

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Instruments

Dataset-specific Instrument Name	Tekran Model 2500 or 2600 CVAFS Mercury Detector
Generic Instrument Name	Cold Vapor Atomic Fluorescence Spectrophotometer
Dataset-specific Description	Cold Vapor Atomic Fuorescent Spectrometer (CVAFS) quantitatively measures volatile heavy metals, such as mercury. Gaseous mercury atoms are carried to the detector via inert gas, excited by a UV light source, and radiate the absorbed energy. The fluorescence is detected by either a photomultiplier tube or UV photodiode.
Generic Instrument Description	A Cold Vapor Atomic Fluorescent Spectrophotometer (CVAFS) is an instrument used for quantitative determination of volatile heavy metals, such as mercury. CVAFS make use of the characteristic of mercury that allows vapor measurement at room temperature. Mercury atoms in an inert carrier gas are excited by a collimated UV light source at a particular wavelength. As the atoms return to their non-excited state they re-radiate their absorbed energy at the same wavelength. The fluorescence may be detected using a photomultiplier tube or UV photodiode.

Dataset-specific Instrument Name	GT-C rosette
Generic Instrument Name	GO-FLO Teflon Trace Metal Bottle
Dataset-specific Description	Samples were collected according to Cutter and Bruland 2012, utilizing a trace metal clean rosette (GT-C rosette).
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	McLane in-situ pump
Generic Instrument Name	McLane Pump
Dataset-specific Description	McLane in-situ pumps were used to collect the 1–51 um size fractioned samples.
Generic Instrument Description	McLane pumps sample large volumes of seawater at depth. They are attached to a wire and lowered to different depths in the ocean. As the water is pumped through the filter, particles suspended in the ocean are collected on the filters. The pumps are then retrieved and the contents of the filters are analyzed in a lab.

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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 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: Mercury Speciation and Cycling in the Arctic Ocean (GEOTRACES Arctic Mercury)

Coverage: Western Arctic Ocean

NSF Award Abstract:
In this project, investigators from Woods Hole Oceanographic Institution and Wright State University participating in the 2015 U.S. GEOTRACES Arctic expedition will measure total mercury and mercury species in seawater, particles, sediments, snow and ice samples to better understand its cycling 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. In its methylated form, mercury poses a serious human and ecosystem health threat, and this research will provide important information on the extent and rate of change of mercury in the

sensitive Arctic ecosystem. Results from this study will be shared through outreach efforts to middle schools students in the Dayton, Ohio area, and the research will involve training for graduate and undergraduate students.

Mercury is a toxic trace metal that originates from natural and anthropogenic sources, and can enter the oceans through many processes, most importantly atmospheric deposition, riverine discharge, and coastal erosion in the Arctic Ocean. Mercury in the ocean can be transformed into varying species by a variety of abiotic and biotic processes. Its transformation to methylmercury is of primary concern as it can biomagnify in food webs. Wildlife in the Arctic has experienced unprecedented increases of methylmercury in their tissues during the past 200 years. While there has been a great deal of research related to mercury cycling in the Arctic in recent years, there remain large gaps in fundamental understanding, particularly with respect to mercury distributions and speciation. The researchers will 1) measure the concentration of four mercury species in the water column, particles, sediments, snow and sea ice samples, 2) determine the concentration of other related chemical species (thiols and snow/ice bromine), and 3) explore the mercury-related genomics of bacteria in various samples. Results from this work will yield new insights into the extent and rate of change of mercury loadings in the Arctic Ocean.

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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-1434653
NSF Division of Ocean Sciences (NSF OCE)	OCE-1534315

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