Dissolved trace metals and macronutrients from samples collected using GoFlo on R/V Melville MV1405 (IRN-BRU) cruise in the California Current System in July 2014

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Project
» Accomplishment Based Renewal: An iron limitation mosaic within the central California Current System (iron limitation mosaic)

Contributors	Affiliation	Role
Bruland, Kenneth W.	University of California-Santa Cruz (UCSC)	Principal Investigator
Coale, Tyler	University of California-Santa Cruz (UCSC)	Scientist
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Abstract
This is a suite of dissolved trace metal concentrations, along with macronutrient concentrations, on a cruise investigating the mosaic of the California Current System in July 2014. It includes depth profiles of an active upwelling site nearshore over the shelf in northern California (Station 2), a more aged upwelling site offshore of the shelf break in southern Oregon (Station 28), a station in the Santa Barbara Basin that got suboxic in the lower depths of the water column (Station 29), and a set of stations (9, 12 and 15) that show two cyclonic eddies, one two months younger (station 9) than the other (station 15), but both coming from roughly the same place and moving offshore, with station 12 in between them in an offshoot of the California Current. This dataset also includes transects in some of these locations. Transect 2 started at station 2 and followed the upwelled plume offshore. Transect 5 went through the eddy stations. Transects 8 and 9 went through the plume measured in station 28. The chief scientist of the cruise was Ken Bruland. Trace metal samples were analyzed by Claire Till (nee Parker) as his graduate student. Nutrient samples were analyzed by Tyler Coale. Trace metal samples were collected on a non-metal line with teflon-coated GoFlos; nutrient samples were analyzed from both the GoFlos and from a regular rosette.

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Coverage

Location: The California Current System, 33-44N, 118-128W, surface to 1500m max
Spatial Extent: **N**:42.667 **E**:-120.026 **S**:34.231 **W**:-126.752
Temporal Extent: 2014-07-06 - 2014-07-24

Methods & Sampling

Nitrate-nitrite, Phosphate, Silicate, Nitrite:

Samples were collected from a trace-metal clean towed-fish system (Bruland et al., 2001) (transects), from teflon-coated Go-Flos on a non-metal line, and from the ship's rosette. Samples were analyzed shortly after collection at sea using standard spectrophotometric methods (Parsons 1984) on a Lachat QuickChem 8000 Flow Injection Analysis System.

Dissolved trace metals:

Depth profiles were taken using individual teflon-coated GoFlo bottles on a non-metal line, which were sampled in a trace metal clean van at sea. Surface samples for transects were sampled using a tow-fish system (Bruland et al., 2001). Samples were filtered directly from the GoFlo through 0.2 µm Acropak Supor membrane capsule filters into pre-cleaned LDPE bottles. The acropaks were pre-cleaned and flushed with at least 250 mL of sample before sampling. Sample bottles were pre-cleaned cleaned rigorously as per the GEOTRACES cookbook (Cutter et al., 2014), and were rinsed with sample three times before filling. Samples were acidified at sea to a pH of ~1.7 with quartz-distilled 6 M HCl (4 mL per liter) and stored for analysis post-cruise. Samples were analyzed for trace metals after the cruise with the method of Biller and Bruland (2012), with modifications as described in Parker et al. (2016). Briefly, this involves buffering the seawater to pH 6.0 ± 0.2 immediately before pre-concentrating on PA1 resin. The resin was extracted with 1 N optima nitric acid with rhodium as an internal standard. Extracts were analyzed on the Thermo Fisher Element 2 extended range ICP-MS at UC Santa Cruz.

Iron was additionally analyzed shipboard with a flow injection analysis method published in Lohan et al. (2006) with modifications as described in Biller et al. (2013). Briefly, this method involves pre-concentrating the iron on a toyopearl column at pH 2, eluting it into a buffered (pH ~5.7) reaction stream that contains DPD, a molecule that turns pink when oxidized by iron. H2O2 is also in the reaction stream, which re-oxidizes the iron, so that each iron molecule can react with multiple DPD molecules, another mechanism to increase the iron signal. The reaction stream absorbance is measured with a flow through spectrophotometer.

Generally, the measurements from these two methods for Fe agreed well; where there was a problem with one or the other dataset, we only report one dataset.

Data Processing Description

For the surface transect data, we did not have nutrient data and trace metal data taken from exactly the same moment. In order to directly compare the two datasets, the nutrient data was interpolated based on time to align with the trace metal data.

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Related Publications

Abdala, Z. M., Clayton, S., Einarsson, S. V., Powell, K., Till, C. P., Coale, T. H., & Chappell, P. D. (2022). Examining ecological succession of diatoms in California Current System cyclonic mesoscale eddies. Limnology and Oceanography, 67(11), 2586–2602. Portico. https://doi.org/10.1002/lno.12224
Results

Biller, D. V., & Bruland, K. W. (2012). Analysis of Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb in seawater using the Nobias-chelate PA1 resin and magnetic sector inductively coupled plasma mass spectrometry (ICP-MS). Marine Chemistry, 130-131, 12–20. doi:10.1016/j.marchem.2011.12.001
Methods

Biller, D. V., Coale, T. H., Till, R. C., Smith, G. J., & Bruland, K. W. (2013). Coastal iron and nitrate distributions during the spring and summer upwelling season in the central California Current upwelling regime. Continental Shelf Research, 66, 58–72. https://doi.org/10.1016/j.csr.2013.07.003
Methods

Boiteau, R. M., Till, C. P., Coale, T. H., Fitzsimmons, J. N., Bruland, K. W., & Repeta, D. J. (2018). Patterns of iron and siderophore distributions across the California Current System. Limnology and Oceanography, 64(1), 376–389. Portico. https://doi.org/10.1002/lno.11046

Results

Bruland, K. W., Rue, E. L., & Smith, G. J. (2001). Iron and macronutrients in California coastal upwelling regimes: Implications for diatom blooms. Limnology and Oceanography, 46(7), 1661–1674. Portico. https://doi.org/10.4319/lo.2001.46.7.1661
Methods

Cutter, G.A., Andersson, P., Codispoti, L., Croot, P., Francois, R., Lohan, M., Obata, H., van der Loeff, M. R. (2014) Sampling and Sample-Handing Protocols for GEOTRACES Cruises (cookbook) Version 2.0; December 2014. http://www.geotraces.org/images/stories/documents/intercalibration/Cookbook_v2.pdf
Methods

Lohan, M. C., Aguilar-Islas, A. M., & Bruland, K. W. (2006). Direct determination of iron in acidified (pH 1.7) seawater samples by flow injection analysis with catalytic spectrophotometric detection: Application and intercomparison. Limnology and Oceanography: Methods, 4(6), 164–171. Portico. https://doi.org/10.4319/lom.2006.4.164
Methods

McNair, H. M., Brzezinski, M. A., Till, C. P., & Krause, J. W. (2017). Taxon-specific contributions to silica production in natural diatom assemblages. Limnology and Oceanography, 63(3), 1056–1075. Portico. https://doi.org/10.1002/lno.10754
Results

Parker, C. E., Brown, M. T., & Bruland, K. W. (2016). Scandium in the open ocean: A comparison with other group 3 trivalent metals. Geophysical Research Letters, 43(6), 2758–2764. Portico. https://doi.org/10.1002/2016gl067827 https://doi.org/10.1002/2016GL067827
Methods

Till, C. P., Solomon, J. R., Cohen, N. R., Lampe, R. H., Marchetti, A., Coale, T. H., & Bruland, K. W. (2018). The iron limitation mosaic in the California Current System: Factors governing Fe availability in the shelf/near-shelf region. Limnology and Oceanography, 64(1), 109–123. Portico. https://doi.org/10.1002/lno.11022
Results

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	tow-fish system
Generic Instrument Name	GeoFish Towed near-Surface Sampler
Dataset-specific Description	Surface samples for transects were sampled using a tow-fish system (Bruland et al., 2001).
Generic Instrument Description	The GeoFish towed sampler is a custom designed near surface (

Dataset-specific Instrument Name	Teflon coated GO-Flo bottles
Generic Instrument Name	GO-FLO Bottle
Dataset-specific Description	Samples were collected with Teflon coated GO-Flo bottles (General Oceanics).
Generic Instrument Description	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.

Dataset-specific Instrument Name	Lachat QuickChem 8000 Flow Injection Analysis System
Generic Instrument Name	Lachat QuikChem 8000 flow injection analyzer and Ion Chromatography (IC) system
Dataset-specific Description	Nutrients were analyzed with a Lachat QuickChem 8000 Flow Injection Analysis System.
Generic Instrument Description	The Lachat QuikChem 8000 can operate flow injection analysis and ion chromatography simultaneously and independently on the same instrument platform. Instrument includes sampler, dilutor, sampling pump, electronics unit, and data station. Analysis takes 20-60 seconds, with a sample throughput of 60-120 samples per hour. Measurements are in the range of parts per trillion to parts per hundred.

Dataset-specific Instrument Name	Thermo Element XR magnetic sector inductively coupled plasma mass spectrometer (ICP-MS)
Generic Instrument Name	Thermo Scientific ELEMENT XR high resolution inductively coupled plasma mass spectrometer
Dataset-specific Description	Trace metal extracts were analyzed with a Thermo Element XR magnetic sector inductively coupled plasma mass spectrometer (ICP-MS)
Generic Instrument Description	A high-resolution (HR) inductively coupled plasma (ICP) mass spectrometer (MS) composed of a dual mode secondary electron multiplier (SEM) and a Faraday detector. The ELEMENT XR instrument has a dynamic range of 5 x 10^7 to 1 x 10^12 counts per second (cps), and allows simultaneous measurement of elements at concentrations over 1000 ug/g.

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Deployments

MV1405

Website	https://www.bco-dmo.org/deployment/559966
Platform	R/V Melville
Start Date	2014-07-03
End Date	2014-07-26
Description	Deployment MV1405 on R/V Melville. Cruise took place during July 2014.

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Project Information

Accomplishment Based Renewal: An iron limitation mosaic within the central California Current System (iron limitation mosaic)

NSF Award Abstract:
Eastern boundary upwelling systems have long been recognized for their high phytoplankton productivity. Carr and Kearns (2003), in a detailed comparison of eastern boundary current systems, reported that biomass sustained by a given macronutrient concentration in Atlantic eastern boundary current systems was twice as large as those systems in the Pacific. The authors concluded "It is not clear whether the apparent difference in biomass supported by available nutrients is due to differences in the efficiency of the phytoplankton community, perhaps related to the availability of iron, or to grazing pressure." They suggested that the width of the shelf might be considered a proxy for the benthic availability of iron. The lowest biomass for a given macronutrient concentration was in the Peru-Humboldt Current and in the northern California region of the California Current System, both areas with low dust inputs and a relatively narrow shelf.

In this Accomplishment Based Renewal project, a marine trace metal geochemist at the University of California - Santa Cruz and his students and colleagues will continue a decades-old quest to understand the role of iron in the central California Current System (cCCS). Field efforts will combine continuous underway iron and nutrient data in surface waters and a series of vertical profiles. The focus will include three regions within the cCCS: a variety of active Fe-replete and Fe-deplete coastal upwelling regimes, the eddy-rich California Current transition zone that is Fe-limited and has elevated nitrate but relatively low and uniform chlorophyll concentrations, and the offshore, oligotrophic California Current. They will map surface and depth distributions of Fe and other micro- and macronutrients. There are four specific goals dealing with characterizing the organic Fe(III)-binding organic ligands, determining Fe(II) and Fe(III) concentrations in hypoxic waters over the shelf, examining the exchange between particulate and dissolved forms of Fe, and studying the roles of eddies in the eddy-rich transition waters of the cCCS.

Broader Impacts

Direct Benefits to Science: There is a great deal of interest in the CCS because of its importance in terms of phytoplankton productivity and the support of higher trophic levels. Until now, the emphasis in studies of the CCS has been on relationships between physics and biology. This study will insert the important role of micronutrient chemistry into the picture. It will also serve an important role in securing ship time in advance and providing logistical support for other collaborative studies. This is extremely valuable and cost effective for collaborating scientists since with the hydrography, nutrient and trace metal data provided, they can focus on their complimentary research efforts.

Outreach and Education: The project will provide funding for two current graduate students at UCSC, where they will also receive course training in a curriculum that includes i) scientific communication, ii) careers in marine science, and iii) grant writing. A broader impact goal of this project is to facilitate teaching and learning on marine science-related topics through translating research objectives into widely distributed educational materials for classroom use. To accomplish this, the team will partner with the Seymour Discovery Center at the Long Marine Lab, UCSC. The Discovery Center receives 14,000 visitors each year, and the project will provide funds to develop an interactive display on limiting nutrients and phytoplankton bloom development in the CCS.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1259776

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