Cross-polarized photon yield, beam attenuation coefficient, and fluorescence data derived from optical particle sensors deployed during casts of the GTC rosette on the GP17-OCE R/V Roger Revelle (RR2214) cruise Dec 2022 - Jan 2023

Website: https://www.bco-dmo.org/dataset/956233
Data Type: Cruise Results
Version: 1
Version Date: 2025-03-17

Project
» US GEOTRACES GP17 Section: South Pacific and Southern Ocean (GP17-OCE) (GP17-OCE)
» Autonomous Ocean Carbon Observer Development and Calibration (OCO Development)

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

Contributors	Affiliation	Role
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Abstract
This data set was derived from optical particle sensors deployed during casts of the GEOTRACES Trace Metal Carousel (GTC) as part of the GEOTRACES GP17-OCE Expedition from the south Pacific gyre to Southern Ocean (R/V Roger Revelle RR2214). Data files are provided containing data for the 0-500 meter depth interval and also for the full water column. Data include measures of particle birefringence photon yield (units of parts per million per meter) and particle beam attenuation coefficient (units of per meter). The two PIC sensors (PIC010, and PIC011) used in this study have been extensively documented (Bishop et al. 2022). Briefly, the sensors are built on a digital WETLabs C-star 25-centimeter pathlength 6000-meter rated transmissometer. A 660-nanometer laser replaced the transmissometer's LED light source. High crossing efficiency polarizers were externally mounted to both source and receiver windows; the source polarizer is aligned with the plane of polarization of the laser and the receiver polarizer is crossed to minimize transmission of the direct beam. As light from the primary beam encounters birefringent particles, its plane of polarization is rotated and the sensor receives a signal. Details of methodology are included in Bishop et al., 2022 (doi: 10.3389/frsen.2022.837938).

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Coverage

Spatial Extent: **N**:-19.9998 **E**:-75.0972 **S**:-66.9998 **W**:-152.0002
Temporal Extent: 2022-12-04 - 2023-01-24

Methods & Sampling

Methods and Sampling information are described by Bishop, et al. (2022) as well as in supplemental information accompanying this dataset.

Data Processing Description

Data Processing notes:

Transmissometer data reduction CST1035
CST1035 exhibits significant thermal hysteresis during profiling.
Adjustments of profiles are set to match the transmissometer (CST1874) data from the ODF CTD.
The main value of the derived beam attenuation coefficient "cp1035" is in the upper 500m.
Transmittance values are used to correct the Birefringence data from sensor PIC010.
#
these terms are described in Li et al. (2025) and in the parameter descriptions accompanying this data set.
#
cst1035c=(cst1035-CST1035Z)/cst1035r
cst1035cc=cst1035c+cst1035t*CST1035t_MULT-cum1035dr*CST1035DR_MULT
tr1035=cst1035cc/CST1035NetVref
cp1035=-4*ln(tr1035)+press*press_cft
cp1035_sd=-4*ln((CST1035NetVref-cst1035_sd)/CST1035NetVref)
cp1035_n=cst1035_n
#
PIC sensor data reduction. PIC010
#
pic010c=(pic010-PIC010Z-PIC010_V_CROSS*tr1035)/pic010r
pic010simp=(pic010-PIC010Z-PIC010X)/pic010r+PIC010_PrCofft*press/1000
pic010cc=pic010c/tr1035^0.5+PIC010_PrCofft*press/1000
pic010Biref=pic010cc*PIC010_Birefringence
pic010noTr_Biref=pic010simp*PIC010_Birefringence
pic010Biref_sd=pic010_sd*PIC010_Birefringence
pic010Biref_n=pic010_n
#
Flourometer data reduction
#
The main adjustment to data was to subtract readings found in deepwater
The results are NOT absolutely calibrated in Chlorophyll units but are close
#
Chl_flsp=flsp-flsp_z
Chl_flsp_sd=flsp_sd
Chl_flsp_n=flsp_n

==========

Problem Description

Notes on profile data sets.
"ByCast" profile data do not include up or down cast results if pic010_Birefingence data are not calculated.
See Flag descriptions in the file GP17_GTC_CTD_Cast_MetaData_Parameters_Submit.csv and
Cast specific data in the file GP17_GTC_CTD_Cast_MetaData_Values_Submit.csv
#
we excluded obviously bad data from the 10 second averaged and filtered data sets
For PIC010 data
Stations 27 (cast 6) and 29 (cast 7) uptrace [updn=1] data had significant contamination of the pic sensor

signal
at rosette sampling depths.
Stations 32 (cast 3) and 35 (cast 8) exibited similar behavior.
These data are summarized in file: GP17_GTC_CTD_PICbad.csv

#

For CST1035 data

At GP17 Station 18 (cast 3), the upcast profile data was contaminated by the likely interception of foreign material which resulted in

high and very scattered data from 2500 m to ~900 m. These data are summarized in file GP17_GTC_CTD__cpbad.csv

#

============ end of notes ==========

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Supplemental Files

File	
01_GP17_GTC_CTD_Cast_MetaData_Parameters_Submit.csv	(Comma Separated Values (.csv), 3.10 KB) MD5:fcd4d6bb6e7f655e29303767e0677ba5
Metadata file for dataset ID 956233, version 1. This file contains the parameter (column) definitions for file "02_GP17_GTC_CTD_Cast_MetaData_Values_Submit.csv". Includes dates, times, latitude, longitude, etc. and cast specific parameters used in the Optical Sensor data reduction. Also included are hydrographic parameters such as Mixed Layer Depth and depths of the fluorescence maximum and euphotic zone.	
02_GP17_GTC_CTD_Cast_MetaData_Values_Submit.csv	(Comma Separated Values (.csv), 15.11 KB) MD5:64e21565d9bdd01b55a3040c75337fb2
Data file for dataset ID 956233, version 1. This file contains the CTD data used in Optical Sensor data reduction. Also included are hydrographic parameters such as Mixed Layer Depth and depths of the fluorescence maximum and euphotic zone.	
03_GP17_GTC_CTD_Profile_Average_Parameters_Submit.csv	(Comma Separated Values (.csv), 2.22 KB) MD5:bd534605106146e3226afec9a06aebc6
Metadata file for dataset ID 956233, version 1. This file contains the parameter (column) definitions for files "04_GP17_GTC_CTD_Profile_Average_0500m_data_Submit.csv" and "05_GP17_GTC_CTD_Profile_Average_6000m_data_Submit.csv".	
04_GP17_GTC_CTD_Profile_Average_0500m_data_Submit.csv	(Comma Separated Values (.csv), 416.58 KB) MD5:f4f715e6a159d64035d808b7b32036b2
Data file for dataset ID 956233, version 1. This file contains the profile data for hydrographic and optical data (mean and standard deviation) over all CTD casts at each GP17-OCE station. Data are averaged over 5-meter (m) intervals and profiles extend from ~5 m to 500 m. Stations 1 through 38	
05_GP17_GTC_CTD_Profile_Average_6000m_data_Submit.csv	(Comma Separated Values (.csv), 2.30 MB) MD5:a68a7b19194019412223163efe516cec
Data file for dataset ID 956233, version 1. This file contains the profile data for hydrographic and optical data (mean and standard deviation) over all CTD casts at each GP17-OCE station. Data are averaged over 10-meter (m) intervals and profiles extend from ~5 m to 6000 m.	
06_GP17_GTC_CTD_Profile_ByCast_Parameters_Submit.csv	(Comma Separated Values (.csv), 2.72 KB) MD5:3efa3a678a06178972fc16e35abe2ff9
Metadata file for dataset ID 956233, version 1. This file contains the parameter definitions for files "07_GP17_GTC_CTD_Profile_ByCast_0500m_data_Submit.csv" and "08_GP17_GTC_CTD_Profile_ByCast_6000m_data_Submit.csv".	

File	
07_GP17_GTC_CTD_Profile_ByCast_0500m_data_Submit.csv	(Comma Separated Values (.csv), 1.73 MB) MD5:204459a5309c19ad6ef1d9c558550cea
Data file for dataset ID 956233, version 1. This file contains the profile data for hydrographic and optical data (mean and standard deviation) for specific CTD casts (up and down profiles are distinct) at each GP17-OCE station. Data are averaged over 5-meter (m) intervals and profiles extend from ~5 m to 500 m. Stations 1 through 38. Also included in the "ByCast" data files are the standard deviations and number of points averaged initially over 10 second intervals from 24 Hz CTD data.	
08_GP17_GTC_CTD_Profile_ByCast_6000m_data_Submit.csv	(Comma Separated Values (.csv), 7.13 MB) MD5:69fc9680395c07bef21e04417cd93ba7
Data file for dataset ID 956233, version 1. This file contains the profile data for hydrographic and optical data (mean and standard deviation) for specific CTD casts (up and down profiles are distinct) at each GP17-OCE station. Data are averaged over 10-meter (m) intervals and profiles extend from ~5 m to 6000 m. Stations 1 through 38. Also included in the "ByCast" data files are the standard deviations and number of points averaged initially over 10 second intervals from 24 Hz CTD data.	
09_GP17_GTC_CTD__cpbad.csv	(Comma Separated Values (.csv), 9.22 KB) MD5:dcdf0c28adbd55c901bda2ff951eab47
Data file for dataset ID 956233, version 1. This file contains a summary of the beam attenuation coefficient data substituted with '-9999' values in the original 10 second averaged and filtered data prior to depth binning and averaging to produce the above profile data products. Station 18, cast 3, up-trace data accounted for most of the data substitutions.	
GP17_GTC_CTD_PICbad.csv filename: 10_GP17_GTC_CTD_PICbad.csv	(Comma Separated Values (.csv), 73.75 KB) MD5:32d1270f3b86072eeb2a98a7448d5240
Data file for dataset ID 956233, version 1. This file contains a summary of particle cross polarized photon yield data substituted with '-9999' values in the original 10 second averaged and filtered data prior to depth binning and averaging to produce the above profile data products. Stations 27 (cast 6) and 29 (cast 7) uptrace [updn=1] data had significant contamination of the pic sensor signal at rosette sampling depths. Stations 32 (cast 3) and 35 (cast 8) exhibited similar behavior.	

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Related Publications

Bishop, J. K. B., Amaral, V. J., Lam, P. J., Wood, T. J., Lee, J.-M., Laubach, A., Barnard, A., Derr, A., & Orrico, C. (2022). Transmitted Cross-Polarized Light Detection of Particulate Inorganic Carbon Concentrations and Fluxes in the Ocean Water Column: Ships to ARGO Floats. Frontiers in Remote Sensing, 3. https://doi.org/10.3389/frsen.2022.837938
Methods

Li, Y., Bishop, J. K. B., Lam, P. J., & Ohnemus, D. (2025). Analysis of Satellite and in-situ Optical Proxies for PIC and POC during GEOTRACES GP15 and GP17-OCE Transects from the Subarctic North Pacific to the Southern Ocean. https://doi.org/10.22541/essoar.172988067.75831081/v2
Results

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	Birefringence Sensor PIC010 (built on a SeaBird CSTAR platform)
Generic Instrument Name	PIC Sensor
Generic Instrument Description	Description from Bishop et al. (2022) (doi: 10.3389/frsen.2022.837938) PIC Sensor Concept: The sensor concept has been described by Guay and Bishop (2002) (doi: 10.1016/s0967-0637(01)00049-8) and Bishop (2009) (doi: 10.5670/oceanog.2009.48). The first profiling sensor was a modified version of an analog WETLabs C-Star 25 cm pathlength transmissometer. A 660-nm laser replaced the LED source, and a cell with high crossing efficiency polarizers (630–700 nm, Polarcor, Corning) was inserted into the water path length of the instrument. At the source end, the polarizer is aligned with the plane of polarization of the laser; on the receiver end, the polarizer is crossed, thus minimizing the detection of the primary beam. The sensor thus detects the photon yield resulting from the interaction of polarized laser light with birefringent particles in the beam. The first full water column profiles of the first sensor (PIC001) took place in 2003 in the North Atlantic (Bishop, 2009). This sensor was stabilized in 2006 by replacing the cell with body-mounted polarizers. Over many iterations of the basic design and multiple sea trials, it was demonstrated in 2013 that multiple PIC sensors yielded identical results and exceeded the performance of PIC001.

Dataset-specific Instrument Name	SeaBird (formerly WETLabs) Transmissometer 1035
Generic Instrument Name	Transmissometer
Dataset-specific Description	The transmissometer used was a SeaBird transmissometer operating at 650 nM. They used to be made by WETLabs Inc., Philomath, OR. The complete ID is CST1035DR (meaning it was 6000 m rated and operating at a red wavelength of 650 nm). See: https://www.seabird.com/c-star-transmissometer/product?id=60762467717
Generic Instrument Description	A transmissometer measures the beam attenuation coefficient of the lightsource over the instrument's path-length. This instrument designation is used when specific manufacturer, make and model are not known.

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Deployments

RR2214

Website	https://www.bco-dmo.org/deployment/905754
Platform	R/V Roger Revelle
Report	https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/rogerrevelle_rr2214.pdf
Start Date	2022-12-01
End Date	2023-01-25
Description	The U.S. GEOTRACES GP17-OCE expedition departed Papeete, Tahiti (French Polynesia) on December 1st, 2022 and arrived in Punta Arenas, Chile on January 25th, 2023. The cruise took place in the South Pacific and Southern Oceans aboard the R/V Roger Revelle with a team of 34 scientists led by Ben Twining (Chief Scientist), Jessica Fitzsimmons, and Greg Cutter (Co-Chief Scientists). GP17 was planned as a two-leg expedition, with its first leg (GP17-OCE) as a southward extension of the 2018 GP15 Alaska-Tahiti expedition and a second leg (GP17-ANT; December 2023-January 2024) into coastal and shelf waters of Antarctica's Amundsen Sea. The GP17-OCE section encompassed three major transects: (1) a southbound pseudo-meridional section (~152-135 degrees West) from 20 degrees South to 67 degrees South; (2) an eastbound zonal transect from 135 degrees West to 100 degrees West; (3) and a northbound section returning to Chile (100-75 degrees West). Additional cruise information is available from the following sources: R2R: https://www.rvdata.us/search/cruise/RR2214 CCHDO: https://cchdo.ucsd.edu/cruise/33RR20221201 More information can also be found at: https://usgeotraces.ldeo.columbia.edu/content/gp17-oce

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Project Information

US GEOTRACES GP17 Section: South Pacific and Southern Ocean (GP17-OCE) (GP17-OCE)

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

Coverage: Papeete, Tahiti to Punta Arenas, Chile

The U.S. GEOTRACES GP17-OCE expedition departed Papeete, Tahiti (French Polynesia) on December 1st, 2022 and arrived in Punta Arenas, Chile on January 25th, 2023. The cruise took place in the South Pacific and Southern Oceans aboard the R/V Roger Revelle (cruise ID RR2214) with a team of 34 scientists lead by Ben Twining (Chief Scientist), Jessica Fitzsimmons and Greg Cutter (Co-Chief Scientists). GP17 was planned as a two-leg expedition, with its first leg (GP17-OCE) as a southward extension of the 2018 GP15 Alaska-Tahiti expedition and a second leg (GP17-ANT; December 2023-January 2024) into coastal and shelf waters of Antarctica's Amundsen Sea.

The South Pacific and Southern Oceans sampled by GP17-OCE play critical roles in global water mass circulation and associated global transfer of heat, carbon, and nutrients. Specific oceanographic regions of interest for GP17-OCE included: the most oligotrophic gyre in the global ocean, the Antarctic Circumpolar Current (ACC) frontal region, the previously unexplored Pacific- Antarctic Ridge, the Pacific Deep Water (PDW) flow along the continental slope of South America, and the continental margin inputs potentially emanating from South America.

Further information is available on the US GEOTRACES website and in the cruise report (PDF).

NSF Project Title: Collaborative Research: Management and Implementation of US GEOTRACES GP17 Section: South Pacific and Southern Ocean (GP17-OCE)

NSF Award Abstract:
This award will support the management and implementation of a research expedition from Tahiti to Chile that will enable sampling for a broad suite of trace elements and isotopes (TEI) across oceanographic regions of importance to global nutrient and carbon cycling as part of the U.S. GEOTRACES program. GEOTRACES is a global effort in the field of Chemical Oceanography, the goal of which is to understand the distributions of trace elements and their isotopes in the ocean. Determining the distributions of these elements and isotopes will

increase understanding of processes that shape their distributions, such as ocean currents and material fluxes, and also the processes that depend on these elements, such as the growth of phytoplankton and the support of ocean ecosystems. The proposed cruise will cross the South Pacific Gyre, the Antarctic Circumpolar Current, iron-limited Antarctic waters, and the Chilean margin. In combination with a proposed companion GEOTRACES expedition on a research icebreaker (GP17-ANT) that will be joined by two overlapping stations, the team of investigators will create an ocean section from the ocean's most nutrient-poor waters to its highly-productive Antarctic polar region - a region that plays an outsized role in modulating the global carbon cycle. The expedition will support and provide management infrastructure for additional participating science projects focused on measuring specific external fluxes and internal cycling of TEIs along this section.

The South Pacific Gyre and Pacific sector of the Southern Ocean play critical roles in global water mass circulation and associated global transfer of heat, carbon, and nutrients, but they are chronically understudied for TEIs due to their remote locale. These are regions of strong, dynamic fronts where sub-surface water masses upwell and subduct, and biological and chemical processes in these zones determine nutrient stoichiometries and tracer concentrations in waters exported to lower latitudes. The Pacific sector represents an end member of extremely low external TEI surface fluxes and thus an important region to constrain inputs from the rapidly-changing Antarctic continent. Compared to other ocean basins, TEI cycling in these regions is thought to be dominated by internal cycling processes such as biological uptake, regeneration, and scavenging, and these are poorly represented in global ocean models. The cruise will enable funded investigators to address research questions such as: 1) what are relative rates of external TEI fluxes to this region, including dust, sediment, hydrothermal, and cryospheric fluxes? 2) What are the (micro) nutrient regimes that support productivity, and what impacts do biomass accumulation, export, and regeneration have on TEI cycling and stoichiometries of exported material? 3) What are TEI and nutrient stoichiometries of subducting water masses, and how do scavenging and regeneration impact these during transport northward? This management project has several objectives: 1) plan and coordinate a 55-day research cruise in 2021-2022; 2) use both conventional and trace-metal 'clean' sampling systems to obtain TEI samples, as well as facilitate sampling for atmospheric aerosols and large volume particles and radionuclides; 3) acquire hydrographic data and samples for salinity, dissolved oxygen, algal pigments, and macro-nutrients; and deliver these data to relevant repositories; 4) ensure that proper QA/QC protocols, as well as GEOTRACES intercalibration protocols, are followed and reported; 5) prepare the final cruise report to be posted with data; 6) coordinate between all funded cruise investigators, as well as with leaders of proposed GP17-ANT cruise; and 7) conduct broader impact efforts that will engage the public in oceanographic research using immersive technology. The motivations for and at-sea challenges of this work will be communicated to the general public through creation of immersive 360/Virtual Reality experiences, via a collaboration with the Texas A&M University Visualization LIVE Lab. Through Virtual Reality, users will experience firsthand what life and TEI data collection at sea entail. Virtual reality/digital games and 360° experiences will be distributed through GEOTRACES outreach websites, through PI engagement with local schools, libraries, STEM summer camps, and adult service organizations, and through a collaboration with the National Academy of Sciences.

Autonomous Ocean Carbon Observer Development and Calibration (OCO Development)

Coverage: Pacific Ocean

NSF Award Abstract

The very fast and dynamic ocean biological carbon pump (OBCP) plays a fundamental role in the global carbon cycle and in setting concentrations of atmospheric carbon dioxide. Photosynthetic organisms that that fuel the OCBP live and die on a week to week basis, and the resulting sinking (or export) of organic and inorganic carbon particles from the surface layer and consumption losses of these particles in deeper waters are similarly variable. Simply stated, the OCBP is poorly understood due to dependence on short- term, and seasonally and spatially limited ship observations; thus model estimates of its strength and future trajectory are highly uncertain. To address this gap, the investigators will engineer and sea-test two robotic Lagrangian Ocean Carbon Observer (OCO) floats capable of 8 month to multi-year missions, yet able to resolve flux processes on hourly to daily time scales and relay data in real time via satellite telemetry while operating anywhere in the ocean. The development of the OCO enables the identification of specific pathways and controls on the vertical transfer of particulate organic and inorganic carbon (POC and PIC) from the surface ocean to subsurface waters. The project logically follows on from the investigator’s development and successful deployment of robotic Lagrangian Carbon Explorer (CE) and Carbon Flux Explorer (CFE) floats, which measure optically POC and PIC concentration and flux variability to depths of 1000 m. A unique capability of the CFE is that it is able to measure the sinking flux of carbon carried by different sizes and classes of

particles. The project will merge CFE and CE capabilities to create the OCO. The team will contribute to the development of a STEM workforce by engaging UC Berkeley undergraduates and one graduate student in all phases (development, laboratory, seagoing, and interpretive) of the project and in the class room.

Specifically, CFEs and two new Ocean Carbon Observers (OCOs) that simultaneously measure both particle flux and concentration profiles will be constructed and test-deployed at sea in January 2023. During the times that these autonomous instruments drift at target depths within the upper kilometer (interrupted by transit to the surface for location and real time bidirectional telemetry), they will autonomously quantify the inherent optical properties and size distributions of sinking material captured. Bishop et al. (2016; Biogeosciences 13, 3019-3129, doi:10.5194/bg-13-3109) describe CFE capabilities and methodology for rendering raw OSR imagery to rigorously defined inherent optical measures of particle loading -- attenuance and cross-polarized photon yield. Bourne et al. (2019; Biogeosciences, 16, 1249-1264; doi:10.5194/bg-16-1249-2019) show that attenuance is strongly correlated ($r^2 > 0.86$) with POC and PN sampled at 150 m by sampler-equipped CFEs "(CFE-Cal floats)" over a broad range of particle flux and particle size distributions. Planned further deployment of the CFE-Cal floats to sample sinking material to depths of at least 500 m will enable validation of our calibration of the attenuance proxy and to enable a first calibration of the PIC optical flux proxy. Bourne et al. (2021; Biogeosciences, 18, 3053–3086, doi:10.5194/bg-18-3053-2021) demonstrate the unique capability of CFEs to resolve and quantify the vertical flux carried by different particle size classes in the mesopelagic; furthermore, they describe prototype algorithms that will lead to flux size-distribution analysis in real time on the CFEs. The project will enable fully autonomous long-term deployments of CFE and OCO systems in the global ocean. The involvement a commercial float vendor (MRV Systems) and sensor manufacturer (Seabird Scientific) may lead to a commercialization pathway for the OCO.

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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-1657781
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023315
NSF Division of Ocean Sciences (NSF OCE)	OCE-1736601
NSF Division of Ocean Sciences (NSF OCE)	OCE-2123942

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