Results from Optimum Multiparameter Water Mass Analysis (OMPA) obtained using temperature, salinity, nutrient, and oxygen data from R/V Thomas G. Thompson cruise TN303 in the Eastern Tropical Pacific from October to December 2013

Website: https://www.bco-dmo.org/dataset/713003
Data Type: Cruise Results
Version: 1
Version Date: 2017-08-17

Project
» U.S. GEOTRACES East Pacific Zonal Transect (U.S. GEOTRACES EPZT)
» GEOTRACES Peru-Tahiti Nitrogen Isotope Measurements (EPZT Nitrogen Isotopes)
» Measurement of Helium Isotopes, Tritium, Noble Gases, and Radiocarbon (EPZT Noble Gases He Tritium)

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

Contributors	Affiliation	Role
Casciotti, Karen L.	Stanford University	Principal Investigator
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Abstract
Results from Optimum Multiparameter Water Mass Analysis (OMPA) obtained using temperature, salinity, nutrient, and oxygen data from R/V Thomas G. Thompson cruise TN303 in the Eastern Tropical Pacific from October to December 2013.

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Coverage

Spatial Extent: **N**:-10.25 **E**:-77.3761 **S**:-16.0006 **W**:-152.0006
Temporal Extent: 2013-10-29 - 2013-12-18

Dataset Description

Water mass percentage data from Optimum Multiparameter Water Mass Analysis (OMPA) for GP16 obtained using temperature, salinity, nutrient, and oxygen data.

Acquisition Description

We use the Optimum Multiparameter Analysis (OMPA) method to determine water mass percentages along the GP16 transect. This involves the use of hydrographic measurements from GP16 (temperature, salinity, oxygen, and nutrients), which can be found in a separate BCO-DMO dataset (see CTD - ODF Bottle). For samples having potential density anomalies greater than 27 kg m-3, the OMPA was conducted according to the procedure outlined by Tomczak (1981), Tomczak and Large (1989), and others. For samples in the thermocline, defined as those samples having densities between 26 and 27, we use the 'thermocline array' method to determine the water mass fractions, according to the procedure outlined by Jenkins et al. (2015). Samples having densities less than 26 kg m-3 were not included in the water mass analysis. The uncertainty in water mass percentage is calculated using a Monte Carlo routine, where the defined properties of each water mass are varied to encompass the reported range of properties in that water mass. Lastly, the signal to noise ratio is calculated by dividing the percentage of given water mass in a each sample by the uncertainty of that water mass.

Processing Description

BCO-DMO GEOTRACES Processing:
As was done for the GEOTRACES-NAT data, 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:

cruise_id, EXPOCODE,SECT_ID, STNNBR, CASTNO, GEOTRC_EVENTNO, GEOTRC_SAMPNO, GEOTRC_INSTR, SAMPNO, GF_NO, BTLNBR, BTLNBR_FLAG_W, DATE_START_EVENT, TIME_START_EVENT, ISO_DATETIME_UTC_START_EVENT, EVENT_LAT, EVENT_LON, DEPTH_MIN, DEPTH_MAX, BTL_DATE, BTL_TIME, BTL_ISO_DATETIME_UTC, BTL_LAT, BTL_LON, ODF_CTDPRS, SMDEPTH, FMDEPTH, BTMDEPTH, CTDPRS, CTDDEPTH.

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 and ODF_Bottle datasets. Non-bottle parameters, including those from GeoFish tows, Aerosol sampling, and McLane Pumps, were taken from the TN303 Event Log (version 30 Oct 2014). Where applicable, pump information was taken from the PUMP_Nuts_Sals dataset.

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.

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Related Publications

Jenkins, W. J., Smethie, W. M., Boyle, E. A., & Cutter, G. A. (2015). Water mass analysis for the U.S. GEOTRACES (GA03) North Atlantic sections. Deep Sea Research Part II: Topical Studies in Oceanography, 116, 6–20. doi:10.1016/j.dsr2.2014.11.018
Methods

Mackas, D. L., Denman, K. L., & Bennett, A. F. (1987). Least squares multiple tracer analysis of water mass composition. Journal of Geophysical Research, 92(C3), 2907. doi:10.1029/jc092ic03p02907 https://doi.org/10.1029/JC092iC03p02907
General

Peters, B. D., Jenkins, W. J., Swift, J. H., German, C. R., Moffett, J. W., Cutter, G. A., … Casciotti, K. L. (2018). Water mass analysis of the 2013 US GEOTRACES eastern Pacific zonal transect (GP16). Marine Chemistry, 201, 6–19. doi:10.1016/j.marchem.2017.09.007
General

Tomczak, M. (1981). A multi-parameter extension of temperature/salinity diagram techniques for the analysis of non-isopycnal mixing. Progress in Oceanography, 10(3), 147–171. doi:10.1016/0079-6611(81)90010-0
Methods

Tomczak, M., & Large, D. G. B. (1989). Optimum multiparameter analysis of mixing in the thermocline of the eastern Indian Ocean. Journal of Geophysical Research, 94(C11), 16141. doi:10.1029/jc094ic11p16141 https://doi.org/10.1029/JC094iC11p16141
Methods

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Parameters

Parameter	Description	Units
cruise_id	Cruise identification	unitless
GEOTRC_INSTR	Sampling instrument; added from BCO-DMO EPZT master data file	unitless
STNNBR	Station number	unitless
LATITUDE	Station latitude (south is negative)	decimal degrees
LONGITUDE	Station longitude (west is negative)	decimal degrees
GEOTRC_SAMPNO	Unique GEOTRACES sample number	unitless

GEOTRC_EVENTNO	GEOTRACES event number; added from BCO-DMO EPZT master data file	unitless
CASTNO	Cast number; added from BCO-DMO EPZT master data file	unitless
CTDPRS	CTD pressure; added from BCO-DMO EPZT master data file	decibars (db)
CTDDEPTH	CTD bottle firing depth; added from BCO-DMO EPZT master data file	meters (m)
SAMPNO	Sequential sample number within the cast (usually corresponds to bottle number); added from BCO-DMO EPZT master data file	unitless
BTLNBR	Bottle number; typically 1-24; added from BCO-DMO EPZT master data file	unitless
BTLNBR_FLAG_W	Bottle number quality flag; follows WOCE conventions. 2 = no problems noted; 3 = leaking; 4 = did not trip correctly; 9 = samples not drawn from this bottle. Added from BCO-DMO EPZT master data file	unitless
BTL_ISO_DATETIME_UTC	Date and time, formatted to the ISO 8601 standard, at the time of bottle firing. Format: YYYY-MM-DDTHH:MM:SS[.xx]Z	unitless
BTL_LAT	Latitude of bottle firing; north is positive. Added from BCO-DMO EPZT master data file	decimal degrees
BTL_LON	Lonitude of bottle firing; east is positive. Added from BCO-DMO EPZT master data file	decimal degrees
ESSW_PCT	the amount of Equatorial Subsurface Water in a sample, in units of percent	percent (%)
ESSW_UNCT	the uncertainty in the percent of Equatorial Subsurface Water, in units of percent	percent (%)
ESSW_STN	the signal to noise ratio for Equatorial Subsurface Water	dimensionless
ESPIW_PCT	the amount of Eastern South Pacific Intermediate Water, in units of percent	percent (%)
ESPIW_UNCT	the uncertainty of Eastern South Pacific Intermediate Water, in units of percent	percent (%)
ESPIW_STN	the signal to noise ratio of Eastern South Pacific Intermediate Water	dimensionless
SPCW_PCT	the amount of South Pacific Central Water in a sample, in units of percent	percent (%)
SPCW_UNCT	the uncertainty in South Pacific Central Water, in units of percent	percent (%)
SPCW_STN	the signal to nose ratio of South Pacific Central Water	dimensionless
AAIW_PCT	the amount of Antarctic Intermediate Water in a sample, in units of percent	percent (%)
AAIW_UNCT	the uncertainty of Antarctic Intermediate Water, in units of percent	percent (%)
AAIW_STN	the signal to noise ratio of Antarctic Intermediate Water	dimensionless
EQPIW_PCT	the amount of Equatorial Pacific Intermediate Water in a sample, in units of percent	percent (%)
EQPIW_UNCT	the uncertainty in Equatorial Pacific Intermediate Water, in units of percent	percent (%)

EQPIW_STN	the signal to noise ratio of Equatorial Pacific Intermediate Water	dimensionless
UCDW_PCT	the amount of Upper Circumpolar Deep Water in a sample, in units of percent	percent (%)
UCDW_UNCT	the uncertainty of Upper Circumpolar Deep Water, in units of percent	percent (%)
UCDW_STN	the signal to noise ratio of Upper Circumpolar Deep Water	dimensionless
PDW_PCT	the amount of Pacific Deep Water in a sample, in units of percent	percent (%)
PDW_UNCT	the uncertainty of Pacific Deep Water, in units of percent	percent (%)
PDW_STN	the signal to noise ratio in Pacific Deep Water	dimensionless
LCDW_PCT	the amount of Lower Circumpolar Deep Water in a sample, in units of percent	percent (%)
LCDW_UNCT	the uncertainty of Lower Circumpolar Deep Water, in units of percent	percent (%)
LCDW_STN	the signal to noise ratio in Lowe Circumpolar Deep Water	dimensionless
AABW_PCT	the amount of Antarctic Bottom Water in a sample, in units of percent	percent (%)
AABW_UNCT	the uncertainty of Antarctic Bottom Water, in units of percent	percent (%)
AABW_STN	the signal to noise ratio in Antarctic Bottom Water	dimensionless
total	Sum of percentages for the sample	percent (%)

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Niskin bottle
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	
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Generic Instrument Description	The Sea-Bird SBE 911plus is a type of CTD instrument package for continuous measurement of conductivity, temperature and pressure. The SBE 911plus includes the SBE 9plus Underwater Unit and the SBE 11plus Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9plus and SBE 11plus is called a SBE 911plus. The SBE 9plus uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3plus and SBE 4). The SBE 9plus CTD can be configured with up to eight auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorescence, light (PAR), light transmission, etc.). more information from Sea-Bird Electronics

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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] Original data are available from the NSF R2R data catalog

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Project Information

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

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

Coverage: Eastern Tropical Pacific - Transect from Peru to Tahiti

From the NSF Award Abstract The mission of the International GEOTRACES Program (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 Peru-Tahiti Nitrogen Isotope Measurements (EPZT Nitrogen Isotopes)

Coverage: East Pacific Zonal Transect

Description from NSF award abstract: Nitrogen (N) is an essential macronutrient whose availability can limit primary production and the capacity of the biological pump to export carbon from the surface ocean on seasonal, annual, decadal, and millennial timescales. The inventory of fixed (bioavailable) N in the ocean is driven by biological processes such as nitrogen fixation, denitrification, and anaerobic ammonia oxidation (anammox). Water column oxygen deficient zones (ODZs) are important sites for fixed N loss, as well as N2O production, and they are projected to expand and intensify in the coming years as global warming increases ocean stratification and decreases ventilation. It is important to understand the distribution of nitrate, nitrite, and N2O isotopes in relation to current ocean conditions of oxygen and trace element availability order to interpret past and future changes in nitrate signals. In this project, a team of researchers from Stanford University, University of Massachusetts at Dartmouth, and Brown University will measure the nitrogen- and oxygen-isotopic composition (del15N and del18O) of nitrate, nitrite, and nitrous oxide in seawater samples collected along the GEOTRACES Pacific Peru-Tahiti Section. Values of del15N and del18O will also be measured in nitrate from aerosol and rain samples to inform our interpretation of the N isotope budget and isotopic gradients within the tropical South Pacific. Finally, N2/Ar and N2 del15N

will be determined to close the N mass and isotope budgets. Nitrate del15N is a GEOTRACES "core parameter" that will complement other measurements, such as bioactive trace element concentrations and speciation, Si isotope variations, as well as redox and productivity proxies. The GEOTRACES Peru-Tahiti section provides a rare opportunity to track the fate of the isotopic signals of N loss from one of the largest water column ODZs. Furthermore, little is known about the effect of N recycling through hydrothermal vents on nitrate isotopes in the deep ocean, and this section will allow quantitative tracking of this input. Together, these measurements will yield insight into the relative rates of modern N cycle processes and will provide background information for paleoceanographic applications.

Measurement of Helium Isotopes, Tritium, Noble Gases, and Radiocarbon (EPZT Noble Gases He Tritium)

Coverage: Oxygen minium zone; East Pacific Rise

The biogeochemical cycling of trace elements and isotopes (TEIs) in the marine environment is an important research area within the context of global change that motivates the International GEOTRACES program. Some trace elements are known to play potentially important roles as micronutrients in biological cycling, particularly in regard to enzymatic and catalytic processes in the marine environment. Radioisotopes, transient tracers, and noble gases are valuable tracers of these and related processes, and of the ocean?s interaction with the atmosphere and the solid earth, which in turn play a role in shaping many trace element distributions within the ocean. According to the GEOTRACES Science Plan, the guiding mission of the GEOTRACES program is "to identify processes and quantify fluxes that control the distributions of key trace elements and isotopes in the ocean". The key observational strategy for GEOTRACES is an internationally-coordinated global-scale ocean survey of key TEIs. The second US GEOTRACES section, set for the Eastern South Pacific in 2013, is aimed at the characterization of key processes in an oxygen minimum zone (OMZ), as well as a major abyssal hydrothermal plume extending westward from the East Pacific Rise. To help achieve these goals, with support from this grant, a research team at the Woods Hole Oceanographic Institution will collaborate with other GEOTRACES investigators on the Eastern South Pacific expedition to measure a suite of tracers useful for interpreting the rest of the synoptic TEI data. Specifically, the team will make measurements of the noble gases, helium isotopes, tritium, and radiocarbon include in order to: (1) quantify ventilation, circulation, and diapycnal mixing in the OMZ to enable estimation of fluxes and transformation rates of key TEIs; (2) determine upwelling rates in the oxygen minimum zone (OMZ) over a range of timescales to constrain the fluxes of biogeochemically important properties; (3) estimate hydrothermal fluxes of key TEIs using 3He as a flux gauge, and also use 3He as a measure of downstream dilution in the hydrothermal plume; (4) use radiocarbon to estimate abyssal remineralization rates for key TEIs; and (5) probe for evidence of off-axis contribution of hydrothermal processes to TEI distribution. The collective effort will allow marine geochemists to understand mechanistically and quantitatively how a variety of physical, chemical, and biological processes join to determine the distribtuion of TEIs in the ocean. It has been argued that anthropogenic influence on the global cycles of many elements is emerging as significant. As outlined in the International GEOTRACES Science Plan, the broader impacts of this activity include both an important "baseline snapshot" of the biogeochemical state of the oceanic environment, and a quantitative improvement in the characterization and understanding of important processes in the marine environment. Both of these build a foundation for improved models and quantitative predictions of the oceanic response and role in global change and climate, particularly with anthropogenic forcing. For example, recent evidence of "ocean deoxygenation" has profound implications for marine biologic response. In particular, the evolving state of marine OMZs represents an important biogeochemical "climate canary". A key benefit of diagnosing trace metal dynamics and response to changing redox conditions is the improvement in prognostic capabilities of coupled ocean-atmosphere biogeochemical models for global change.

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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-1130870
NSF Division of Ocean Sciences (NSF OCE)	OCE-1233339
NSF Division of Ocean Sciences (NSF OCE)	OCE-1232991
NSF Division of Ocean Sciences (NSF OCE)	OCE-1130245
NSF Division of Ocean Sciences (NSF OCE)	OCE-1233028

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