GN01 Dissolved Methane (CH4)

Website: https://www.bco-dmo.org/dataset/946112
Data Type: Cruise Results
Version: 1
Version Date: 2024-12-16

Project
» U.S. Arctic GEOTRACES Study (GN01) (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
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Whitmore, Laura	University of Southern Mississippi (USM)	Scientist
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Abstract
This dataset reports dissolved methane (CH4) concentrations from the US GEOTRACES Arctic Expedition on USCGC Healy (GN01, HLY1502) from August to October 2015. Seawater samples were collected using the ODF rosette. Both GEOTRACES samples and GO-SHIP samples from the same cruise were analyzed. Methane was analyzed using cavity ringdown spectroscopy to determine its concentration in an equilibrated headspace. Arctic waters are a possibly significant source of this Greenhouse Gas to the atmosphere and global change is likely exacerbating its release. Methane is also a potentially valuable indicator of interactions with the shelf as well as of river inputs. Dissolved methane concentrations in this section were highest over the continental shelves and slope, which supports our understanding of the major sources of methane (i.e., from microbes in oxygen-limited sediments, from gas seeps, and from gas-hydrates).

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Coverage

Location: Bering Sea and Western Arctic Ocean to the North Pole

Methods & Sampling

Samples were collected from the ODF rosette rather than GEOTRACES carousel. The GEOTRACES Cookbook does not specifically address sample collection for methane; however, this rosette system was used during the cruise for sampling various ancillary parameters (e.g., oxygen, nutrients) and thus sampling overall followed Chpt. III (HYDROGRAPHY AND ANCILLARY PARAMETERS) of the Cookbook. Sampling methodology (from the

Niskin bottles) followed that of Roberts and Shiller (2015). The dissolved methane samples were obtained from the Niskin bottles immediately after other dissolved gases were sampled.

Dissolved CH4 was determined cavity ringdown spectroscopy (CRDS) following headspace equilibration following the method of Roberts and Shiller (2015). Samples were collected from the Niskin bottles immediately after the other dissolved gas samples, equilibrated with methane-free zero-air (approximately 70 milliliters (mL) water and 70 mL zero air) immediately after samples were collected. Equilibrated head-space methane was determined using a Picarro G2301 Greenhouse Gas Analyzer. Calibration was performed using both methane-free zero air and a 5 ppmv CH4 gas standard (NIST traceable). Variability of dissolved methane in deep ocean samples from the GP15 section suggests a standard deviation of better than 0.06 nanomoles per kilogram (nmol/kg) on samples of ~0.6 nmol/kg, similar to the results of Roberts and Shiller (2015).

Data Processing Description

Gaseous methane concentrations in the equilibrated headspace are converted to dissolved phase methane concentrations using Henry's Law using an Excel spreadsheet template as described in Roberts and Shiller (2015).

Quality Flags: Quality flags were applied following the GEOTRACES policy (https://www.geotraces.org/geotraces-quality-flag-policy/), which recommends the SeaDataNet Scheme:

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; (see attached Supplemental File for detection limits for Be-7 samples)
7 = value in excess;
8 = interpolated value;
9 = missing value;
A = value phenomenon uncertain.

BCO-DMO Processing Description

currently being processed

Problem Description

No problems noted. SeaDataNet quality flags were used.

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Related Publications

Cutter, G.A., Andersson, P., Codispoti, L., Croot, P., Francois, R., Lohan, M., Obata, H., van der Loeff, M. R. (2014) Sampling and Sample-Handing Protocols for GEOTRACES Cruises (cookbook) Version 2.0; December 2014. http://www.geotraces.org/images/stories/documents/intercalibration/Cookbook_v2.pdf
Methods

Roberts, H. M., & Shiller, A. M. (2015). Determination of dissolved methane in natural waters using headspace analysis with cavity ring-down spectroscopy. Analytica Chimica Acta, 856, 68–73. https://doi.org/10.1016/j.aca.2014.10.058
Methods

Whitmore, L.M., L.T. Jensen, J. Granger, Y. Xiang, L.E. Kipp, A. Pasqualini, R. Newton, A.M. Agather, R.F. Anderson, E.E. Black, K.L. Bowman, A. Bourbonnais, M.A. Brzezinski, R.M. Bundy, M.A. Charette, R.L. Edwards,

J.N. Fitzsimmons, D.A. Hansell, P.J. Lam, P. Morton, M. Saito, A.M. Shiller, W.M. Smethie, B.S. Twining, R.J. Woosley, and R. Zhang. A U.S. GEOTRACES synthesis of the Arctic Ocean Upper Halocline: multielemental tracers in the Amerasian Basin reveal interlinked biogeochemical and physical processes. Global Biogeochemical Cycles, in review.
Results

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	Niskin bottle
Generic Instrument Name	Niskin bottle
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	Picarro G2301 Greenhouse Gas Analyzer
Generic Instrument Name	Picarro G2301 Greenhouse Gas Analyzer
Generic Instrument Description	The Picarro G2301 is a cavity ringdown spectrometer designed to measure the concentration of methane, carbon dioxide, and water vapor in a gaseous sample. It provides simultaneous, precise measurement of carbon dioxide (CO2) and methane (CH4) at parts-per-billion (ppb), and water (H2O) vapor at parts-per-million (ppm) sensitivity. Patented Picarro cavity ring-down spectroscopy (CRDS) technology enables an effective measurement path length up to 20 km in a compact cavity. Precision at 5 seconds and 5 minutes is 70 and 25 ppb for CO2; 0.5 and 0.22 ppb for CH4; and 80 and 30 ppm for H2O. Maximum drift at standard temperature and pressure (STP) over 24 hours is 120 ppb for CO2; 1 ppb for CH4; 100 ppm for H2O.

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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.

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-1436312

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