Dissolved and particulate trace elements collected on cruise RR1604 (GO-SHIP transect IO9N) in the Eastern Indian Ocean from March to April 2016

Website: https://www.bco-dmo.org/dataset/767658
Data Type: Cruise Results
Version: 1
Version Date: 2019-05-13

Project
» Collaborative Research: Regional variation of phytoplankton diversity and biogeochemical functioning in the subtropical Indian Ocean (IO Phytoplankton)

Contributors	Affiliation	Role
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Abstract
This dataset includes measurements of dissolved and particulate trace elements collected on cruise RR1604 (GO-SHIP transect IO9N) in the Eastern Indian Ocean from March to April 2016.

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Coverage

Spatial Extent: **N**:17 **E**:95 **S**:-28.31 **W**:87.07
Temporal Extent: 2016-03-21 - 2016-04-28

Dataset Description

Dissolved and particulate trace elements collected on cruise RR1604 (GO-SHIP transect IO9N) in the Eastern Indian Ocean from March to April 2016.

Methods & Sampling

Samples were collected from 5 L Teflon-coated Niskin-X bottles hung on non-metal line, and clean techniques were followed throughout (Bruland et al., 1979). Niskin-X bottles were transferred to a clean lab immediately after retrieval. At most stations a single sample was collected from 20 m. Four-depth profiles extending to 200 m were collected at 6 stations along the transect.

For dissolved metal analysis, 300 mL of seawater was filtered through acid-washed 47 mm 0.4 µm polycarbonate filters into 250 mL LDPE bottles which were acid-cleaned following GEOTRACES protocols (Cutter et al., 2010). A vacuum filtration apparatus was used, with all parts in contact with the sample composed of acid-washed PFA. The assembly was rinsed with 3 aliquots of sample prior to sample collection. Samples were acidified with Optima HCl to 0.024 M, double bagged, and stored for analysis on shore.

Dissolved samples were analyzed using an ESI seaFAST SP2 coupled to a Perkin Elmer Nexion 350D ICP-MS. Sample aliquots were transferred to 30 mL LDPE bottles. Approximately 8 mL of sample was taken up to rinse and fill a 6 mL preconcentration loop. Samples were buffered in-line with resin-cleaned 4 M ammonium acetate buffer-adjusted to pH = 6.0 ± 0.1 and passed through an ESI pre-concentration column with a 200 µL resin bed volume. The final concentration of the buffer in the samples was 0.88 M. Metals were eluted off the column with 200 µL of 1.6 M Optima-grade HNO_3. Eluted metals passed through a PFA nebulizer, quartz spray chamber, and nickel cones on their way to an ammonia-filled dynamic reaction cell (0.55 mL/min flow).

Quantification was achieved by standard additions automated by the seaFAST system. A standard addition solution of 6.9 nM Fe, 46 nM Mn, 4.5 nM Zn, and 1.1 nM Pb was made in 0.024 M HCl. Concentrations in this solution were quantified using an external curve. Additions were introduced as the sample filled the preconcentration loop. The volume introduced by standard additions was kept constant, with 0.024 M Optima HCl making up the difference for samples with no additions. Each sample was spiked with 2 additions averaging roughly 100% and 200% of the sample concentration.

Approximately 4L of water from Niskin bottles was filtered for particulate metals. The bottles were pressurized to approximately 5 psi with 0.2 µm filtered air and seawater passed through 25 mm 0.4 µm Supor filter membranes. The membranes were housed in Swinnex polypropylene filter holders and attached to the Niskin-X bottles with Teflon tubing and polycarbonate fittings. The membrane was transferred to an acid washed petri-slide, double bagged, and kept frozen at -20°C for analysis on shore.

Labile and total particulate concentrations were analyzed through sequential digestion of the Supor membranes following protocol of Rauschenberg and Twining (2015). Membranes were first leached using an acetic acid-hydroxylamine solution (Berger et al., 2008) then transferred to a PFA vial and digested with a 4M HCl/4M HNO3/4M HF mixture (Ohnemus et al., 2014). Reference materials and process blanks – filters that had 2 L of 0.2 µm filtered seawater passed through them –were sequentially digested alongside the samples.

Digests were analyzed using a Thermo Element2 HR-ICP-MS equipped with a quartz nebulizer, cyclonic spray chamber, and nickel cones. Cd was analyzed in low resolution while all other elements were analyzed in medium resolution. In-115 was used as a drift monitor, and quantification was performed using an external curve.

Data Processing Description

Dissolved metal samples were instrument blank corrected and quantified using standard additions. Multiple 'process blanks' (0.024 M HCl spiked with 0.1% seawater) were run daily, and daily detection limits were calculated based on 3x the standard deviation of the process blanks.

All particulate ICP-MS data were normalized to an internal standard (In-115) and quantified using external calibration curves. Concentrations of each element per filter were calculated and the contribution of the process blank (measured as the elements contained in an acid-washed filter through which 0.2-µm filtered water was passed during the cruise) was then subtracted. Separate process blanks were calculated for the labile and total digestions. Element concentrations (per liter of water filtered) were calculated by dividing the per filter concentration by the volume of water passed through each filter.

Data quality:
Data are flagged with the following:
1 = Good data, passed QC;
3 = Questionable or suspect data, used when a data point was oceanographically inconsistent;
4 = Bad;
6 = Below detection limit.

BCO-DMO Processing: modified parameter names (removed units, replaced hyphens and spaces with underscores, added "_flag" to flag columns, replaced blank cells with "nd")

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Data Files

File
dissolved_and_particulate.csv (Comma Separated Values (.csv), 11.19 KB) MD5:3acb5950d4f65609b128ed1ee97e1d8a Primary data file for dataset ID 767658

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Supplemental Files

File
IO9N blanks and QC filename: IO9N_blanks_and_QC_for_BCODMO.xlsx (Microsoft Excel, 12.08 KB) MD5:65e14b249ca8cb18a7207c50faee4ab8 IO9N_blanks_and_QC_for_BCODMO.xlsx

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Related Publications

Berger, C. J. M., Lippiatt, S. M., Lawrence, M. G., & Bruland, K. W. (2008). Application of a chemical leach technique for estimating labile particulate aluminum, iron, and manganese in the Columbia River plume and coastal waters off Oregon and Washington. Journal of Geophysical Research, 113. doi:10.1029/2007jc004703 https://doi.org/10.1029/2007JC004703
Methods

Bruland, K. W., Franks, R. P., Knauer, G. A., & Martin, J. H. (1979). Sampling and analytical methods for the determination of copper, cadmium, zinc, and nickel at the nanogram per liter level in sea water. Analytica Chimica Acta, 105, 233–245. doi:10.1016/s0003-2670(01)83754-5 https://doi.org/10.1016/S0003-2670(01)83754-5
Methods

Cutter, G., Andersson, P., Codispoti, L., Croot, P., François, R., Lohan, M. C., Obata, H. and Rutgers v. d. Loeff, M. (2010). Sampling and Sample-handling Protocols for GEOTRACES Cruises, [Miscellaneous] Version 1. http://www.geotraces.org/libraries/documents/Intercalibration/Cookbook.pdf
Methods

Ohnemus, D. C., Auro, M. E., Sherrell, R. M., Lagerström, M., Morton, P. L., Twining, B. S., … Lam, P. J. (2014). Laboratory intercomparison of marine particulate digestions including Piranha: a novel chemical method for dissolution of polyethersulfone filters. Limnology and Oceanography: Methods, 12(8), 530–547. doi:10.4319/lom.2014.12.530
Methods

Rauschenberg, S., & Twining, B. S. (2015). Evaluation of approaches to estimate biogenic particulate trace metals in the ocean. Marine Chemistry, 171, 67–77. doi:10.1016/j.marchem.2015.01.004
Methods

Twining, B. S., Rauschenberg, S., Baer, S. E., Lomas, M. W., Martiny, A. C., & Antipova, O. (2019). A nutrient limitation mosaic in the eastern tropical Indian Ocean. Deep Sea Research Part II: Topical Studies in Oceanography. doi:10.1016/j.dsr2.2019.05.001
Results

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Parameters

Parameter	Description	Units

Station	Station number	unitless
Latitude	station latitude; positive values = North	degrees N
Longitude	station longitude; positive values = East	degrees E
Depth	sample depth	meters
dFe	dissolved iron	nanomolar (nM)
dFe_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
dMn	dissolved manganese	nM
dMn_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
dZn	dissolved zinc	nM
dZn_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
dPb	dissolved lead	nM
dPb_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Cd_Lab	labile particulate cadmium	pM
Cd_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Mo_Lab	labile particulate molybdenum	pM
Mo_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Pb_Lab	labile particulate lead	pM
Pb_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Ba_Lab	labile particulate barium	pM
Ba_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Al_Lab	labile particulate aluminum	pM
Al_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Mn_Lab	labile particulate manganese	pM
Mn_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Fe_Lab	labile particulate iron	pM
Fe_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless

Co_Lab	labile particulate cobalt	pM
Co_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Cu_Lab	labile particulate copper	pM
Cu_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Ni_Lab	labile particulate nickel	pM
Ni_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
P_Lab	labile particulate phosphorus	nM
P_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Ti_Lab	labile particulate titanium	pM
Ti_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
V_Lab	labile particulate vanadium	pM
V_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Zn_Lab	labile particulate zinc	pM
Zn_Lab_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Cd_Tot	total particulate cadmium	pM
Cd_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Mo_Tot	total particulate molybdenum	pM
Mo_Tot_Flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Pb_Tot	total particulate lead	pM
Pb_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Ba_Tot	total particulate barium	pM
Ba_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Al_Tot	total particulate aluminum	pM
Al_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Mn_Tot	total particulate manganese	pM

Mn_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Fe_Tot	total particulate iron	pM
Fe_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Co_Tot	total particulate cobalt	pM
Co_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Cu_Tot	total particulate copper	pM
Cu_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Ni_Tot	total particulate nickel	pM
Ni_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
P_Tot	total particulate phosphorus	nM
P_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Ti_Tot	total particulate titanium	pM
Ti_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
V_Tot	total particulate vanadium	pM
V_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless
Zn_Tot	total particulate zinc	pM
Zn_Tot_flag	quality flag for element indicated: 1 = Good data, passed QC; 3 = Questionable or suspect data, used when a data point was oceanographically inconsistent; 4 = Bad; 6 = Below detection limit.	unitless

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Instruments

Dataset-specific Instrument Name	Perkin Elmer Nexion 350D ICP-MS
Generic Instrument Name	Inductively Coupled Plasma Mass Spectrometer
Dataset-specific Description	ESI seaFAST SP2 coupled to a Perkin Elmer Nexion 350D ICP-MS was used for dissolved element analysis.
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	Thermo Element2 HR-ICP-MS
Generic Instrument Name	Inductively Coupled Plasma Mass Spectrometer
Dataset-specific Description	Thermo Element2 HR-ICP-MS was used for particulate analysis.
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	Teflon-coated Niskin-X 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

RR1604

Website	https://www.bco-dmo.org/deployment/723194
Platform	R/V Roger Revelle
Start Date	2016-03-21
End Date	2016-04-28

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Project Information

Collaborative Research: Regional variation of phytoplankton diversity and biogeochemical functioning in the subtropical Indian Ocean (IO Phytoplankton)

Coverage: GO-SHIP IO9N transect: 20S 95E to 20N 95E

Description from NSF award abstract:
The Indian Ocean accounts for nearly a fifth of global ocean photosynthesis and is likely a key component in global ocean nutrient and carbon cycles. However, the Indian Ocean may be the least studied major marine body on the planet. Our limited understanding suggests extensive variations in physical and chemical environmental conditions, but how this variation influences biodiversity, nutrient stress, and more broadly regional differences in the functioning of phytoplankton is unknown. To help address these gaps, the investigators will conduct a study by joining an already-funded major research cruise to this region. It will cover a northern region with some of the highest temperatures recorded in open ocean waters, an area around 10°S of predicted (but not tested in situ) iron stress, and a southern subtropical gyre with unique nitrogen to phosphorous(or N:P) ratios. The focus of this project is to quantify and synthesize the interconnectedness of environmental conditions, phytoplankton diversity and genome content, and nutrient biogeochemistry, with the goal of understanding how these may lead to unique biogeochemical regions in Indian Ocean. The research will have broader impacts on many levels. First, it will increase public awareness of the role of phytoplankton on ocean functioning, climate, and people's lives through a new partnership with the Aquarium of the Pacific (AOP), which is the fourth most-attended aquarium in the nation. Secondly, the project will train a postdoctoral scholar as well as a graduate and undergraduate students. Third, the research will dramatically increase our basic knowledge ocean biogeochemistry and in many cases will be the first measurements of their kind made in the Indian Ocean.

This project will address two major questions: How do environmental conditions, phytoplankton diversity, phytoplankton physiology, and biogeochemistry vary across the central Indian Ocean? Are there distinct biogeochemical regimes in the central IO? The researchers hypothesize that environmental conditions, including the relative availability of nitrogen (N) and iron (Fe), lead to three distinct phytoplankton communities and biogeochemical regimes. They will employ a series of advanced analytical tools including high sensitivity measurements of dissolved and particulate nutrients (nitrogen, phosphorus, and iron), genomics, bioassays to test for nutrient stress, and cell-sorting of specific taxa followed by measures of nutrient content and uptake. A focus of this project is to quantify and synthesize the interconnectedness of environmental conditions, phytoplankton diversity and genome content, and nutrient biogeochemistry, and how these lead to unique biogeochemical regions in Indian Ocean. This extensive set of observations can ultimately be linked to ocean models and satellite data to provide a comprehensive view of regional differences in chemistry, biodiversity and phytoplankton biogeochemical functioning in the Indian Ocean.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1559021

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