Isotopic composition and concentrations of dissolved and particulate nickel, cadmium, iron, zinc, and copper from the Eastern Tropical North Pacific Ocean on R/V Revelle cruise RR1804 and on R/V Sikuliaq cruise SKQ201617S

Website: https://www.bco-dmo.org/dataset/842086
Data Type: Cruise Results
Version: 1
Version Date: 2021-02-25

Project
» The role of cryptic nutrient cycling within sinking particles on trace element transport in oxygen minimum zones (OMZ Nutrient Cycling)

Contributors	Affiliation	Role
John, Seth G.	University of Southern California (USC)	Principal Investigator
Moffett, James W.	University of Southern California (USC)	Co-Principal Investigator
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Abstract
Isotopic composition and concentrations of dissolved and particulate nickel, cadmium, iron, zinc, and copper from the Eastern Tropical North Pacific Ocean on R/V Revelle cruise RR1804 and on R/V Sikuliaq cruise SKQ201617S.

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Coverage

Spatial Extent: **N**:25.2 **E**:-105.69 **S**:16.54 **W**:-112.72
Temporal Extent: 2017-01-01 - 2018-04-29

Methods & Sampling

Seawater and suspended particles were collected using 5 L acid-cleaned Teflon-coated external-spring "Niskin-type" bottles (Ocean Test Equipment) on a powder-coated trace metal clean rosette (Sea-Bird Electronics). After collection, seawater was filtered through acid-cleaned 47 mm-diameter 0.2 µm Supor polyethersulfone filters (Pall) into acid-washed 1 L low density polyethylene bottles (Nalgene). The filters with suspended particles (>0.2 µm) were stored in acid-washed 50 mL polyethylene centrifuge tubes. Size-fractionated marine particles were also collected at station P1 using a McLane pump (McLane Research Laboratories, Falmouth, MA, USA) equipped with a 4 mm mesh screen, a 142 mm-diameter Sefar polyester mesh prefilter (51 µm pore size) and a 142 mm-diameter 0.8 µm Pall Supor polyethersulfone filter at each sampling depth. All filters and filter holders

were acid leached before use based.

Seawater samples (1L) were acidified to pH = 1.8 with 1 mL concentrated distilled HCl and added with 1 mL 30% H2O2, and left for over 1 month. For particulate samples, each 47 and 142 mm-diameter filter was digested by placing the filter in a 25 mL acid-washed Teflon vial containing 5 mL of 8 M HNO_3. HF was not used to digest the samples in order to minimize the decomposition of lithogenic materials. Samples were digested on a hot plate at 120°C for 12 h. After digestion, the filters were taken out, placed into acid-washed 15 mL centrifuge tubes and rinsed with 5 mL Milli-Q water. The Milli-Q water was transferred into the same digestion vials. The digested solution was then heated on a hot plate at 80°C in a trace-metal clean hood to nearly dry. Digested and dried particle samples were re-dissolved by adding 10 mL of 4 M HNO_3, transferred into acid-washed 15 mL centrifuge tubes, and then centrifuged at 2000 rpm for 5 mins to segregate insoluble particles and filter debris.

Seawater and particulate samples were then amended with double isotope spikes of 61Ni and 62Ni, 57Fe and 58Fe, 64Zn and 67Zn, and 110Cd and 112Cd in a spike-to-sample ratio of 2:1 for Fe, and 1:1 for Ni, Zn and Cd. Ni, Cd, Fe, Zn, and Cu in both types of samples were then extracted using Nobias PA1 resin. Metals of the seawater and particle extract were further separated and purified for isotopic analysis via anion exchange chromatography with AG-MP1 resin. As Fe, Zn and Cd samples were ready for analysis after the treatment, Cu required to be purified again by AG-MP1 resin and Ni required additional purification by Nobias PA-1 resin, followed by another separation using AG-MP1 to remove contaminants. Detailed information of the whole purification steps is described in Yang et al. (2020).

Isotopic measurements were performed using a multi-collector ICP-MS (Thermo Neptune) with a desolvator nebulizer as the sample introduction system (ESI Apex- IR), and the concentrations were determined using an high-resolution ICP-MS (Thermo Element 2) with a PC3 desolvation system.

Data Processing Description

Data processing was done using Excel 2016 with home-made data reduction algorithms. The data reduction algorithms were modified from Rudge et al. (2009).

BCO-DMO Processing:
- replaced "N/A" with "nd" to indicate "no data";
- added date-time field in ISO8601 format;
- renamed fields to comply with BCO-DMO naming conventions.

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Data Files

File
Metals.csv (Comma Separated Values (.csv), 46.65 KB) MD5:649a35161cd35e615555526bf41f465e Primary data file for dataset ID 842086

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Related Publications

Rudge, J. F., Reynolds, B. C., & Bourdon, B. (2009). The double spike toolbox. Chemical Geology, 265(3-4), 420–431. doi:10.1016/j.chemgeo.2009.05.010
Methods

Yang, S.-C., Hawco, N. J., Pinedo-González, P., Bian, X., Huang, K.-F., Zhang, R., & John, S. G. (2020). A new purification method for Ni and Cu stable isotopes in seawater provides evidence for widespread Ni isotope fractionation by phytoplankton in the North Pacific. Chemical Geology, 547, 119662. doi:10.1016/j.chemgeo.2020.119662
Methods

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Parameters

Parameter	Description	Units
Cruise_id	Cruise identifier	unitless
Bottle	Bottle number	unitless
Station	Station number	unitless
Depth	Sample depth	meters (m)
Ni_60_58_UF_DELTA_BOTTLE	d60/58Ni in seawater (<0.02 µm)	per mil
SD1_Ni_60_58_UF_DELTA_BOTTLE	One standard deviation of Ni_60_58_UF_DELTA_BOTTLE	per mil
Cd_114_110_UF_DELTA_BOTTLE	d114/110Cd in seawater (<0.02 µm)	per mil
SD1_Cd_114_110_UF_DELTA_BOTTLE	One standard deviation of Cd_114_110_UF_DELTA_BOTTLE	per mil
Fe_56_54_UF_DELTA_BOTTLE	d56/54Fe in seawater (<0.02 µm)	per mil
SD1_Fe_56_54_UF_DELTA_BOTTLE	One standard deviation of Fe_56_54_UF_DELTA_BOTTLE	per mil
Zn_66_64_UF_DELTA_BOTTLE	d66/64Zn in seawater (<0.02 µm)	per mil
SD1_Zn_66_64_UF_DELTA_BOTTLE	One standard deviation of Zn_66_64_UF_DELTA_BOTTLE	per mil
Ni_60_58_TD_DELTA_BOTTLE	Total dissolved d60/58Ni (<0.2 µm)	per mil
SD1_Ni_60_58_TD_DELTA_BOTTLE	One standard deviation of Ni_60_58_TD_DELTA_BOTTLE	per mil
Cd_114_110_TD_DELTA_BOTTLE	Total dissolved d114/110Cd (<0.2 µm)	per mil

SD1_Cd_114_110_TD_DELTA_BOTTLE	One standard deviation of Cd_114_110_TD_DELTA_BOTTLE	per mil
Fe_56_54_TD_DELTA_BOTTLE	Total dissolved d56/54Fe (<0.2 µm)	per mil
SD1_Fe_56_54_TD_DELTA_BOTTLE	One standard deviation of Fe_56_54_TD_DELTA_BOTTLE	per mil
Zn_66_64_TD_DELTA_BOTTLE	Total dissolved d66/64Zn (<0.2 µm)	per mil
SD1_Zn_66_64_TD_DELTA_BOTTLE	One standard deviation of Zn_66_64_TD_DELTA_BOTTLE	per mil
Cu_65_63_TD_DELTA_BOTTLE	Total dissolved d65/63Cu (<0.2 µm)	per mil
SD1_Cu_65_63_TD_DELTA_BOTTLE	One standard deviation of Cu_65_63_TD_DELTA_BOTTLE	per mil
Ni_60_58_SPT_DELTA_PUMP	d60/58Ni determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm)	per mil
SD1_Ni_60_58_SPT_DELTA_PUMP	One standard deviation of Ni_60_58_SPT_DELTA_PUMP	per mil
Cd_114_110_SPT_DELTA_PUMP	d114/110Cd determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm)	per mil
SD1_Cd_114_110_SPT_DELTA_PUMP	One standard deviation of Cd_114_110_SPT_DELTA_PUMP	per mil
Fe_56_54_SPT_DELTA_PUMP	d56/54Fe determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm)	per mil
SD1_Fe_56_54_SPT_DELTA_PUMP	One standard deviation of Fe_56_54_SPT_DELTA_PUMP	per mil
Zn_66_64_SPT_DELTA_PUMP	d66/64Zn determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm)	per mil
SD1_Zn_66_64_SPT_DELTA_PUMP	One standard deviation of Zn_66_64_SPT_DELTA_PUMP	per mil

Cu_65_63_SPT_DELTA_PUMP	d65/63Cu determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm)	per mil
SD1_Cu_65_63_SPT_DELTA_PUMP	One standard deviation of Cu_65_63_SPT_DELTA_PUMP	per mil
Ni_60_58_LPT_DELTA_PUMP	d60/58Ni determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm)	per mil
SD1_Ni_60_58_LPT_DELTA_PUMP	One standard deviation of Ni_60_58_LPT_DELTA_PUMP	per mil
Cd_114_110_LPT_DELTA_PUMP	d114/110Cd determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm)	per mil
SD1_Cd_114_110_LPT_DELTA_PUMP	One standard deviation of Cd_114_110_LPT_DELTA_PUMP	per mil
Fe_56_54_LPT_DELTA_PUMP	d56/54Fe determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm)	per mil
SD1_Fe_56_54_LPT_DELTA_PUMP	One standard deviation of Fe_56_54_LPT_DELTA_PUMP	per mil
Zn_66_64_LPT_DELTA_PUMP	d66/64Zn determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm)	per mil
SD1_Zn_66_64_LPT_DELTA_PUMP	One standard deviation of Zn_66_64_LPT_DELTA_PUMP	per mil
Cu_65_63_LPT_DELTA_PUMP	d65/63Cu determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm)	per mil
SD1_Cu_65_63_LPT_DELTA_PUMP	One standard deviation of Cu_65_63_LPT_DELTA_PUMP	per mil
Ni_UF_CONC_BOTTLE	Dissolved Ni in seawater (<0.02 µm)	nanomoles per kilogram (nmol/kg)
Cd_UF_CONC_BOTTLE	Dissolved Cd in seawater (<0.02 µm)	nanomoles per kilogram (nmol/kg)
Fe_UF_CONC_BOTTLE	Dissolved Fe in seawater (<0.02 µm)	nanomoles per kilogram (nmol/kg)

Zn_UF_CONC_BOTTLE	Dissolved Zn in seawater (<0.02 µm)	nanomoles per kilogram (nmol/kg)
Ni_TD_CONC_BOTTLE	Total dissolved Ni (<0.2 µm)	nanomoles per kilogram (nmol/kg)
Cd_TD_CONC_BOTTLE	Total dissolved Cd (<0.2 µm)	nanomoles per kilogram (nmol/kg)
Fe_TD_CONC_BOTTLE	Total dissolved Fe (<0.2 µm)	nanomoles per kilogram (nmol/kg)
Zn_TD_CONC_BOTTLE	Total dissolved Zn (<0.2 µm)	nanomoles per kilogram (nmol/kg)
Cu_TD_CONC_BOTTLE	Total dissolved Cu (<0.2 µm)	nanomoles per kilogram (nmol/kg)
Ni_SPT_CONC_PUMP	Ni determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm particles)	picomoles per kilogram (pmol/kg)
Cd_SPT_CONC_PUMP	Cd determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm particles)	picomoles per kilogram (pmol/kg)
Fe_SPT_CONC_PUMP	Fe determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm particles)	picomoles per kilogram (pmol/kg)
Zn_SPT_CONC_PUMP	Zn determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm particles)	picomoles per kilogram (pmol/kg)
Cu_SPT_CONC_PUMP	Cu determined by in situ filtration (pump) collected on a 0.8 µm filter (0.8-51 µm particles)	picomoles per kilogram (pmol/kg)
Ni_LPT_CONC_PUMP	Ni determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm particles)	picomoles per kilogram (pmol/kg)
Cd_LPT_CONC_PUMP	Cd determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm particles)	picomoles per kilogram (pmol/kg)
Fe_LPT_CONC_PUMP	Fe determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm particles)	picomoles per kilogram (pmol/kg)
Zn_LPT_CONC_PUMP	Zn determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm particles)	picomoles per kilogram (pmol/kg)
Cu_LPT_CONC_PUMP	Cu determined by in situ filtration (pump) collected on a 51 µm filter (>51 µm particles)	picomoles per kilogram (pmol/kg)

Ni_TP_CONC_BOTTLE	Total particulate Ni	picomoles per kilogram (pmol/kg)
Cd_TP_CONC_BOTTLE	Total particulate Cd	picomoles per kilogram (pmol/kg)
Fe_TP_CONC_BOTTLE	Total particulate Fe	picomoles per kilogram (pmol/kg)
Zn_TP_CONC_BOTTLE	Total particulate Zn	picomoles per kilogram (pmol/kg)
Cu_TP_CONC_BOTTLE	Total particulate Cu	picomoles per kilogram (pmol/kg)
Longitude	Longitude (positive values = East)	decimal degrees East
Latitude	Latitude (positive values = North)	decimal degrees North
Date	Date; format: MM/DD/YYYY	unitless
Time_UTC	Time (UTC); format: hh:mm:ss	unitless
ISO_DateTime_UTC	Date and time (UTC) formatted to ISO8601 standard: YYYY-MM-DDThh:mm:ssZ	unitless

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Instruments

Dataset-specific Instrument Name	multi-collector ICP-MS (Thermo Neptune) and high-resolution ICP-MS (Thermo Element 2)
Generic Instrument Name	Inductively Coupled Plasma Mass Spectrometer
Generic Instrument Description	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.

Dataset-specific Instrument Name	McLane pump
Generic Instrument Name	McLane Pump
Generic Instrument Description	McLane pumps sample large volumes of seawater at depth. They are attached to a wire and lowered to different depths in the ocean. As the water is pumped through the filter, particles suspended in the ocean are collected on the filters. The pumps are then retrieved and the contents of the filters are analyzed in a lab.

Dataset-specific Instrument Name	"Niskin-type" bottles
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.

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Deployments

RR1804

Website	https://www.bco-dmo.org/deployment/776766
Platform	R/V Roger Revelle
Start Date	2018-03-27
End Date	2018-04-13
Description	More information is available from R2R: https://www.rvdata.us/search/cruise/RR1804

SKQ201617S

Website	https://www.bco-dmo.org/deployment/828218
Platform	R/V Sikuliaq
Start Date	2016-12-20
End Date	2017-01-16
Description	Cruise DOI: 10.7284/907444 See more cruise information from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/SKQ201617S

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Project Information

The role of cryptic nutrient cycling within sinking particles on trace element transport in oxygen

minimum zones (OMZ Nutrient Cycling)

Coverage: Eastern Tropical North Pacific

NSF Award Abstract:
The major process controlling the internal cycling of biologically active trace metals in the oceans is through uptake onto and remineralization from sinking particles. Uptake can occur through active biological uptake into living cells as micronutrients, or chemical adsorption onto sinking materials. This latter process is often referred to as scavenging. The relative importance of these processes is often unclear, especially for elements that are both biologically active and also "particle reactive." The latter characteristic is associated with sparing solubility in seawater and the formation of strong complexes with surface sites, with examples such as iron. Recent evidence suggests that the simplistic view of a sinking particle as a passive surface for metal complexation may require some revision. Investigators James Moffett and Seth John propose to study the chemistry of transition metals within large sinking particles and the resultant effects on metal biogeochemical cycling. They will collaborate with a group at the University of Washington, recently funded to study the microbiology and molecular biology of these particles. The central hypothesis of this project is that reducing microbial microenvironments within large particles support high rates of nitrogen and sulfur cycling, greatly enhancing the particles' influence on metal chemistry. The investigators will study these processes in the Eastern Tropical North Pacific Oxygen Minimum Zone (OMZ). This regime was selected because of the wide range of redox conditions in the water column, and strong preliminary evidence that microenvironments within sinking particles have major biogeochemical impacts.

The primary objective is to investigate the interactions of metals with particles containing microenvironments that are more highly reducing than the surrounding waters. Such microenvironments arise when the prevailing terminal electron acceptor (oxygen, or nitrate in oxygen minimum zones) becomes depleted and alternative terminal electron acceptors are utilized. Within reducing microenvironments metal redox state and coordination chemistry are different from the bulk water column, and these microenvironments may dominate metal particle interactions. For example, reduction of sulfate to sulfide could bind metals that form strong sulfide complexes, such as cadmium and zinc, processes previously thought to be confined to sulfidic environments. Reducing microenvironments may account for the production of reduced species such as iron(II), even when their formation is thermodynamically unfavorable in the bulk water column. Tasks include observational characterization of dissolved and particulate trace metals and stable isotopes in the study area, sampling and in situ manipulation of particles using large-dimension sediment traps, shipboard experimental incubations under a range of redox conditions, and modeling, providing insight from microscopic to global scales. The metal chemistry data will be interpreted within a rich context of complimentary data including rates of nitrogen and sulfur cycling, phylogenetics and proteomic characterization of the concentration of key enzymes. Broader impacts include training of a postdoctoral scientist, international collaborations with Mexican scientists, and involvement of undergraduate students in the research.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1636332

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