

Cellular elemental content of individual phytoplankton cells collected during US GEOTRACES North Atlantic Transect cruises in the Subtropical western and eastern North Atlantic Ocean during Oct and Nov, 2010 and Nov. 2011

Website: <https://www.bco-dmo.org/dataset/549122>

Data Type: Cruise Results

Version: 2015-02-17

Project

» [U.S. GEOTRACES North Atlantic Transect \(GA03\)](#) (U.S. GEOTRACES NAT)

Program

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

Contributors	Affiliation	Role
Twining, Benjamin	Bigelow Laboratory for Ocean Sciences	Principal Investigator
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Table of Contents

- [Coverage](#)
- [Dataset Description](#)
 - [Methods & Sampling](#)
 - [Data Processing Description](#)
- [Data Files](#)
- [Parameters](#)
- [Instruments](#)
- [Deployments](#)
- [Project Information](#)
- [Program Information](#)
- [Funding](#)

Coverage

Spatial Extent: N:39.68403 E:-18.2545 S:17.3505 W:-69.8139

Temporal Extent: 2010-10-01 - 2011-11-30

Dataset Description

Individual phytoplankton cells were collected on the GEOTRACES North Atlantic Transect cruises were analyzed for elemental content using SXRF (Synchrotron radiation X-Ray Fluorescence). Carbon was calculated from biovolume using the relationships of Menden-Deuer & Lessard (2000). Trace metal concentrations are reported.

Download zipped images:

[Chlorophyll](#)

[Light](#)

[SXRF maps](#)

[SXRF spectra](#)

Related references:

Menden-Deuer, S. and E. J. Lessard (2000). Carbon to volume relationships for dinoflagellates, diatoms, and other protist plankton. *Limnology and Oceanography* 45(3): 569-579.

* Twining, B. S., S. Rauschenberg, P. L. Morton, and S. Vogt. 2015. Metal contents of phytoplankton and labile particulate material in the North Atlantic Ocean. *Progress in Oceanography* 137: 261-283.)

Methods & Sampling

SXRF samples were prepared from unfiltered water taken from GEOTRACES GO-Flo bottles at the shallowest depth and deep chlorophyll maximum. Cells were preserved with 0.25% trace-metal clean buffered glutaraldehyde and centrifuged onto C/formvar-coated Au TEM grids. Grids were briefly rinsed with a drop of ultrapure water and dried in a Class-100 cabinet. SXRF analysis was performed using the 2-ID-E beamline at the Advanced Photon source (Argonne National Laboratory) following the protocols of Twining et al. (2011).

Data Processing Description

Data were processed as described in Twining et al. (2015)

Between 9 and 20 cells were analyzed from the shallowest bottle and deep chlorophyll maximum at the subset of stations. The elemental content of each cell has been corrected for elements contained in the carbon substrate. Trace element concentrations are presented as mmol/mol P. Geometric mean concentrations (+/- standard error of the mean) are presented, along with the number of cells analyzed.

BCO-DMO Processing:

- added conventional header with dataset name, PI name, version date
- renamed parameters to BCO-DMO standard
- replaced blank cells with nd
- sorted by cruise, station, grid#
- changed station 99 and 153 to cruise AT199-05 from AT199-04
- revised station 9 depths to match master events log

With the agreement of BODC and the US GEOTRACES lead PIs, BCO-DMO added standard US GEOTRACES information, such as the US GEOTRACES event number. To accomplish this, BCO-DMO compiled a 'master' dataset composed of the following parameters: station_GEOTRC, cast_GEOTRC (bottle and pump data only), event_GEOTRC, sample_GEOTRC, sample_bottle_GEOTRC (bottle data only), bottle_GEOTRC (bottle data only), depth_GEOTRC_CTD (bottle data only), depth_GEOTRC_CTD_rounded (bottle data only), BTL_ISO_DateTime_UTC (bottle data only), and GeoFish_id (GeoFish data only). This added information will facilitate subsequent analysis and inter comparison of the datasets.

Bottle parameters in the master file were taken from the GT-C_Bottle_GT10, GT-C_Bottle_GT11, ODF_Bottle_GT10, and ODF_Bottle_GT11 datasets. Non-bottle parameters, including those from GeoFish tows, Aerosol sampling, and McLane Pumps, were taken from the Event_Log_GT10 and Event_Log_GT11 datasets. McLane pump cast numbers missing in event logs were taken from the Particulate Th-234 dataset submitted by Ken Buesseler.

A standardized BCO-DMO method (called "join") was then used to merge the missing parameters to each US GEOTRACES dataset, most often by matching on sample_GEOTRC or on some unique combination of other parameters.

If the master parameters were included in the original data file and the values did not differ from the master file, the original data columns were retained and the names of the parameters were changed from the PI-submitted names to the standardized master names. If there were differences between the PI-supplied parameter values and those in the master file, both columns were retained. If the original data submission included all of the master parameters, no additional columns were added, but parameter names were modified to match the naming conventions of the master file.

See the dataset parameters documentation for a description of which parameters were supplied by the PI and which were added via the join method.

[[table of contents](#) | [back to top](#)]

Data Files

File
cellular_trace_elements_v2_joined.csv (Comma Separated Values (.csv), 68.98 KB) MD5:ac7c8f0993de7188bef4bdc9f68c45f3
Primary data file for dataset ID 549122

[[table of contents](#) | [back to top](#)]

Parameters

Parameter	Description	Units
cruise_id	cruise identification	unitless
station_GEOTRC	GEOTRACES station number; ranges from 1 through 12 for KN199-04 and 1 through 24 for KN204-01. Stations 7 and 9 were skipped on KN204-01. Some GeoFish stations are denoted as X_to_Y indicating the tow occurred between stations X and Y. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	unitless
lat	station latitude; north is positive	decimal degrees
lon	station longitude; east is postive	decimal degrees
cast_GEOTRC	Cast identifier; numbered consecutively within a station. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	unitless
event_GEOTRC	Unique identifying number for US GEOTRACES sampling events; ranges from 2001 to 2225 for KN199-04 events and from 3001 to 3282 for KN204-01 events. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	unitless
depth_GEOTRC_CTD	Observation/sample depth in meters; calculated from CTD pressure. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	meters
depth_GEOTRC_CTD_round	Rounded observation/sample depth in meters; calculated from CTD pressure. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	meters

sample_GEOTRC	Unique identifying number for US GEOTRACES samples; ranges from 5033 to 6078 for KN199-04 and from 6112 to 8148 for KN204-01. PI-supplied values were identical to those in the intermediate US GEOTRACES master file. Originally submitted as 'GEOTRACES #'; this parameter name has been changed to conform to BCO-DMO's GEOTRACES naming conventions.	unitless
sample_bottle_GEOTRC	Unique identification numbers given to samples taken from bottles; ranges from 1 to 24; often used synonymously with bottle number. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	unitless
bottle_GEOTRC	Alphanumeric characters identifying bottle type (e.g. NIS representing Niskin and GF representing GOFLO) and position on a CTD rosette. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	unitless
project	GEOTRACES project: North Atlantic Zonal Transect	unitless
grid_type	grid type: plankton samples were mounted onto either gold (Au) or aluminum (Al) electron microscopy grids	unitless
grid_num	GEOTRACES bottle number followed by an internal designation for the grid	unitless
SXRF_run	samples were analyzed by synchrotron x-ray fluorescence (SXRF) during two analytical runs in July 2011 (2011r2) or August 2012 (2012r2).	unitless
mda_id	unique identifier given to each SXRF scan during each run	unitless
cell_type	each cell was classified as either an autotrophic flagellate (Aflag); autotrophic picoplankter (Apico); or a diatom.	unitless
cell_vol	biovolume of each cell estimated from microscope measurements of cell dimensions	um ³
cell_C	cellular C content calculated from biovolume using the relationships of Menden-Deuer & Lessard (2000)	mol/cell
cell_Si	total elemental Si content of each cell was measured with SXRF. Details provided in Twining et al. (2015).	mol/cell

cell_P	total elemental P content of each cell was measured with SXRF. Details provided in Twining et al. (2015).	mol/cell
cell_S	total elemental S content of each cell was measured with SXRF. Details provided in Twining et al. (2015).	mol/cell
cell_Mn	total elemental Mn content of each cell was measured with SXRF. Details provided in Twining et al. (2015).	mol/cell
cell_Fe	total elemental Fe content of each cell was measured with SXRF. Details provided in Twining et al. (2015).	mol/cell
cell_Co	total elemental Co content of each cell was measured with SXRF. Details provided in Twining et al. (2015).	mol/cell
cell_Ni	total elemental Ni content of each cell was measured with SXRF. Details provided in Twining et al. (2015).	mol/cell
cell_Cu	total elemental Cu content of each cell was measured with SXRF. Details provided in Twining et al. (2015).	mol/cell
cell_Zn	total elemental Zn content of each cell was measured with SXRF. Details provided in Twining et al. (2015).	mol/cell
light_image_filename	light image filename	unitless
chl_image_filename	Chl image filename	unitless
SXRF_map_filename	SXRF map filename	unitless
SXRF_spectrum_filename	SXRF spectrum filename	unitless
BTL_ISO_DateTime_UTC	Date and time (UTC) variable recorded at the bottle sampling time in ISO compliant format. Values were added from the intermediate US GEOTRACES master file (see Processing Description). This standard is based on ISO 8601:2004(E) and takes on the following form: 2009-08-30T14:05:00[.xx]Z (UTC time)	yyyy-MM-dd'THH:mm:ss.SS'Z'
sta_PI	station number given by PI	unitless

Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	GeoFish Towed near-Surface Sampler
Generic Instrument Description	The GeoFish towed sampler is a custom designed near surface (

Dataset-specific Instrument Name	
Generic Instrument Name	GO-FLO Bottle
Generic Instrument Description	GO-FLO bottle cast used to collect water samples for pigment, nutrient, plankton, etc. The GO-FLO sampling bottle is specially designed 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	
Generic Instrument Name	Microscope - Optical
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

Dataset-specific Instrument Name	
Generic Instrument Name	X-ray fluorescence analyzer
Dataset-specific Description	SXRF analysis was performed on the 2-ID-E beamline at the Advanced Photon source (Argonne National Laboratory). The synchrotron consists of a storage ring which produces high energy electromagnetic radiation. X-rays diverted to the 2-ID-E beamline are used for x-ray fluorescence mapping of biological samples. X-rays were tuned to an energy of 10 keV to enable the excitation of K-alpha fluorescence for the elements reported. The beam is focused using Fresnel zoneplates to achieve high spatial resolution; for our application a focused spot size of 0.5um was used. A single element germanium energy dispersive detector is used to record the X-ray fluorescence spectrum.
Generic Instrument Description	Instruments that identify and quantify the elemental constituents of a sample from the spectrum of electromagnetic radiation emitted by the atoms in the sample when excited by X-ray radiation.

[[table of contents](#) | [back to top](#)]

Deployments

KN199-04

Website	https://www.bco-dmo.org/deployment/58066
Platform	R/V Knorr
Report	http://bcodata.whoi.edu/US_GEOTRACES/AtlanticSection/Cruise_Report_for_Knorr_199_Final_v3.pdf
Start Date	2010-10-15
End Date	2010-11-04
Description	<p>This cruise constitutes the first survey section as part of the U.S. participation in an international program named GEOTRACES. Funding: NSF OCE award 0926423 Science Objectives: To obtain state of the art trace metal and isotope measurements on a suite of samples taken on a mid-latitude zonal transect of the North Atlantic. In particular, sampling targeted the oxygen minimum zone extending off the west African coast near Mauritania, the TAG hydrothermal field, and the western boundary current system along Line W. For additional information, please refer to the GEOTRACES program Web site (https://www.geotraces.org/) for overall program objectives and a summary of properties measured. Science Activities include seawater sampling via GoFLO and Niskin carousels, in situ pumping (and filtration), CTDO2 and transmissometer sensors, underway pumped sampling of surface waters, and collection of aerosols and rain. Hydrography, CTD and nutrient measurements were supported by the Ocean Data Facility (J. Swift) at Scripps Institution of Oceanography and funded through NSF Facilities. They provided an additional CTD rosette system along with nephelometer and LADCP. A trace metal clean Go-Flo Rosette and winch were provided by the group at Old Dominion University (G. Cutter) along with a towed underway pumping system. Additional cruise information is available from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/KN199-04 Other Relevant Links: List of cruise participants: [PDF] Cruise track: JPEG image (from Woods Hole Oceanographic Institution, vessel operator) ADCP data are available from the Currents ADCP group at the University of Hawaii: KN199-04 ADCP</p>

KN199-05

Website	https://www.bco-dmo.org/deployment/58142
Platform	R/V Knorr
Start Date	2010-11-08
End Date	2010-11-26
Description	<p>KN199-05 is the completion of the US GEOTRACES Zonal North Atlantic Survey Section cruise originally planned for late Fall 2010 from Lisboa, Portugal to Woods Hole, MA, USA. Due to engine failure, the science activities scheduled for the KN199-04 cruise were canceled on 2 November 2010. On 4 November the R/V Knorr put in at Porto Grande, Cape Verde (ending KN199 leg 4) and was scheduled to depart November 8, under the direction of Acting Chief Scientist Oliver Wurl of Old Dominion University. The objective of KN199 leg 5 (KN199-05) was to carry the vessel in transit to Charleston, SC while conducting abbreviated science activities originally planned for KN199-04. Funding: NSF OCE award 0926423 Science Objectives: To obtain state of the art trace metal and isotope measurements on a suite of samples taken on a mid-latitude zonal transect of the North Atlantic. In particular, sampling targeted the oxygen minimum zone extending off the west African coast near Mauritania, the TAG hydrothermal field, and the western boundary current system along Line W. For additional information, please refer to the GEOTRACES program Web site (https://www.geotraces.org/) for overall program objectives and a summary of properties measured. Science Activities include seawater sampling via GoFLO and Niskin carousels, in situ pumping (and filtration), CTDO2 and transmissometer sensors, underway pumped sampling of surface waters, and collection of aerosols and rain. Hydrography, CTD and nutrient measurements were supported by the Ocean Data Facility (J. Swift) at Scripps Institution of Oceanography and funded through NSF Facilities. They provided an additional CTD rosette system along with nephelometer and LADCP. A trace metal clean Go-Flo Rosette and winch were provided by the group at Old Dominion University (G. Cutter) along with a towed underway pumping system. Additional cruise information is available from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/KN199-05 Other Relevant Links: List of cruise participants: [PDF] ADCP data are available from the Currents ADCP group at the University of Hawaii: KN199-05 ADCP</p>

KN204-01

Website	https://www.bco-dmo.org/deployment/58786
Platform	R/V Knorr
Report	http://bcodata.whoi.edu/US_GEOTRACES/AtlanticSection/STS_Prelim_GT11_Doc.pdf
Start Date	2011-11-06
End Date	2011-12-11
Description	<p>The US GEOTRACES North Atlantic cruise aboard the R/V Knorr completed the section between Lisbon and Woods Hole that began in October 2010 but was rescheduled for November-December 2011. The R/V Knorr made a brief stop in Bermuda to exchange samples and personnel before continuing across the basin. Scientists disembarked in Praia, Cape Verde, on 11 December. The cruise was identified as KN204-01A (first part before Bermuda) and KN204-01B (after the Bermuda stop). However, the official deployment name for this cruise is KN204-01 and includes both part A and B. Science activities included: ODF 30 liter rosette CTD casts, ODU Trace metal rosette CTD casts, McLane particulate pump casts, underway sampling with towed fish and sampling from the shipboard "uncontaminated" flow-through system. Full depth stations are shown in the accompanying figure (see below). Additional stations to sample for selected trace metals to a depth of 1000 m are not shown. Standard stations are shown in red (as are the ports) and "super" stations, with extra casts to provide large-volume samples for selected parameters, are shown in green. Station spacing is concentrated along the western margin to evaluate the transport of trace elements and isotopes by western boundary currents. Stations across the gyre will allow scientists to examine trace element supply by Saharan dust, while also contrasting trace element and isotope distributions in the oligotrophic gyre with conditions near biologically productive ocean margins, both in the west, to be sampled now, and within the eastern boundary upwelling system off Mauritania, sampled last year. Funding: The cruise was funded by NSF OCE awards 0926204, 0926433 and 0926659. Additional cruise information is available from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/KN204-01 Other Relevant Links: ADCP data are available from the Currents ADCP group at the University of Hawaii at the links below: KN204-01A (part 1 of 2011 cruise; Woods Hole, MA to Bermuda) KN204-01B (part 2 of 2011 cruise; Bermuda to Cape Verde)</p>

[[table of contents](#) | [back to top](#)]

Project Information

U.S. GEOTRACES North Atlantic Transect (GA03) (U.S. GEOTRACES NAT)

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

Coverage: Subtropical western and eastern North Atlantic Ocean (GA03)

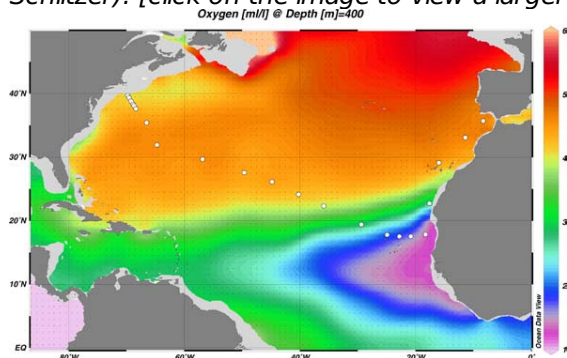
Much of this text appeared in an article published in OCB News, October 2008, by the OCB Project Office.

The first U.S. GEOTRACES Atlantic Section will be specifically centered around a sampling cruise to be carried out in the North Atlantic in 2010. Ed Boyle (MIT) and Bill Jenkins (WHOI) organized a three-day planning workshop that was held September 22-24, 2008 at the Woods Hole Oceanographic Institution. The main goal of the workshop, sponsored by the National Science Foundation and the U.S. GEOTRACES Scientific Steering Committee, was to design the implementation plan for the first U.S. GEOTRACES Atlantic Section. The primary cruise design motivation was to improve knowledge of the sources, sinks and internal cycling of Trace Elements and their Isotopes (TEIs) by studying their distributions along a section in the North Atlantic (Figure 1). The North Atlantic has the full suite of processes that affect TEIs, including strong meridional advection, boundary scavenging and source effects, aeolian deposition, and the salty Mediterranean Outflow. The North Atlantic is particularly important as it lies at the "origin" of the global Meridional Overturning Circulation.

It is well understood that many trace metals play important roles in biogeochemical processes and the carbon cycle, yet very little is known about their large-scale distributions and the regional scale processes that affect

them. Recent advances in sampling and analytical techniques, along with advances in our understanding of their roles in enzymatic and catalytic processes in the open ocean provide a natural opportunity to make substantial advances in our understanding of these important elements. Moreover, we are motivated by the prospect of global change and the need to understand the present and future workings of the ocean's biogeochemistry. The GEOTRACES strategy is to measure a broad suite of TEIs to constrain the critical biogeochemical processes that influence their distributions. In addition to these "exotic" substances, more traditional properties, including macronutrients (at micromolar and nanomolar levels), CTD, bio-optical parameters, and carbon system characteristics will be measured. The cruise starts at Line W, a repeat hydrographic section southeast of Cape Cod, extends to Bermuda and subsequently through the North Atlantic oligotrophic subtropical gyre, then transects into the African coast in the northern limb of the coastal upwelling region. From there, the cruise goes northward into the Mediterranean outflow. The station locations shown on the map are for the "fulldepth TEI" stations, and constitute approximately half of the stations to be ultimately occupied.

Figure 1. The proposed 2010 Atlantic GEOTRACES cruise track plotted on dissolved oxygen at 400 m depth. Data from the World Ocean Atlas (Levitus et al., 2005) were plotted using Ocean Data View (courtesy Reiner Schlitzer). [click on the image to view a larger version]

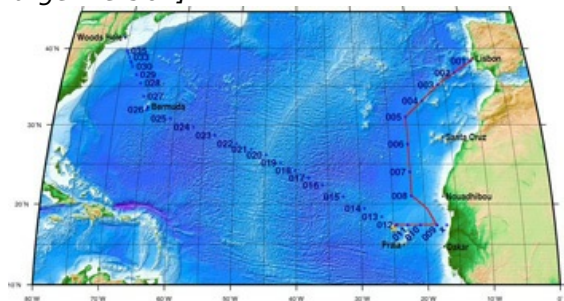


Hydrography, CTD and nutrient measurements will be supported by the Ocean Data Facility (J. Swift) at Scripps Institution of Oceanography and funded through NSF Facilities. They will be providing an additional CTD rosette system along with nephelometer and LADCP. A trace metal clean Go-Flo Rosette and winch will be provided by the group at Old Dominion University (G. Cutter) along with a towed underway pumping system.

The North Atlantic Transect cruise began in 2010 with KN199 leg 4 (station sampling) and leg 5 (underway sampling only) (Figure 2).

[KN199-04 Cruise Report \(PDF\)](#)

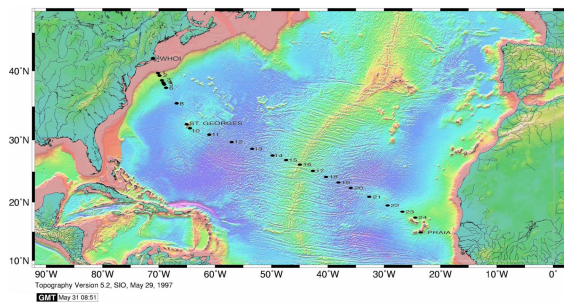
Figure 2. The red line shows the cruise track for the first leg of the US Geotraces North Atlantic Transect on the R/V Knorr in October 2010. The rest of the stations (beginning with 13) will be completed in October-December 2011 on the R/V Knorr (courtesy of Bill Jenkins, Chief Scientist, GNAT first leg). [click on the image to view a larger version]



The section completion effort resumed again in November 2011 with KN204-01A,B (Figure 3).

[KN204-01A,B Cruise Report \(PDF\)](#)

Figure 3. Station locations occupied on the US Geotraces North Atlantic Transect on the R/V Knorr in November 2011. [click on the image to view a larger version]



Data from the North Atlantic Transect cruises are available under the Datasets heading below, and consensus values for the SAFe and North Atlantic GEOTRACES Reference Seawater Samples are available from the GEOTRACES Program Office: [Standards and Reference Materials](#)

ADCP data are available from the Currents ADCP group at the University of Hawaii at the links below:

[KN199-04](#) (leg 1 of 2010 cruise; Lisbon to Cape Verde)
[KN199-05](#) (leg 2 of 2010 cruise; Cape Verde to Charleston, NC)
[KN204-01A](#) (part 1 of 2011 cruise; Woods Hole, MA to Bermuda)
[KN204-01B](#) (part 2 of 2011 cruise; Bermuda to Cape Verde)

[[table of contents](#) | [back to top](#)]

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.

[[table of contents](#) | [back to top](#)]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0928289

[[table of contents](#) | [back to top](#)]