Concentrations of CFC-11, CFC-12, CFC-113 and SF6 in seawater from the GEOTRACES-Arctic program, aboard RV/HLY-1502, 2015.

Website: https://www.bco-dmo.org/dataset/643166
Data Type: Cruise Results
Version: 1b
Version Date: 2016-10-24

Project
» U.S. Arctic GEOTRACES Study (GN01) (U.S. GEOTRACES Arctic)
» US GEOTRACES Arctic Section - Water mass composition, circulation and mean residence times derived from measurements of natural and manmade tracers (GT-Arctic Tracer Circulation)

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

Contributors	Affiliation	Role
Ho, David T.	University of Hawai'i (UH)	Principal Investigator
Smethie Jr., William M.	Lamont-Doherty Earth Observatory (LDEO)	Principal Investigator
Gorman, Eugene	Lamont-Doherty Earth Observatory (LDEO)	Technician
Hickman, Benjamin	University of Hawai'i (UH)	Technician
Lee, Hoyle	Lamont-Doherty Earth Observatory (LDEO)	Data Manager
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

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Coverage

Spatial Extent: **N**:89.9876 **E**:-148 **S**:60.252 **W**:167
Temporal Extent: 2015-08-12 - 2015-10-06

Dataset Description

Concentrations of CFC-11, CFC-12, CFC-113 and SF6 in seawater from the Artic section of the US-GEOTRACES project.

CFC-11 CCl_3F trichlorofluoromethane pmol/kg (10^-12 moles/kg)
CFC-12 CCl_2F_2 dichlorodifluoromethane pmol/kg
CFC-113 $C_2Cl_3F_3$ 1,1,2-trichlorotrifluloroethane pmol/kg
SF_6 sulfur hexafluoride fmol/kg (10^-15 moles/kg)

Methods & Sampling

Water samples for CFC and SF6 measurements were collected using either a 12-place 30-liter bottle rosette or a 36-place 10-liter bottle rosette. The CFC/SF6 sample was the first sample drawn from the rosette bottle. The samples were collected in a 500 cc glass stoppered bottle through a PVC tube connected to the rosette bottle drain valve. Bubbles were cleared from the tube with water flowing and the tube was inserted to the bottom of the 500 cc glass bottle. The glass bottle was placed in a wide mouth plastic jar that extended above the opening of the glass bottle by 4 cm. The overflow water collected in the jar, filling and overflowing the jar and covering the glass bottle opening. The flow continued for 3 overflow volumes of the glass bottle (1.5 liters) and the glass stopper was then inserted underwater preventing air from being trapped in the sample. The jar was then capped and the sample stored at room temperature until measurement, which was within 8 hours of collection. The measurements were carried out using a dual purge and trap system interfaced to a dual ECD (electron capture detector) HP6890 gas chromatograph. When a water sample is introduced into the system, it is split into two aliquots, a 20 cc aliquot for CFC measurement and a 350 cc aliquot for SF6 measurement. The aliquots are transferred to appropriately sized sparging chambers and stripped with ultra high purity nitrogen, which transports the extracted gases to cold traps (Unibeads-2s for CFCs, Carboxan-1000 for SF6) cooled to -80°C. The traps are then heated to 110°C for CFCs and 165°C for SF6 and flushed into the gas chromatograph where CFCs are separated with a Porasil-B pre-column and a Carbograph 1AC main column and SF6 is separated with a pre-column and main column of Molecular Sieve 5A. The gases are detected by the ECDs. The ECDs are calibrated by running gas standards with known concentrations of CFCs and SF6. Duplicate samples are collected and measured to provide a combined precision for sampling and measurement. The average differences from these duplicate measurements was the larger of 0.005 pmol/kg or 0.5% for CFC-11, 0.008 pmol/kg or 1.1% for CFC-12, 0.005 pmol/kg for CFC-113 and 0.02 fmol/kg or 1.5% for SF6.

Data Processing Description

The gas chromatograph produces a peak for each compound being measured. Each chromatogram is digitally acquired on a PC and the peak areas integrated with software developed specifically for this purpose. Calibration curves relating peak area to concentration are generated using the gas standard data and this information is used to convert peak areas for the samples to concentrations. Blanks and reference standards are run about every 2 hours to provide data to correct for detector drift and blanks. After completion of the cruise, plots of the CFCs and SF6 against each other and against hydrographic variables are prepared to determine trends in the data and identify questionable data. Questionable data are checked for possible data processing errors, sampling problems, equipment problems, etc. Mistakes are corrected and samples judged to be bad measurements are flagged as such. The WOCE flagging convention is used. The gas standard used was prepared by Dr. John Bullister of NOAA/PMEL specifically for the CLIVAR Repeat Hydrography program; CFC concentrations are reported on the SIO98 calibration scale and SF6 concentrations on the SIO2005 calibration scale.

BCO-DMO Processing Notes:
2016-04-22: initially served data
2016-10-24: changed parameter names from F11, F12, F113 to CFC-11, CFC-12, CFC113
2017-05-24: dataset made publicly available

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Data Files

File
CFC_SF6.csv (Comma Separated Values (.csv), 173.23 KB) MD5:d43bffddaf33c983fd4675c7f6367435 Primary data file for dataset ID 643166

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Parameters

Parameter	Description	Units
cruise_id	Cruise identification	unitless
station	Station Number	unitless
cast	Cast number	unitless
GEOTRC_EVENTNO	GEOTRACES Event Number. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	unitless
sample	GEOTRACES sample number	unitless
BTLNBR	Bottle number. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	unitless
mon	Month	1-12
day	UTC day	1-31
year	Year	yyyy
lat	Latitude of bottle firing; north is positive. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	decimal degrees
lon	Lonitude of bottle firing; east is positive. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	decimal degrees
depth_w	Water depth	meters
PRES_R	Pressure	decibars
TEMP	Temperature	degrees Celsius
CTDSAL	Salinity from the CTD	PSU
SALT	Salinity from bottle	PSU
CTDO2	Oxygen concentration from CTD	ml/l

OXYCTD_umol_kg	Oxygen concentration from CTD	umol/kg
O2_ml_l	Oxygen concentration from bottle	ml/l
BTLOXY_umol_kg	Oxygen concentration from bottle	umol/kg
SIO3_CONC	SiO3 silicate concentration	umol/kg
NO3_CONC	NO3 nitrate concentration	umol/kg
NO2_CONC	NO2 nitrite concentration	umol/kg
PO4_CONC	PO4 phosphate concentration	umol/kg
F11_CONC	CCl3F trichlorofluoromethane	pmol/kg (10-12 moles/kg)
FLAG_F11	WOCE quality flag: 2 = good; 3 = questionable; 4 = bad; 9 = missing dat	unitless
F12_CONC	CCl_2F_2 dichlorodifluoromethane	pmol/kg
FLAG_F12	WOCE quality flag: 2 = good; 3 = questionable; 4 = bad; 9 = missing dat	unitless
F113_CONC	$C_2Cl_3F_3$ 1,1,2-trichlorotrifluloroethane	pmol/kg
FLAG_F113	WOCE quality flag: 2 = good; 3 = questionable; 4 = bad; 9 = missing dat	unitless
SF6_CONC	SF6 sulfur hexafluoride	fmol/kg (10-15 moles/kg)
FLAG_SF6	WOCE quality flag: 2 = good; 3 = questionable; 4 = bad; 9 = missing dat	unitless

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Automated Purge and Trap System
Generic Instrument Description	This equipment removes dissolved gases from the water samples, traps the extracted compounds on a cold trap and then heats the trap and injects the trapped gases into the gas chromatograph. It is automated and controlled by a laptop computer.

Dataset-specific Instrument Name	
Generic Instrument Name	Gas Chromatograph
Dataset-specific Description	Dual ECD (electron capture detector) HP6890 gas chromatograph
Generic Instrument Description	Instrument separating gases, volatile substances, or substances dissolved in a volatile solvent by transporting an inert gas through a column packed with a sorbent to a detector for assay. (from SeaDataNet, BODC)

Dataset-specific Instrument Name	
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Two rosettes were used, one with 30-l bottles and one with 10-l bottles.
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

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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.

US GEOTRACES Arctic Section - Water mass composition, circulation and mean residence times derived from measurements of natural and manmade tracers (GT-Arctic Tracer Circulation)

Coverage: Arctic Ocean

In this project, investigators participating in the 2015 U.S. GEOTRACES Arctic expedition will measure six oceanic tracers in order to better understand oceanic water movement in the Arctic Ocean. With this information in-hand, it will be much easier for other investigators to interpret their own seawater chemistry data. In common with other national initiatives in the International GEOTRACES Program, the goals of the U.S. Arctic expedition are to identify processes and quantify fluxes that control the distributions of key trace elements and isotopes in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions. Some trace elements are essential to life, others are known biological toxins, and still others are important because they can be used as tracers of a variety of physical, chemical, and biological processes in the sea. The tracers to be measured as part of this study have proven their value for studies of water mass composition, circulation, and mean residence times on short to long time scales. This project will also provide training for two high school teachers, and develop curriculum for high school students.

The Arctic is presently undergoing system-scale environmental change at a pace not seen elsewhere on the globe. Thus, it is essential to establish a baseline of the distributions of trace elements and isotopes (TEIs) for future reference and to begin understanding the processes that determine the TEI distributions in the Arctic Ocean. Particularly with respect to the receding sea ice cover, it is imperative to understand how TEIs impact vital functions of the Arctic system, such as primary productivity or, more generally, the cycling of carbon under these rapidly changing environmental conditions. To further understanding on water movement and thus trace element distributions in the Arctic, this team of researchers will measure chlorofluorocarbons (CFCs), sulfur hexafluoride (SF6), tritium, helium isotopes, stable isotopes of water and C-14 along the transect. These tracers have been used successfully in past studies for determination of water mass composition, circulation pathways, and mean residence times on time scales from less than one year (CFCs/SF6 and tritium/He-3) to several hundred years (C-14). The researchers plan to make underway measurements of the saturations of CFCs and SF6 in partially and totally ice covered waters along the cruise track, and will also calculate forward and backward sea ice trajectories at all station locations to determine sources of sea ice samples. These trajectories will be used as a first step towards understanding the pathways of waters in the surface mixed layer.

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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-1436666
NSF Division of Ocean Sciences (NSF OCE)	OCE-1436125

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