

# Lead (Pb) concentrations and Pb isotope ratios ( $^{206}\text{Pb}/^{207}\text{Pb}$ , $^{208}\text{Pb}/^{207}\text{Pb}$ , $^{206}\text{Pb}/^{204}\text{Pb}$ ) from Leg 2 (Hilo, HI to Papeete, French Polynesia) of the US GEOTRACES Pacific Meridional Transect (PMT) cruise (GP15, RR1815) on R/V Roger Revelle from Oct-Nov 2018

**Website:** <https://www.bco-dmo.org/dataset/933383>

**Data Type:** Cruise Results

**Version:** 2

**Version Date:** 2025-05-21

## Project

- » [US GEOTRACES Pacific Meridional Transect \(GP15\)](#) (U.S. GEOTRACES PMT)
- » [Collaborative Research: US GEOTRACES PMT: Pb and Cr isotopes](#) (PMT Pb and Cr)

## Program

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

Contributors	Affiliation	Role
<a href="#">Boyle, Edward A.</a>	Massachusetts Institute of Technology (MIT)	Principal Investigator
<a href="#">Lanning, Nathan</a>	Massachusetts Institute of Technology (MIT)	Scientist
<a href="#">Jiang, Shuo</a>	East China Normal University (ECNU)	Student
<a href="#">Rauch, Shannon</a>	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

## Abstract

During September 23 to November 22, 2018, the R/V Roger Revelle completed a trace element (and their isotopes) hydrographic section along  $\sim 152^\circ$  West from  $56^\circ$  North to  $20^\circ$  South (GEOTRACES GP15). Full water column trace metal clean samples were obtained with the U.S. GEOTRACES Carousel (GTC) composed of 24 12-liter trace metal clean GO-Flow sampling systems mounted on a trace metal free powder-coated titanium rosette system. Three of the stations had lead (Pb) concentrations determined at Massachusetts Institute of Technology (MIT) by isotope dilution quadrupole inductively coupled plasma mass spectrometry (ICPMS) for intercalibration with the Texas A&M (TAMU) lab of Jessica Fitzsimmons who analyzed all of the cruise stations. The rest of the full- and super-stations were analyzed at MIT for Pb isotope ratios ( $^{206}\text{Pb}/^{207}\text{Pb}$ ,  $^{208}\text{Pb}/^{207}\text{Pb}$ ,  $^{206}\text{Pb}/^{204}\text{Pb}$ ). These data are collected to document the penetration of atmospherically-transported anthropogenic Pb into the ocean and its subsequent dispersion by circulation and chemical interactions between sinking particles and Pb dissolved in solution. Shuo Jiang, Nathan Lanning, and Edward Boyle performed the extractions and the ICPMS analyses. This dataset includes data from Leg 2 of the cruise, RR1815.

## Table of Contents

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

## Coverage

**Spatial Extent:** N:17.5 E:-151.993 S:-20 W:-156.962

**Temporal Extent:** 2018-10-27 - 2018-11-22

## Methods & Sampling

During September 23 to November 22, 2018, the R/V Roger Revelle completed a trace element (and their isotopes) hydrographic section along ~152° West from 56° North to 20° South (GEOTRACES GP15; cruise IDs RR1814 and RR1815). Full water column trace metal clean samples were obtained with the U.S. GEOTRACES Carousel (GTC) composed of 24 12-liter trace metal clean GO-Flow sampling systems mounted on a trace metal free powder-coated titanium rosette system. Two-liter samples were drawn into TE clean high-density polyethylene bottles with polypropylene lids, double-bagged, and returned to the shore lab where they were acidified to pH 2 with TE clean hydrochloric acid and allowed to sit for at least one month prior to sample analysis.

Three of the stations had lead (Pb) concentrations determined at Massachusetts Institute of Technology (MIT) by isotope dilution quadrupole inductively coupled plasma mass spectrometry (ICPMS) (VG Plasmaquad 2+) for intercalibration with the Texas A&M (TAMU) lab of Jessica Fitzsimmons who analyzed all of the cruise stations. The rest of the full- and super-stations were analyzed at MIT for Pb isotope ratios (206Pb/207Pb, 208Pb/207Pb, 206Pb/204Pb) after Pb extraction and purification on a GV Isoprobe multicollector magnetic sector plasma mass spectrometer with calibration to NBS981 standard.

## Data Processing Description

**Note about replicates:** Sample IDs 15232 and 15537 appear twice in the dataset because there were replicate analyses of the same bottle.

### Quality Flags:

The standard Ocean Data View / SeaDataNet flags were used (definitions for all flags can be found at <https://vocab.nerc.ac.uk/collection/L20/current/>):

1: Good Value: Good quality data value that is not part of any identified malfunction and has been verified as consistent with real phenomena during the quality control process.

2: Probably Good Value: Data value that is probably consistent with real phenomena but this is unconfirmed or data value forming part of a malfunction that is considered too small to affect the overall quality of the data object of which it is a part. [Used when only one replicate confirmed the reported value.]

3: Probably Bad Value: Data value recognized as unusual during quality control that forms part of a feature that is probably inconsistent with real phenomena.

4: Bad Value: An obviously erroneous data value.

## BCO-DMO Processing Description

Version 1:

Version 1 Date: 2024-11-21

- Imported original file "RR1815\_dataTemplate.xlsx" into the BCO-DMO system.
- Renamed fields to comply with BCO-DMO naming conventions.
- Changed dates with year "2019" to "2018".
- Created date-time fields in ISO 8601 format.
- Removed the original date and time columns.
- Changed Longitude values of "-1562" to "-156.962"
- Removed empty columns: Gear\_ID, Rosette\_Position, End\_Latitude, End\_Longitude, and the BOAT\_PUMP columns.
- Saved the final file as "933383\_v1\_gp15\_pb\_and\_pb\_isotopes\_leg2.csv".

Version 2:

Version 2 Date: 2025-05-21

- Made the following corrections:
  - For Event\_ID 6958, changed Sample\_ID from 15340 to 15319.
  - Removed duplicate row for Sample\_ID 15581 with the wrong Event\_ID.
  - For Sample\_ID 15635, changed Event\_ID from 6989 to 6994; also corrected Start\_ISO\_DateTime\_UTC and End\_ISO\_DateTime\_UTC to match those of 6994.
  - For Sample\_ID 15821, changed Event\_ID from 6820 to 7021; also corrected Station\_ID, Start\_ISO\_DateTime\_UTC, End\_ISO\_DateTime\_UTC, and Start\_Latitude to match those of 7021.
- Saved the final file as "933383\_v2\_gp15\_pb\_and\_pb\_isotopes\_leg2.csv".

## Data Files

File
<b>933383_v2_gp15_pb_and_pb_isotopes_leg2.csv</b> (Comma Separated Values (.csv), 33.38 KB) MD5:ae547bf45c877a549c3069746468264a
Primary data file for dataset ID 933383, version 2

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

## Related Datasets

### Continues

Boyle, E. A., Lanning, N., Jiang, S. (2025) **Lead (Pb) concentrations and Pb isotope ratios (206Pb/207Pb, 208Pb/207Pb, 206Pb/204Pb) from Leg 1 (Seattle, WA to Hilo, HI) of the US GEOTRACES Pacific Meridional Transect (PMT) cruise (GP15, RR1814) on R/V Roger Revelle from September to October 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 2) Version Date 2025-05-21 doi:10.26008/1912/bco-dmo.933318.2 [[view at BCO-DMO](#)]

*Relationship Description: GP15 was made up of two cruise legs, RR1814 (Leg 1) and RR1815 (Leg 2)*

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

## Parameters

Parameter	Description	Units
Station_ID	Station ID number	unitless
Event_ID	Event ID number	unitless
Start_ISO_DateTime_UTC	Date and time (UTC) at start of the sample collection event	unitless
End_ISO_DateTime_UTC	Date and time (UTC) at end of the sample collection event	unitless
Start_Latitude	Latitude at start of event; negative values = South	decimal degrees
Start_Longitude	Longitude at start of event; negative values = West	decimal degrees
Sample_ID	GEOTRACES sample ID number	unitless
Sample_Depth	Sample depth	meters (m)
Pb_208_207_D_RATIO_FISH_dx6trs	Atom ratio of given isotopes for dissolved Pb referenced to {NBS981} from towed GeoFish samples	unitless

SD1_Pb_208_207_D_RATIO_FISH_dx6trs	One standard deviation of Pb_208_207_D_RATIO_FISH_dx6trs	unitless
Flag_Pb_208_207_D_RATIO_FISH_dx6trs	ODV quality flag for Pb_208_207_D_RATIO_FISH_dx6trs	unitless
Pb_206_204_D_RATIO_FISH_xqphwk	Atom ratio of given isotopes for dissolved Pb referenced to {NBS981} from towed GeoFish samples	unitless
SD1_Pb_206_204_D_RATIO_FISH_xqphwk	One standard deviation of Pb_206_204_D_RATIO_FISH_xqphwk	unitless
Flag_Pb_206_204_D_RATIO_FISH_xqphwk	ODV quality flag for Pb_206_204_D_RATIO_FISH_xqphwk	unitless
Pb_D_CONC_BOTTLE_zdz7dg	Concentration of dissolved Pb from bottle samples	picomoles per kilogram (pmol/kg)
SD1_Pb_D_CONC_BOTTLE_zdz7dg	One standard deviation of Pb_D_CONC_BOTTLE_zdz7dg	picomoles per kilogram (pmol/kg)
Flag_Pb_D_CONC_BOTTLE_zdz7dg	ODV quality flag for Pb_D_CONC_BOTTLE_zdz7dg	unitless
Pb_D_CONC_FISH_4jdn8v	Concentration of dissolved Pb from towed GeoFish samples	picomoles per kilogram (pmol/kg)
SD1_Pb_D_CONC_FISH_4jdn8v	One standard deviation of Pb_D_CONC_FISH_4jdn8v	picomoles per kilogram (pmol/kg)
Flag_Pb_D_CONC_FISH_4jdn8v	ODV quality flag for Pb_D_CONC_FISH_4jdn8v	unitless
Pb_206_207_D_RATIO_FISH_s1muh9	Atom ratio of given isotopes for dissolved Pb referenced to {NBS981} from towed GeoFish samples	unitless
SD2_Pb_206_207_D_RATIO_FISH_s1muh9	Two standard deviations of Pb_206_207_D_RATIO_FISH_s1muh9	unitless
Flag_Pb_206_207_D_RATIO_FISH_s1muh9	ODV quality flag for Pb_206_207_D_RATIO_FISH_s1muh9	unitless
Pb_206_204_D_RATIO_BOTTLE_obwcdg	Atom ratio of given isotopes for dissolved Pb referenced to {NBS981} from bottle samples	unitless
SD2_Pb_206_204_D_RATIO_BOTTLE_obwcdg	Two standard deviations of Pb_206_204_D_RATIO_BOTTLE_obwcdg	unitless

Flag_Pb_206_204_D_RATIO_BOTTLE_obwcdg	ODV quality flag for Pb_206_204_D_RATIO_BOTTLE_obwcdg	unitless
Pb_206_207_D_RATIO_BOTTLE_ul6vdu	Atom ratio of given isotopes for dissolved Pb referenced to {NBS981} from bottle samples	unitless
SD2_Pb_206_207_D_RATIO_BOTTLE_ul6vdu	Two standard deviations of Pb_206_207_D_RATIO_BOTTLE_ul6vdu	unitless
Flag_Pb_206_207_D_RATIO_BOTTLE_ul6vdu	ODV quality flag for Pb_206_207_D_RATIO_BOTTLE_ul6vdu	unitless
Pb_208_207_D_RATIO_BOTTLE_vl0cax	Atom ratio of given isotopes for dissolved Pb referenced to {NBS981} from bottle samples	unitless
SD2_Pb_208_207_D_RATIO_BOTTLE_vl0cax	Two standard deviations of Pb_208_207_D_RATIO_BOTTLE_vl0cax	unitless
Flag_Pb_208_207_D_RATIO_BOTTLE_vl0cax	ODV quality flag for Pb_208_207_D_RATIO_BOTTLE_vl0cax	unitless

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

## Instruments

<b>Dataset-specific Instrument Name</b>	
<b>Generic Instrument Name</b>	GO-FLO Bottle
<b>Generic Instrument Description</b>	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.

<b>Dataset-specific Instrument Name</b>	quadrupole ICPMS (VG Plasmaquad 2+)
<b>Generic Instrument Name</b>	Inductively Coupled Plasma Mass Spectrometer
<b>Generic Instrument Description</b>	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

<b>Dataset-specific Instrument Name</b>	GV Isoprobe multicollector magnetic sector plasma mass spectrometer
<b>Generic Instrument Name</b>	Multi Collector Inductively Coupled Plasma Mass Spectrometer
<b>Generic Instrument Description</b>	A Multi Collector Inductively Coupled Plasma Mass Spectrometry (MC-ICPMS) is a type of mass spectrometry where the sample is ionized in a plasma (a partially ionized gas, such as Argon, containing free electrons) that has been generated by electromagnetic induction. A series of collectors is used to detect several ion beams simultaneously. A MC-ICPMS is a hybrid mass spectrometer that combines the advantages of an inductively coupled plasma source and the precise measurements of a magnetic sector multicollector mass spectrometer. The primary advantage of the MC-ICPMS is its ability to analyze a broader range of elements, including those with high ionization potential that are difficult to analyze by Thermal Ionization Mass Spectrometry (TIMS). The ICP source also allows flexibility in how samples are introduced to the mass spectrometer and allows the analysis of samples introduced either as an aspirated solution or as an aerosol produced by laser ablation.

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

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## Deployments

### RR1815

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/776917">https://www.bco-dmo.org/deployment/776917</a>
<b>Platform</b>	R/V Roger Revelle
<b>Report</b>	<a href="https://datadocs.bco-dmo.org/docs/geotraces/GEOTRACES_PMT/casciotti/data_docs/GP15_Cruise_Report_with_ODF_Report.pdf">https://datadocs.bco-dmo.org/docs/geotraces/GEOTRACES_PMT/casciotti/data_docs/GP15_Cruise_Report_with_ODF_Report.pdf</a>
<b>Start Date</b>	2018-10-24
<b>End Date</b>	2018-11-24
<b>Description</b>	Additional cruise information is available from the Rolling Deck to Repository (R2R): <a href="https://www.rvdata.us/search/cruise/RR1815">https://www.rvdata.us/search/cruise/RR1815</a>

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

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## Project Information

### US GEOTRACES Pacific Meridional Transect (GP15) (U.S. GEOTRACES PMT)

**Website:** <http://www.geotraces.org/>

**Coverage:** Pacific Meridional Transect along 152W (GP15)

A 60-day research cruise took place in 2018 along a transect from Alaska to Tahiti at 152° W. A description of the project titled "*Collaborative Research: Management and implementation of the US GEOTRACES Pacific Meridional Transect*", funded by NSF, is below. Further project information is available on the [US GEOTRACES website](#) and on the [cruise blog](#). A detailed [cruise report is also available](#) as a PDF.

*Description from NSF award abstract:*

GEOTRACES is a global effort in the field of Chemical Oceanography in which the United States plays a major role. The goal of the GEOTRACES program is to understand the distributions of many elements and their isotopes in the ocean. Until quite recently, these elements could not be measured at a global scale. Understanding the distributions of these elements and isotopes will increase the understanding of processes that shape their distributions and also the processes that depend on these elements. For example, many "trace elements" (elements that are present in very low amounts) are also important for life, and their presence or absence can play a vital role in the population of marine ecosystems. This project will launch the next major U.S. GEOTRACES expedition in the Pacific Ocean between Alaska and Tahiti. The award made here would support all of the major infrastructure for this expedition, including the research vessel, the sampling equipment, and some of the core oceanographic measurements. This project will also

support the personnel needed to lead the expedition and collect the samples.

This project would support the essential sampling operations and infrastructure for the U.S. GEOTRACES Pacific Meridional Transect along 152° W to support a large variety of individual science projects on trace element and isotope (TEI) biogeochemistry that will follow. Thus, the major objectives of this management proposal are: (1) plan and coordinate a 60 day research cruise in 2018; (2) obtain representative samples for a wide variety of TEIs using a conventional CTD/rosette, GEOTRACES Trace Element Sampling Systems, and in situ pumps; (3) acquire conventional CTD hydrographic data along with discrete samples for salinity, dissolved oxygen, algal pigments, 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 data to the GEOTRACES Data Assembly Centre (via the US BCO-DMO data center); and (6) coordinate all cruise communications between investigators, including preparation of a hydrographic report/publication. This project would also provide baseline measurements of TEIs in the Clarion-Clipperton fracture zone (~7.5°N-17°N, ~155°W-115°W) where large-scale deep sea mining is planned. Environmental impact assessments are underway in partnership with the mining industry, but the effect of mining activities on TEIs in the water column is one that could be uniquely assessed by the GEOTRACES community. In support of efforts to communicate the science to a wide audience the investigators will recruit an early career freelance science journalist with interests in marine science and oceanography to participate on the cruise and do public outreach, photography and/or videography, and social media from the ship, as well as to submit articles about the research to national media. The project would also support several graduate students.

### **Collaborative Research: US GEOTRACES PMT: Pb and Cr isotopes (PMT Pb and Cr)**

#### *NSF Award Abstract:*

Most of the lead (Pb) in the ocean has been put there by human activities. These activities include high temperature industrial processes such as smelting, coal combustion, and incineration, as well as leaded gasoline consumption during the middle portion of the 20th century. Lead from these sources moves as fine particles around the world by the atmosphere's winds and eventually deposits on the surface ocean where it dissolves. Fortunately, it is possible to determine the different origins of these Pb sources (e.g. U.S., European, and Asian inputs) from its isotopic composition (isotopes are atoms of the same element with different numbers of neutrons in the nucleus). Lead has been shown to have different isotope ratios because the Pb has been extracted from mineral deposits from different geological periods. This project aims to determine how much of this Pb has moved into the deep North Pacific by ocean circulation or by attaching to sinking particles. This will be done by collecting seawater samples from the surface to the bottom of the ocean at about 30 stations between Tahiti and Alaska and analyzing these for their Pb concentration and Pb isotope ratios. This project will also determine variations in the chromium (Cr) isotope composition of Pacific seawater that are created when the lighter isotopes of Cr are selectively removed from the ocean in extremely low oxygen zones in the eastern tropical Pacific Ocean. This tool can help understand the ongoing evolution of decreasing oxygen in the ocean and past changes in the oxygen in the ocean established from geological archives such as sediments.

The first measurements of anthropogenic Pb in the ocean resulted in a profile in the North Pacific Ocean by Schaule and Patterson in 1981, and since then several labs have sparsely and erratically measured other profiles showing that the Pb in the Pacific Ocean is responding to regional changes in Pb fluxes - from the phasing out of leaded gasoline (mainly in Japan, Canada, Mexico, and the United States) to increasing amounts of coal combustion (mainly in China). The concentration of Pb decreased near Hawaii by a factor of two between 1981 and the present, and the 206Pb/207Pb isotopic composition of Pb decreased from ~1.20 (mainly U.S. Pb) to 1.165 (mainly Chinese coal Pb). The U.S. GEOTRACES Pacific Meridional Transect cruise will give us an unprecedented opportunity to obtain a detailed view of the penetration of anthropogenic Pb into the deep Pacific Ocean which can be used to determine the pathways that dissolved and particulate Pb take in arriving in the deep sea. This project will also determine the stable isotope composition of Cr, an element whose redox state is determined by the oxygen (O<sub>2</sub>) concentration in the ocean. In oxygen deficient zones (ODZs) where [O<sub>2</sub>] < 2 μmol/kg, Cr is reduced from chromate CrO<sub>4</sub><sup>2-</sup> (hexavalent chromium) to Cr<sup>3+</sup> ion (trivalent chromium). The isotopically lighter atoms of Cr are preferentially reduced, and the reduced Cr<sup>3+</sup> ion is "particle-reactive" (attaches to sinking particles) and removed from the water column. That leaves the residual Cr isotopically heavier, so we can detect this process by measurements of 53Cr/52Cr. This process occurs in conjunction with nitrogen reduction (denitrification) and can be used to trace the consequences as ODZ waters mix out into the oxic ocean.

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

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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.

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

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## Funding

Funding Source	Award
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-1736996</a>

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