

# Nutrients, cobalt, dissolved iron, and dissolved manganese from trace metal bottles from R/V Knorr cruise KN192-05 in the South Atlantic subtropical gyre and Benguela upwelling region in 2007 (CoFeMUG project)

**Website:** <https://www.bco-dmo.org/dataset/3233>

**Data Type:** Cruise Results

**Version:** 2

**Version Date:** 2013-03-20

## Project

» [Cobalt, Iron and Micro-organisms from the Upwelling zone to the Gyre](#) (CoFeMUG)

## Programs

» [Ocean Carbon and Biogeochemistry](#) (OCB)

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

Contributors	Affiliation	Role
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## Abstract

Analysis of nutrients, Cobalt (total and labile), dissolved Iron, and dissolved Manganese of water samples drawn from Trace Metal Rosette (TMR) bottle casts.

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## Coverage

**Spatial Extent:** N:-11 E:14.5 S:-25 W:-30

**Temporal Extent:** 2007-11-18 - 2007-12-11

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## Dataset Description

Analysis of nutrients, Cobalt (total and labile), dissolved Iron, and dissolved Manganese of water samples drawn from Trace Metal Rosette (TMR) bottle casts.

See Related Publications: Noble et al. (2012) and Sohm et al. (2011)

## Acquisition Description

Three transects were sampled using the Trace Metal Rosette (TMR) on the CoFeMUG cruise aboard R/V Knorr in 2007. Refer to Noble et al. (2012) for detailed information on acquisition and processing.

**Nutrient Analyses:** Technicon AutoAnalyzer II components were used to measure phosphate and ammonium. Alpkem rapid flow analyzer (RFA) 300 components were used to measure silicic acid, nitrate+nitrite, and nitrite.

**Cobalt Analyses:** Total dissolved and labile cobalt concentrations were determined using cathodic stripping voltammetry, previously described by Saito and Moffet (2001) and Saito et al. (2004). Measurements were made using Eco-Chemie uAutolab-III systems connected to Metrohm 663 VA Stands with hanging mercury drop electrodes and Teflon sampling cups.

**Iron and Manganese Analyses:** Total dissolved iron and manganese concentrations were measured using inductively coupled plasma mass spectrometry (ICP-MS). SAFe seawater intercalibration standards were analyzed at the beginning of each analysis day with iron concentrations of  $0.96 \pm 0.095$  nmol L<sup>-1</sup> for D2 and  $0.125 \pm 0.046$  nmol L<sup>-1</sup> for S1 (n = 10), which are within the reported ranges of  $0.91 + 0.17$  nmol L<sup>-1</sup> and  $0.097 + 0.043$  nmol L<sup>-1</sup> (Johnson et al. 2007).

## Processing Description

Asterisks next to some values for Fe and Mn denote samples where contamination is suspected. Quality flags indicate values below detection limits and potentially erroneous data according to the codes below.

### **Quality Flag Codes:**

**0** = no quality control = No quality control procedures have been applied to the data value. This is the initial status for all data values entering the working archive.

**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.

**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.

**5** = changed value = Data value adjusted during quality control. Best practice strongly recommends that the value before the change be preserved in the data or its accompanying metadata.

**6** = value below detection = The level of the measured phenomenon was too small to be quantified by the technique employed to measure it. The accompanying value is the detection limit for the technique or zero if that value is unknown.

**7** = missing = Bottle didn't trip or sample wasn't taken.

### **BCO-DMO Processing Notes:**

-Modified original parameter names to conform with BCO-DMO naming conventions;

-Missing values (blank) were replaced with 'nd' to indicate 'no data'.

History:

7 October 2009 - nutrients and preliminary Co data submitted to BCO-DMO; awaiting documentation from originating PI.

February 2010 - units for nutrient data confirmed to be micromolar; Cobalt measurements will be added in the future and are picomolar.

20 March 2013 - Co, Fe, Mn data submitted and joined to nutrients. Quality flags were also added by investigator.

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## **Related Publications**

Johnson, K. S., Boyle, E., Bruland, K., Coale, K., Measures, C., Moffett, J., ... Wu, J. (2007). Developing Standards for Dissolved Iron in Seawater. *Eos, Transactions American*

Geophysical Union, 88(11), 131. doi:10.1029/2007eo110003

<https://doi.org/10.1029/2007EO110003> [details]

Noble, A. E., Lamborg, C. H., Ohnemus, D. C., Lam, P. J., Goepfert, T. J., Measures, C. I., ... Saito, M. A. (2012). Basin-scale inputs of cobalt, iron, and manganese from the Benguela-Angola front to the South Atlantic Ocean. *Limnology and Oceanography*, 57(4), 989–1010. doi:10.4319/lo.2012.57.4.0989 [details]

Saito, M. A., & Moffett, J. W. (2001). Complexation of cobalt by natural organic ligands in the Sargasso Sea as determined by a new high-sensitivity electrochemical cobalt speciation method suitable for open ocean work. *Marine Chemistry*, 75(1-2), 49–68. doi:10.1016/s0304-4203(01)00025-1 [https://doi.org/10.1016/S0304-4203\(01\)00025-1](https://doi.org/10.1016/S0304-4203(01)00025-1) [details]

Saito, M. A., Moffett, J. W., & DiTullio, G. R. (2004). Cobalt and nickel in the Peru upwelling region: A major flux of labile cobalt utilized as a micronutrient. *Global Biogeochemical Cycles*, 18(4), n/a–n/a. doi:10.1029/2003gb002216 <https://doi.org/10.1029/2003GB002216> [details]

Sohm, J. A., Hilton, J. A., Noble, A. E., Zehr, J. P., Saito, M. A., & Webb, E. A. (2011). Nitrogen fixation in the South Atlantic Gyre and the Benguela Upwelling System. *Geophysical Research Letters*, 38(16), n/a–n/a. doi:10.1029/2011gl048315 <https://doi.org/10.1029/2011GL048315> [details]

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## Parameters

Parameter	Description	Units
cruise_id	Ship's cruise designation	dimensionless
sta	Station number	dimensionless
cast	Cast number	dimensionless
date	date; reported in GMT as YYYYMMDD (year; month; day)	YYYYMMDD
year	year, reported as YYYY	YYYY
mon	month of year; numeric 1 to 12	MM
day	day of month; numeric 1 to 31	DD
time	time of day; reported in GMT as hhmm	hhmm
lon_360	longitude ranging from 0 to 360 degrees	decimal degrees
lon	longitude; East is positive, West is negative	decimal degrees

lat	latitude; North is positive, South is negative	decimal degrees
depth_w	water depth, in meters	meters
depth	Sample depth	meters
PO4	Phosphate concentration in uM.	micromolar
NO3_NO2	Nitrate plus nitrite concentration in uM. (Originally named 'N+N'.)	micromolar
SiO4	Silicate (Orthosilicic Acid) concentration in uM.	micromolar
NO2	Nitrite concentration in uM.	micromolar
NH4	Ammonium concentration in uM.	micromolar
run_id	run ID of sample	dimensionless
ev_code	event code; type and number of sampling event; matches cruise event log	dimensionless
Co_tot	Total Cobalt concentration in pM. (Originally named 'TCo'.)	picomolar
Co_labile	Concentration of labile Cobalt in pM. (Originally named Co'.) Note: It_0.75 = less than 0.75.	picomolar
Fe_Td	Total dissolved Iron concentration in nM.	nanomolar
Mn_Td	Total dissolved Manganese concentration in nM.	nanomolar
NO3_NO2_flag	Quality flag for NO3_NO2. See 'Processing Description' for code definitions.	dimensionless
PO4_flag	Quality flag for PO4. See 'Processing Description' for code definitions.	dimensionless
SiO4_flag	Quality flag for SiO4. See 'Processing Description' for code definitions.	dimensionless
NO2_flag	Quality flag for NO2. See 'Processing Description' for code definitions.	dimensionless
NH4_flag	Quality flag for NH4. See 'Processing Description' for code definitions.	dimensionless
Co_tot_flag	Quality flag for Co_tot. See 'Processing Description' for code definitions.	dimensionless
Co_labile_flag	Quality flag for Co_labile. See 'Processing Description' for code definitions.	dimensionless

Fe_Td_flag	Quality flag for Fe_Td. See 'Processing Description' for code definitions.	dimensionless
Mn_Td_flag	Quality flag for Mn_Td. See 'Processing Description' for code definitions.	dimensionless
ISO_DateTime_UTC	Date/Time (UTC) formatted to ISO8601 standard. T indicates start of time string; Z indicates UTC. Generated from original date and time fields.	YYYY-mm-ddTHH:MM:SS.ssZ

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## Instruments

<b>Dataset-specific Instrument Name</b>	Trace Metal Bottle
<b>Generic Instrument Name</b>	Trace Metal Bottle
<b>Dataset-specific Description</b>	Trace Metal Rosette (11 bottle) plus CTD
<b>Generic Instrument Description</b>	Trace metal (TM) clean rosette bottle used for collecting trace metal clean seawater samples.

<b>Dataset-specific Instrument Name</b>	Nutrient Autoanalyzer
<b>Generic Instrument Name</b>	Nutrient Autoanalyzer
<b>Dataset-specific Description</b>	Technicon AutoAnalyzer II components and Alpkem rapid flow analyzer (RFA) 300 components were used to measure nutrients.
<b>Generic Instrument Description</b>	Nutrient Autoanalyzer is a generic term used when specific type, make and model were not specified. In general, a Nutrient Autoanalyzer is an automated flow-thru system for doing nutrient analysis (nitrate, ammonium, orthophosphate, and silicate) on seawater samples.

<b>Dataset-specific Instrument Name</b>	Metrohm 663 VA Stand mercury electrode
<b>Generic Instrument Name</b>	Metrohm 663 VA Stand mercury electrode
<b>Generic Instrument Description</b>	The Metrohm 663 VA stand forms the wet chemical part of a polarographic and voltammetric analytical system. It features a mercury electrode, an Ag/AgCl reference electrode and a glassy carbon counter electrode. The size of the mercury drop and the stirrer speed are set manually on the VA Stand. The VA Stand can be operated in Dropping Mercury Electrode (DME), Hanging Mercury Drop Electrode (HMDE) and Static Mercury Drop Electrode (SMDE) modes. The VA Stand can be controlled by a potentiostat in conjunction with the Metrohm IME663 interface.

<b>Dataset-specific Instrument Name</b>	Voltammetry Analyzers
<b>Generic Instrument Name</b>	Voltammetry Analyzers
<b>Dataset-specific Description</b>	Eco-Chemie uAutolab-III systems were used.
<b>Generic Instrument Description</b>	Instruments that obtain information about an analyte by applying a potential and measuring the current produced in the analyte.

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## Deployments

### KN192-05

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/57852">https://www.bco-dmo.org/deployment/57852</a>
<b>Platform</b>	R/V Knorr
<b>Report</b>	<a href="http://bcodata.whoi.edu/CoFeMUG/CruiseReport_KN192-5.pdf">http://bcodata.whoi.edu/CoFeMUG/CruiseReport_KN192-5.pdf</a>
<b>Start Date</b>	2007-11-16

<b>End Date</b>	2007-12-13
<b>Description</b>	<p>The South Atlantic subtropical gyre and Benguela Upwelling region were sampled for chemistry and biological properties relating to the trace metal nutrition and phytoplankton diversity and productivity. Specifically cobalt and iron dissolved seawater concentrations will be measured and related to the abundance of cyanobacteria including nitrogen fixers and eukaryotic phytoplankton. The phytoplankton of the Benguela Upwelling region were also examined to determine if their growth was iron or cobalt limited. A total of 27 station locations were occupied in the study area to collect the water chemistry and biological samples for these analyses (see cruise track). Iron and cobalt analyses will be conducted using inductively coupled plasma mass spectrometry and cathodic stripping voltammetry electrochemical methods. The sample preparation and subsequent analyses are technically demanding, but data generated from the cruise samples are being contributed beginning in mid 2009. The CoFeMUG KN192-5 cruise was supported by NSF OCE award # 0452883 <a href="http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0452883">http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0452883</a> A station map showing the 27 sampling locations is available as a PDF file. Original cruise data are available from the NSF R2R data catalog CoFeMUG - South Atlantic 2007 Cruise Participant List 1. Mak Saito (Chief Scientist/WHOI) 2. Abigail Noble (Saito/WHOI) 3. Alysia Cox (Saito/WHOI) 4. Whitney Krey (DeLong/Saito/MIT/WHOI) 5. Carl Lamborg (clamborg AT whoi.edu/WHOI) 6. Phoebe Lam (pjlam AT whoi.edu WHOI) 7. Chad Hammerschmidt (chammerschmidt AT whoi.edu, Wright State) 8. Caitlin Frame (cframe AT whoi.edu, WHOI/Casciotti Student) 9. Tyler Goepfert (tgoepfert AT whoi.edu Webb/Saito) 10. Jill Sohm (sohm AT usc.edu) 11. Maria Intermaggio 12. Jack DiTullio (leep AT cofc.edu U. Charleston) 13. Peter Lee (DiTullio U. Charleston) 14. Sarah Riseman (DiTullio U. Charleston) 15. Amanda McLenan (amanda.mclennon AT gmail.com, DiTullio U. Charleston) 16. Mike Seracki (Bigelow) 17. Nicole Poulton (Bigelow) 18. Juan Alba, juanalba AT usp.br (Bigelow) 19. Jane Heywood (Bigelow) 20. Gabrielle Rocap (rocap AT whoi.edu, U. Washington) 21. Emily Nahas (enahas AT u.washington.edu) 22. Michele Wrable (mlw22 AT u.washington.edu) 23. Bob Morris (rmorris AT lifesci.ucsb.edu) 24. Christian Frazar (Chris, U. Washington, Morris lab) 25. Jason Hilton (Zehr, UCSC) 26. Reserved for Angolan Observers 27. Reserved for Angolan Observers Collecting GEOTRACES-compliant samples for: 1. Laura Robinson (Pa Th isotopes) 2. Bob Anderson (Pa Th isotopes - intercalibration) 3. Olivier Rouxel (Se and Fe isotopes) 4. Karen Casciotti (N isotopes) 5. Ben Reynolds (Si and Fe isotopes) 6. Chris Measures (Al) 7. Kristin Buck (FeL)</p>



## Project Information

### Cobalt, Iron and Micro-organisms from the Upwelling zone to the Gyre (CoFeMUG)

**Coverage:** South Atlantic subtropical gyre and Benguela upwelling region

The geochemistries of dissolved cobalt (Co) and iron (Fe) in the oceanic water column share several characteristics such as extremely low concentrations, redox chemistry, low solubility, and utilization as micronutrients by marine microbes. Iron has been the subject of considerable research focus in recent years due to its role in limiting phytoplankton productivity in oceanic and coastal upwelling environments. Cobalt has been much less studied, but recent data show it may be important in influencing primary productivity or phytoplankton community composition in certain geographical areas. The CoFeMUG project predated GEOTRACES, so while it is not formally recognized as a GEOTRACES section, it is considered a GEOTRACES-related project and the CoFeMUG data are GEOTRACES compliant. State-of-the-art geochemical and molecular biological techniques were used to address biogeochemical questions in the South Atlantic, and focus especially on the two trace metals, cobalt and iron. The 27-day cruise in November and December 2007 to the South Atlantic was designed to study cobalt and iron biogeochemistry and focus on four major hypotheses. (1) Large fluxes of labile cobalt are associated with upwelling systems even in Aeolian dominated environments. (2) Cobalt and phosphate show correlations in (and only in) surface waters due to micronutrient utilization and rapid remineralization. The slope of the correlation is dependent on the chemical speciation of cobalt. (3) The absence of *Trichodesmium* populations in the subtropical and tropical South Atlantic is caused by iron limitation. (4) Based on work from the California and Peru Upwelling regimes, primary productivity in the Benguela upwelling regime off of South West Africa may be iron limited or iron-cobalt colimited. A combination of geochemical and biological/molecular analyses were made across an oligotrophic-upwelling transition to examine how changing metal regimes affect the physiology and growth of the important primary producers *Trichodesmium* and *Synechococcus*. CoFeMUG project results are published in: Noble, Abigail E., Carl H. Lamborg, Dan C. Ohnemus, Phoebe J. Lam, Tyler J. Goepfert, Chris I. Measures, Caitlin H. Frame, Karen L. Casciotti, Giacomo R. DiTullio, Joe Jennings, and Mak A. Saito (2012) Basin-scale inputs of cobalt, iron, and manganese from the Benguela-Angola front to the South Atlantic Ocean. *Limnology & Oceanography*. Vol. 57(4), July 2012. pgs 989-1010. doi:10.4319/lo.2012.57.4.0989 ([www.aslo.org/lo/toc/vol\\_57/issue\\_4/0989.pdf](http://www.aslo.org/lo/toc/vol_57/issue_4/0989.pdf))

## **Program Information**

### **Ocean Carbon and Biogeochemistry (OCB)**

**Website:** <http://us-ocb.org/>

**Coverage:** Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF. The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems. The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO<sub>2</sub> and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two. The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

### **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
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-0452883</a>

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