Water-column total Th-234 from R/V Thomas G. Thompson cruise TN303 in the Eastern Tropical Pacific in 2013 (U.S. GEOTRACES EPZT project)

Website: https://www.bco-dmo.org/dataset/643213
Data Type: Cruise Results
Version: 7
Version Date: 2020-06-11

Project
» U.S. GEOTRACES East Pacific Zonal Transect (GP16) (U.S. GEOTRACES EPZT)
» US GEOTRACES Pacific Zonal Transect: Rates of supply, removal and internal cycling of trace elements and isotopes (EPZT TEI Rates)

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

Contributors	Affiliation	Role
Buesseler, Kenneth O.	Woods Hole Oceanographic Institution (WHOI)	Principal Investigator
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Abstract
Water-column total Th-234 with 4 L method from the 2013 U.S. GEOTRACES EPZT cruise. U-238 from U-salinity relationship was also determined but not reported in this dataset. These data can be made available upon request from the PI and/or dataset contact. Methods are described below.

Table of Contents

Coverage

Spatial Extent: **N**:-10.25 **E**:-77.3761 **S**:-16.0004 **W**:-152.0004
Temporal Extent: 2013-10-29 - 2013-12-18

Dataset Description

Water-column total Th-234 with 4 L method from the 2013 U.S. GEOTRACES EPZT cruise.

U-238 from U-salinity relationship was also determined but not reported in this dataset. These data can be made available upon request from the PI and/or dataset contact. Methods are described below.

Methods & Sampling

Sampling details:
Super stations: approximately 28 discrete total Th-234 samples were collected throughout the water column, a minimum of 12 depths were chosen in the upper 1000 m.
Full stations: approximately 20 discrete total Th-234 samples were collected throughout the water column, a minimum of 12 depths were chosen in the upper 1000 m.
Hemi station: 16 discrete total Th-234 samples were collected from the upper 3000 m.
Demi and Shelf stations: 12 discrete total Th-234 samples were collected, at shelf stations depths spanned the entire water column, at demis the upper 1000 m was sampled.

The shipboard procedures follow Pike et al. (2005).

Thorium-234:
Thorium-234 was determined by the widely-adopted 4 L method. Generally, shallow (< 1000 m) samples were collected from the ODF Rosette and deep samples (>1000 m) were collected from niskin bottles hung above in situ pumps. Data are decay corrected to the mid-point time between when bottles 1 and 12 were fired for shallow casts, when the messenger was dropped for deep casts, and the time of collection for underway samples. All underway samples were collected directly from the ship's underway system in the aft ODF wet lab (denoted as bottle 99, cast 0, depth 3 m). All data have been recovery-corrected using the Th-230/Th-229 recovery method (see references below) to account for any loss of sample material during processing. All samples were analyzed using RISO Laboratory Anti-coincidence Beta Counters, using a helium/1% butane mixture. Overall method efficiency was determined by minimizing the percent difference between mean U-238 and Th-234 values for samples from >1000 m to > 500 m from the bottom (45.72 %). Only stations 6 through 16 and 23 through 36 were used to determine method efficiency so as not to include samples with potential coastal or hydrothermal influences.

Uranium-238:
Value and uncertainty from equation derived in Owens et al. (2011)

U-238 (dpm/L) = (Salinity * 0.0786) – 0.315

Salinity was measured on board the ship by the Scripps Ocean Data Facility (ODF).

For more information on methods and intercalibration procedures, refer to the GEOTRACES Intercalibration Report (PDF) Supplemental File.

Data Processing Description

Detection Limits: Limits of detection are not reported because they are not applicable to the Th-234 beta counting method. A 'non-detect' for Th-234 or a case where there is no Th-234 present (initially or after 6 months of decay) will still result in a measurable amount of background radioactivity due to the beta decay of long-lived natural radionuclides that are also carried by the Mn precipitate used in the shipboard sample processing. These background values are utilized and therefore, they are not reported as non-detections of Th-234.

Uncertainty: At the start and conclusion of each cruise, high activity U-238 standards and background counts (empty detectors) were measured to confirm correct operation of the RISØ detectors and to determine detector to detector variability. The reported uncertainty on each total Th-234 measurement represents the propagated counting uncertainty,

volume (pipettes) and weighing (scales) uncertainties, and detector to detector normalization. Counting uncertainty is generally the largest source of uncertainty so whenever possible samples were counted until errors were below 5%.

Inter-calibration Efforts: Results from the GEOTRACES Th-234 inter-calibration efforts are published in Maiti et al. (2012). Fifteen labs participated in two cruises that centered on particulate, total and dissolved Th-234 inter-calibration. Total Th-234 was assessed on the 2009 GEOTRACES inter-calibration cruise. A short excerpt from Maiti et al. (2012) is included below that summarized the results and recommendations for total Th-234 shipboard analyses:

'*Total 234Th inter-calibration results for deep water samples showed good agreement amongst laboratories. The mean 234Th activity of 2.433 ± 0.035 dpm L-1 for all laboratories was also found to be in very good agreement with the salinity derived expected 234Th activity of 2.442 ± 0.0003 dpm L-1, assuming secular equilibrium. However in comparison, the 234Th activities from SBB [Santa Barbara Basin] surface water had much more variability because of lower initial activity and large ingrowth corrections from 238U. It is thus recommended to keep the time between collection and filtering to a minimum in order to keep in-growth corrections to a minimum. This also reduces the error associated with the uncertainties in both salinity measurements and the 238U-salinity relationship as the error is propagated when ingrowth corrections are made.*'

Because of the short half-life of Th-234 (~24 days), the nature of radionuclide analyses, and the recommendations stated above, inter-calibration between multiple labs was not possible during the 59-day GP16 cruise. Therefore, internal quality control was a priority and addressed in the following ways. First, five replicate deep water samples were analyzed to determine the degree of reproducibility. These samples were collected from the same niskin bottle and processed simultaneously. The results of this analysis are incorporated into the sample measurement uncertainty. Second, the shallow, intermediate, and deep pump casts were made to overlap to provide some means of assessing cast to cast differences and reproducibility. While conditions can change during the duration of a pump cast (~4 hours) as well as from one cast to the next, noticeable differences (larger than expected for natural variability) in overlapping casts were only observed at one station during GP16. This suggested a high degree of reproducibility was achieved for mid-water column total Th-234. Third, all filters measured for total Th-234 were counted twice aboard ship (second count within a few days of the first) and immediately compared to salinity-derived U-238 values. Any abnormal deviations were flagged (>10% between counting results) and the filter was run a third time if necessary. These two counts were averaged for each sample to get a final 'total Th-234' for that depth and location. Lastly, the same internal uranium standards were used by the Buesseler lab during the NAZT and EPZT GEOTRACES cruises and will continue to be used on future cruises. These standards provide a consistent means for calibration and comparison.

Problem reporting:
Data were flagged using the SeaDataNet quality flag scheme. For more information on SeaDataNet flags, see: https://www.geotraces.org/geotraces-quality-flag-policy/ and https://www.seadatanet.org/Standards/Data-Quality-Control

SeaDataNet quality flag definitions:
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;
7 = Value in excess;
8 = Interpolated value;
9 = Missing value;
A = Value phenomenon uncertain.

Two samples were marked as 'bad values' due to issues encountered during sample filtration. Because of the obvious poor quality of these data, the total Thorium-234 values were not included. A few samples were denoted as 'probably good' because of a pipetting issue affecting individual sample recovery calculations. Average recoveries for the surrounding water column depths were used for these samples. Accordingly, uncertainty values were increased for these samples.

BCO-DMO Processing:
- renamed fields:
- added date/time fields in ISO8601 format;
- replaced blanks (missing data) with 'nd' ('no data');
- 11 June 2020: replaced with GEOTRACES DOoR-formatted/IDP version.

[table of contents | back to top]

Data Files

File	
Total_Th234.csv	(Comma Separated Values (.csv), 90.26 KB) MD5:15dea462445c116925143c68a7c73d2b
Primary data file for dataset ID 643213	

[table of contents | back to top]

Supplemental Files

File	
Th-234 Total, SPT, LPT GEOTRACES TN303 Intercalibration Report filename: 0000-0001-7362-8796-TN303-multiple-param-intercal-report.pdf	(Portable Document Format (.pdf), 571.91 KB) MD5:aa975d0e743c703b87de9cd00435c909
GEOTRACES Intercalibration Report for parameters reported by Ken Buesseler (WHOI) from the TN303 (GP16; EPZT) cruise. Parameters reported: Th_234_T_CONC_UWAY::gy2zni, Th_234_T_CONC_BOTTLE::oepuv9, Th_234_SPT_CONC_PUMP::bm10kg, Th_234_LPT_CONC_PUMP::byeecv.	

[table of contents | back to top]

Related Publications

Buesseler, K. O., Pike, S., Maiti, K., Lamborg, C. H., Siegel, D. A., & Trull, T. W. (2009). Thorium-234 as a tracer of spatial, temporal and vertical variability in particle flux in the North Pacific. Deep Sea Research Part I: Oceanographic Research Papers, 56(7), 1143–1167. doi:10.1016/j.dsr.2009.04.001
Methods

Maiti, K., Buesseler, K. O., Pike, S. M., Benitez-Nelson, C., Cai, P., Chen, W., … Xu, C. (2012). Intercalibration studies of short-lived thorium-234 in the water column and marine particles. Limnology and Oceanography: Methods, 10(9), 631–644. doi:10.4319/lom.2012.10.631
Methods

Owens, S. A., Buesseler, K. O., & Sims, K. W. W. (2011). Re-evaluating the 238U-salinity relationship in seawater: Implications for the 238U–234Th disequilibrium method. Marine Chemistry, 127(1-4), 31–39. doi:10.1016/j.marchem.2011.07.005
Results

Pike, S. M., Buesseler, K. O., Andrews, J., & Savoye, N. (2005). Quantification of 234Th recovery in small volume sea water samples by inductively coupled plasma-mass spectrometry. Journal of Radioanalytical and Nuclear Chemistry, 263(2), 355–360. doi:10.1007/s10967-005-0062-9 https://doi.org/10.1007/s10967-005-0594-z
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
Station_ID	Station number	unitless
Start_Date_UTC	Sampling start date (UTC); format: DD/MM/YYYY	unitless
Start_Time_UTC	Sampling start time (UTC); format: hh:mm	unitless
Start_ISO_DateTime_UTC	Sampling start date and time formatted to ISO8601 standard: YYYY-MM-DDThh:mmZ	unitless
End_Date_UTC	Sampling end date (UTC); format: DD/MM/YYYY	unitless
End_Time_UTC	Sampling end time (UTC); format: hh:mm	unitless
End_ISO_DateTime_UTC	Sampling end date and time formatted to ISO8601 standard: YYYY-MM-DDThh:mmZ	unitless
Start_Latitude	Start latitude	decimal degrees North
Start_Longitude	Start longitude	decimal degrees East
End_Latitude	End latitude	decimal degrees North
End_Longitude	End longitude	decimal degrees East
Event_ID	Event number	unitless
Sample_ID	GEOTRACES sample number	unitless
Sample_Depth	Sample depth	meters (m)
Th_234_T_CONC_BOTTLE_oepuv9	Total dissolvable Thorium-234 activity (particulate AND dissolved matter). Samples collected by Niskin bottle.	mBq/kg
SD1_Th_234_T_CONC_BOTTLE_oepuv9	One standard deviation of Th_234_T_CONC_BOTTLE_oepuv9	mBq/kg
Flag_Th_234_T_CONC_BOTTLE_oepuv9	Quality flag for Th_234_T_CONC_BOTTLE_oepuv9	None
Th_234_T_CONC_UWAY_gy2zni	Total dissolvable Thorium-234 activity (particulate AND dissolved matter). Samples collected by the ship's underway system.	mBq/kg
SD1_Th_234_T_CONC_UWAY_gy2zni	One standard deviation of Th_234_T_CONC_UWAY_gy2zni	mBq/kg
Flag_Th_234_T_CONC_UWAY_gy2zni	Quality flag for Th_234_T_CONC_UWAY_gy2zni	None

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Niskin bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Shallow samples for Th-234 were taken using the ODF Rosette (12 30-Liter niskin bottles) and deep samples were taken using niskin bottles hung above in-situ pumps.
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	underway system
Generic Instrument Name	Pump - Surface Underway Ship Intake
Dataset-specific Description	All underway samples were collected directly from the ship's underway system in the aft ODF wet lab
Generic Instrument Description	The 'Pump-underway ship intake' system indicates that samples are from the ship's clean water intake pump. This is essentially a surface water sample from a source of uncontaminated near-surface (commonly 3 to 7 m) seawater that can be pumped continuously to shipboard laboratories on research vessels. There is typically a temperature sensor near the intake (known as the hull temperature) to provide measurements that are as close as possible to the ambient water temperature. The flow from the supply is typically directed through continuously logged sensors such as a thermosalinograph and a fluorometer. Water samples are often collected from the underway supply that may also be referred to as the non-toxic supply. Ideally the data contributor has specified the depth in the ship's hull at which the pump is mounted.

Dataset-specific Instrument Name	RISO Laboratory Anti-coincidence Beta Counters
Generic Instrument Name	Riso Laboratory Anti-coincidence Beta Counters
Dataset-specific Description	Th-234 samples were analyzed using a Riso Anti-coincidence Beta Counter using a helium/1% butane mixture.
Generic Instrument Description	Low-level beta detectors manufactured by Riso (now Nutech) in Denmark. These instruments accept samples that can be mounted on a 25mm filter holder. These detectors have very low backgrounds, 0.17 counts per minute, and can have counting efficiencies as high as 55%.

[table of contents | back to top]

Deployments

TN303

Website	https://www.bco-dmo.org/deployment/499719
Platform	R/V Thomas G. Thompson
Report	http://dmoserv3.whoi.edu/data_docs/GEOTRACES/EPZT/GT13_EPZT_ODFReport_All.pdf
Start Date	2013-10-25
End Date	2013-12-20
Description	A zonal transect in the eastern tropical South Pacific (ETSP) from Peru to Tahiti as the second cruise of the U.S.GEOTRACES Program. This Pacific section includes a large area characterized by high rates of primary production and particle export in the eastern boundary associated with the Peru Upwelling, a large oxygen minimum zone that is a major global sink for fixed nitrogen, and a large hydrothermal plume arising from the East Pacific Rise. This particular section was selected as a result of open planning workshops in 2007 and 2008, with a final recommendation made by the U.S.GEOTRACES Steering Committee in 2009. It is the first part of a two-stage plan that will include a meridional section of the Pacific from Tahiti to Alaska as a subsequent expedition. Figure 1. The 2013 GEOTRACES EPZT Cruise Track. [click on the image to view a larger version] Additional cruise information is available from the Rolling Deck to Repository (R2R): http://www.rvdata.us/catalog/TN303

[table of contents | back to top]

Project Information

U.S. GEOTRACES East Pacific Zonal Transect (GP16) (U.S. GEOTRACES EPZT)

Website: http://www.geotraces.org/

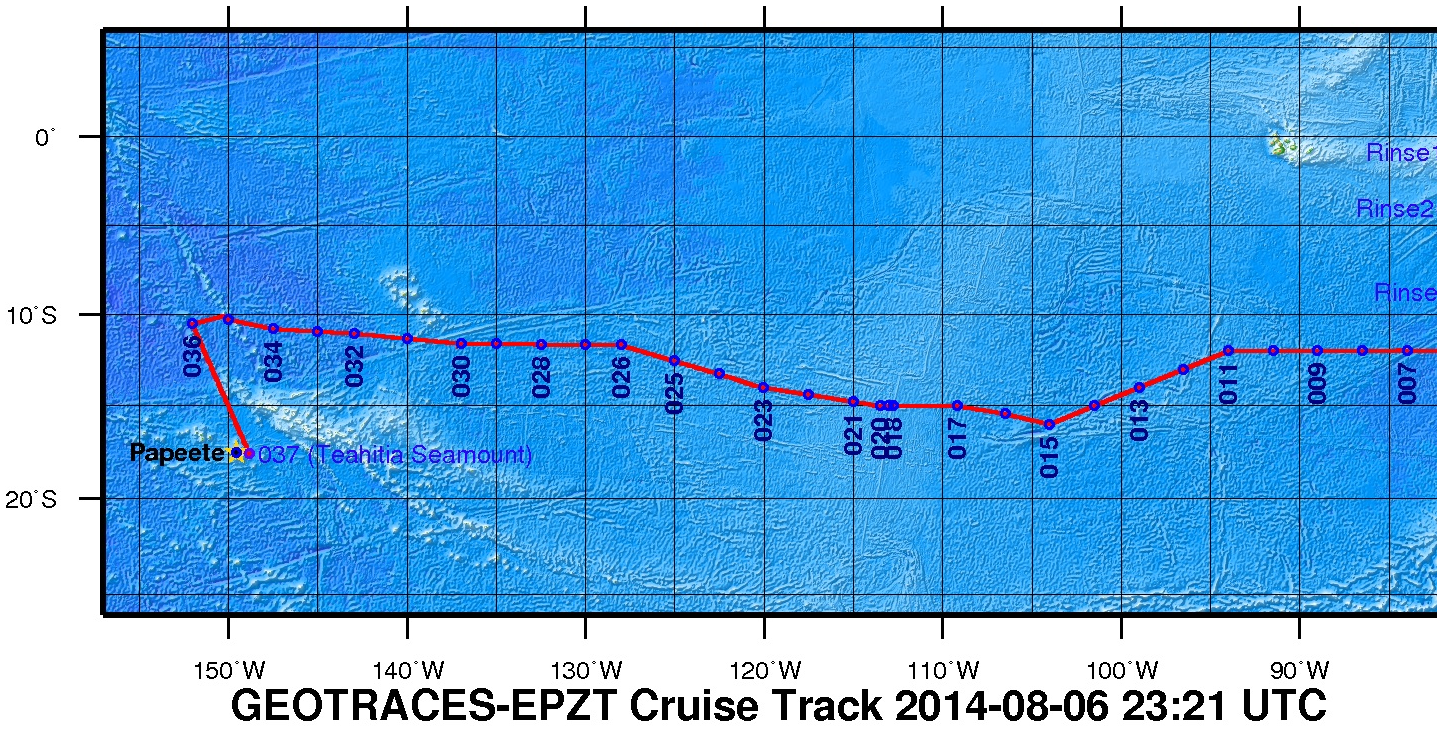
Coverage: Eastern Tropical Pacific - Transect from Peru to Tahiti (GP16)

From the NSF Award Abstract
The mission of the International GEOTRACES Program (https://www.geotraces.org/), of which the U.S. chemical oceanography research community is a founding member, is "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" (GEOTRACES Science Plan, 2006). In the United States, ocean chemists are currently in the process of organizing a zonal transect in the eastern tropical South Pacific (ETSP) from Peru to Tahiti as the second cruise of the U.S.GEOTRACES Program. This Pacific section includes a large area characterized by high rates of primary production and particle export in the eastern boundary associated with the Peru Upwelling, a large oxygen minimum zone that is a major global sink for fixed nitrogen, and a large hydrothermal plume arising from the East Pacific Rise. This particular section was selected as a result of open planning workshops in 2007 and 2008, with a final recommendation made by the U.S.GEOTRACES Steering Committee in 2009. It is the first part of a two-stage plan that will include a meridional section of the Pacific from Tahiti to Alaska as a subsequent expedition.

This award provides funding for management of the U.S.GEOTRACES Pacific campaign to a team of scientists from the University of Southern California, Old Dominion University, and the Woods Hole Oceanographic Institution. The three co-leaders will provide mission leadership, essential support services, and management structure for acquiring the trace elements and isotopes samples listed as core parameters in the International GEOTRACES Science Plan, plus hydrographic and nutrient data needed by participating investigators. With this support from NSF, the management team will (1) plan and coordinate the 52-day Pacific research cruise described above; (2) obtain representative samples for a wide variety of trace metals of interest using conventional CTD/rosette and GEOTRACES Sampling Systems; (3) acquire conventional JGOFS/WOCE-quality hydrographic data (CTD, transmissometer, fluorometer, oxygen sensor, etc) along with discrete samples for salinity, dissolved oxygen (to 1 uM detection limits), plant pigments, redox tracers such as ammonium and nitrite, and dissolved nutrients at micro- and nanomolar levels; (4) ensure that proper QA/QC protocols are followed and reported, as well as fulfilling all GEOTRACES Intercalibration protocols; (5) prepare and deliver all hydrographic-type data to the GEOTRACES Data Center (and US data centers); and (6) coordinate cruise communications between all participating investigators, including preparation of a hydrographic report/publication.

Broader Impacts: The project is part of an international collaborative program that has forged strong partnerships in the intercalibration and implementation phases that are unprecedented in chemical oceanography. The science product of these collective missions will enhance our ability to understand how to interpret the chemical composition of the ocean, and interpret how climate change will affect ocean chemistry. Partnerships include contributions to the infrastructure of developing nations with overlapping interests in the study area, in this case Peru. There is a strong educational component to the program, with many Ph.D. students carrying out thesis research within the program.

Figure 1. The 2013 GEOTRACES EPZT Cruise Track. [click on the image to view a larger version]



GEOTRACES-EPZT Cruise Track 2014-08-06 23:21 UTC

US GEOTRACES Pacific Zonal Transect: Rates of supply, removal and internal cycling of trace elements and isotopes (EPZT TEI Rates)

Coverage: East Pacific

Description from NSF award abstract:
The goal of GEOTRACES is to identify processes and quantify fluxes that control the distribution of trace elements and isotopes (TEIs) in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions. While the distribution of numerous TEIs will be mapped by a large team of GEOTRACES PIs along this transect, their distribution cannot be properly interpreted without concurrent measurement of tracers capable of providing rates of internal TEI cycling processes and fluxes at boundaries and across interfaces. Naturally-occurring radioisotopes of the Uranium-Thorium series are well suited for studying the sources and sinks of TEIs on time and space scales necessary to interpret lateral and vertical TEI distributions.

In this project, a research team from the Woods Hole Oceanographic Institution and the University of South Carolina at Columbia will carry out measurement of a suite of uranium/thorium series radionuclides on the US GEOTRACES cruise to the Eastern Tropical South Pacific (ETSP) Ocean. This radiotracer suite will include shorter-lived 234Th and 228Th as well as the radium quartet (224Ra, 223Ra, 228Ra, 226Ra), which together allow the quantification of rates of horizontal and vertical transport and mixing, as well as removal at ocean boundaries, surface export, and subsurface remineralization.

[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-1232669
NSF Division of Ocean Sciences (NSF OCE)	OCE-1231211

[table of contents | back to top]