

Dissolved Fe, Zn and Cd concentrations and isotope ratios from R/V Knorr KN199-04, KN204-01 in the subtropical North Atlantic Ocean from 2010-2011 (U.S. GEOTRACES NAT project)

Website: <https://www.bco-dmo.org/dataset/3840>

Data Type: Cruise Results

Version: 5

Version Date: 2016-11-30

Project

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

Program

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

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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:39.6933 E:-9.6602 S:17.3512 W:-69.808

Temporal Extent: 2010-10-16 - 2010-11-02

Dataset Description

Dissolved (0.2 micron filtered) Iron, Zinc and Cadmium concentrations and isotope ratios.

Concentration data is freely available. Isotope data (columns L-Q in dataset) was restricted until July 2014. Fe isotope data was made public 2016-11-28.

DMO NOTE:

- 2017-07-07: Changed units of error columns to match those of the concentrations.
- 2017-07-07: Changed units of Cd to pmol/kg.
- version 5: 2016-11-28. All columns were made publicly accessible.
- version 4: 2015-01-16. Fe and Fe_err changed for sample 6128.
- version 3: Revised data served on 5/21/2014. Zn_err_2s changed for samples 7765 and 7767; sample 6862 flag was changed from 2 to 1.
- version 2: 1 January 2014
- version 1: 7 January 2013

Methods & Sampling

Sampling and Analytical Methodology:

Samples were provided from the GEOTRACES trace-metal clean sampling rosette and were sampled into acid-cleaned 1L LDPE bottles by the onboard GEOTRACES clean sampling team. Upon receipt of samples on shore, they were acidified to pH 2 using clean hydrochloric acid and left at this pH for at least 3 months before processing. Every sample was simultaneously extracted and purified for the analysis of $\delta^{56}\text{Fe}$, $\delta^{66}\text{Zn}$, $\delta^{114}\text{Cd}$, $[\text{Fe}]$, $[\text{Zn}]$, and $[\text{Cd}]$ using published methods (Conway et al., 2013). Briefly, Fe, Zn, and Cd double-spikes were added to the acidified samples and allowed to equilibrate for > 1 hour. Metals were then extracted from seawater onto an ethylenediaminetriacetic acid resin (Nobias PA-1; Hitachi) for 2 hours at pH 2 and 2 hours at pH between 6-6.3. Metals were eluted off this resin using 3 N HNO_3 , and were then purified by anion exchange chromatography before being reconstituted in 0.1 N HNO_3 for analysis.

Concentrations and stable isotope ratios were determined simultaneously by analysis on a Neptune multi-collector ICP-MS. Fe and Zn were analyzed in high resolution mode, while Cd was analyzed in low resolution mode. Every sample was analyzed twice, and the mean isotope ratios are presented here, expressed relative to international isotope standards. Instrumental and procedural isotopic fractionation was corrected for using a double-spike data reduction scheme.

Concentrations were calculated using isotope-dilution to calculate ng of metal per sample, and then converted to nmol kg⁻¹ or pmol kg⁻¹ using the weight of each sample processed. Concentration numbers represent the mean of two ICP-MS analyses of each sample. The largest sources of error for concentration analyses are determining the weight of the sample and determining the volume of double-spike added to each sample. We approximate 2% error for each sample based on the combination of these two factors. Accuracy was checked by analysis of S, D1 and D2 SAFe reference standards (for which we determined values identical to the consensus values; see Conway et al, 2013) and inter-comparison with two other groups measuring trace metal concentrations on US GEOTRACES NAZT samples.

Analytical accuracy of stable isotope ratios is equal to the analytical precision (i.e. the analysis is free from systematic errors; John, 2012) and is calculated separately for each sample. Uncertainty for isotope ratios is expressed as the 2 sigma uncertainty on the average isotope ratio, calculated from a combination of the internal standard error of each of two measurements and the bracketing isotope standards used, as described in Conway et al., (2013).

Data Processing Description

Data Processing:

Data are flagged as 1 (good) or 2 (questionable). Data points flagged as questionable are considered to be potential outliers. This may be because the difference between replicate analyses is much larger than the presumed analytical error, (the separation between two replicates was > 4x the 2s error) or because the data appear oceanographically inconsistent (e.g. values which are very different from samples taken above and below), even though there is no obvious analytical reason to dismiss them.

References

Conway, T. M., and John, S. G. (2014). The biogeochemical cycling of zinc and zinc isotopes in the North Atlantic Ocean. *Global Biogeochemical Cycles*. 28 (10). 1111-1128. doi:10.1002/2014GB004862.

Conway, T. M., and John, S. G. (2014). Quantification of dissolved iron sources to the North Atlantic Ocean. *Nature*. 511. 212-215. doi:10.1038/nature13482.

Conway, T. M., and John, S. G. (2015). Biogeochemical cycling of cadmium isotopes along a high-resolution section through the North Atlantic Ocean. *Geochimica et Cosmochimica Acta*. 148 (1). 269-283. doi: 10.1016/j.gca.2014.09.032.

Conway, T.M., Rosenberg, A.D., Adkins, J.F., and S.G. John. (2013). A new method for precise determination of iron, zinc and cadmium stable isotope ratios in seawater by double-spike mass spectrometry. *Analytica Chimica Acta*, 793: 44-52.

John, S. (2012). Optimizing sample and spike concentrations for isotopic analysis by double-spike ICP-MS. *Journal of Analytical Atomic Spectrometry*, 27: 2123-2131.

Additional GEOTRACES Processing:

After the data were submitted to the International Data Management Office, BODC, the office noticed that important identifying information was missing in many datasets. 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 each submitted dataset lacking this information. 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
Fe-Zn-Cd_diss_GT10-11.csv (Comma Separated Values (.csv), 87.40 KB) MD5:2868fc4c85a026b1bba1ce2055ab2481
Primary data file for dataset ID 3840

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

Parameters

Parameter	Description	Units
cruise_id	Official cruise identifier e.g. KN199-04 = R/V Knorr cruise number 199-04.	dimensionless
cruise_name	synonym used by the project to describe the cruise.	alphanumeric
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. PI-supplied values were identical to those in the intermediate US GEOTRACES master file. Originally submitted as 'station', this parameter name has been changed to conform to BCO-DMO's GEOTRACES naming conventions.	dimensionless
bottle	Niskin bottle of 24-bottle sequence; provided in original data submission.	dimensionless

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 'sample', this parameter name has been changed to conform to BCO-DMO's GEOTRACES naming conventions.	unitless
depth	water depth at which bottle tripped; provided in original data submission.	meters
Cd	Cadmium concentration < 0.2 um	picomoles per kilogram (pmol/kg)
Cd_err	Cadmium error; 2% of concentration	picomoles per kilogram (pmol/kg)
delta_114Cd	mean Cd stable isotope ratio; units of permil (0/00) = $((114\text{Cd}/110\text{Cd})_{\text{sample}} / (114\text{Cd}/110\text{Cd})_{\text{NIST SRM 3108}} - 1) * 1000$	permil (0/00)
Cd_err_2s	2 sigma uncertainty in dissolved Cd	permil (0/00)
Fe	Iron concentration < 0.2 um	nanomole/kilogram
Fe_err	Iron error; 2% of concentration	nanomole/kilogram
delta_56Fe	mean Fe stable isotope ratio; $((56\text{Fe}/54\text{Fe})_{\text{sample}} / (56\text{Fe}/54\text{Fe})_{\text{IRMM-014-1}} - 1) * 1000$	permil (0/00)
Fe_err_2s	2 sigma uncertainty in dissolved Fe	permil (0/00)
Zn	Zinc concentration < 0.2 um	nanomole/kilogram
Zn_err	Zinc error; 2% of concentration	nanomole/kilogram
delta_66Zn	mean Zn stable isotope ratio; $((66\text{Zn}/64\text{Zn})_{\text{sample}} / (66\text{Zn}/64\text{Zn})_{\text{Lyons JMC-1}} - 1) * 1000$	permil (0/00)
Zn_err_2s	2 sigma uncertainty in dissolved Zn	permil (0/00)
flag	Data quality flag; 1 (good) or 2 (questionable)	integer
date	date of cast, UTC	yyyymmdd
lat_sta	nominal station latitude; North is positive	decimal degrees
lon_sta	nominal station longitude; East is positive	decimal degrees
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
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).	dimensionless
cast_GEOTRC	Cast identifier numbered consecutively within a station. Values were added from the intermediate US GEOTRACES master file (see Processing Description).	dimensionless
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).	dimensionless
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).	dimensionless

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-DDTHH:MM:SS[.xx] [+/-TZ]
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[[table of contents](#) | [back to top](#)]

Instruments

Dataset-specific Instrument Name	GeoFish
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	GO-FLO Teflon Trace Metal
Generic Instrument Name	GO-FLO Teflon Trace Metal Bottle
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	Mass Spectrometer
Generic Instrument Name	Mass Spectrometer
Dataset-specific Description	Neptune multi-collector ICP-MS
Generic Instrument Description	General term for instruments used to measure the mass-to-charge ratio of ions; generally used to find the composition of a sample by generating a mass spectrum representing the masses of sample components.

[[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>

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)

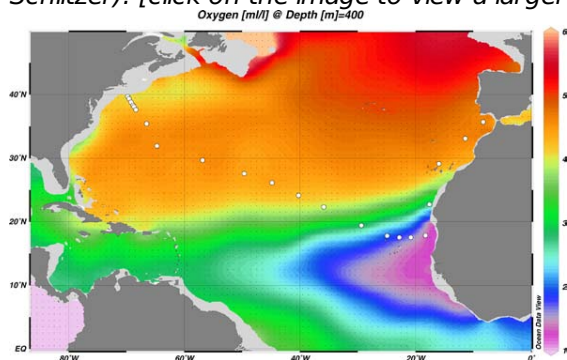
Much of this text appeared in an article published in OCB News, October 2008, by the OCB Project Office.

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]

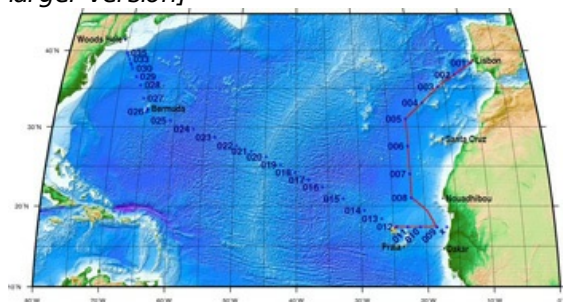


Hydrography, CTD and nutrient measurements will be supported by the Ocean Data Facility (J. Swift) at Scripps Institution of Oceanography and funded through NSF Facilities. They will be providing an additional CTD rosette system along with nephelometer and LADCP. A trace metal clean Go-Flo Rosette and 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 \(PDF\)](#)

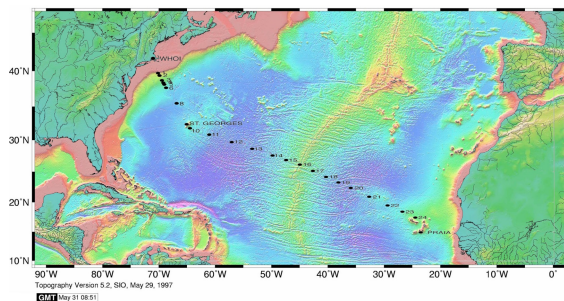
Figure 2. The red line shows the cruise track for the first leg of the US Geotraces North Atlantic Transect on the R/V Knorr in October 2010. The rest of the stations (beginning with 13) will be completed in October-December 2011 on the R/V Knorr (courtesy of Bill Jenkins, Chief Scientist, GNAT first 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-1131387
NSF Division of Ocean Sciences (NSF OCE)	OCE-0929491

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