Dissolved iron concentrations from an iron incubation experiment using upwelled waters in the California Current System during the PUPCYCLE II cruise in May and June 2023

Website: https://www.bco-dmo.org/dataset/1004007
Data Type: experimental, Cruise Results
Version: 1
Version Date: 2026-08-06

Project
» CAREER: An integrated molecular and physiological approach to examining the dynamics of upwelled phytoplankton in current and changing oceans (Upwelled Phytoplankton Dynamics)

Contributors	Affiliation	Role
Marchetti, Adrian	University of North Carolina at Chapel Hill (UNC-Chapel Hill)	Principal Investigator
Till, Claire P.	Cal Poly Humboldt (formerly Humboldt State University)	Scientist
Till, Ralph C.	Cal Poly Humboldt (formerly Humboldt State University)	Scientist
Gerlach, Dana Stuart	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset presents dissolved iron concentrations [**not applicable as main topic?** includes physiological measurements] from an iron incubation experiment using upwelled waters sampled in the California Current System (CCS) during the PUPCYCLE II cruise with Chief Scientist Adrian Marchetti. PUPCYCLE II (Phytoplankton response to the UPwelling CYCLE) took place onboard the R/V Sally Ride from May 29th to June 10th, 2023. Seawater for the incubation experiment was collected within the northern CCS, off the southern coast of Oregon at 43°02'42.7"N, 124°33'07.2"W. The collected seawater was deemed as freshly upwelled water and taken from a depth of 55 meters, then placed into designated cubitainers. Three cubitainers were immediately harvested for the initial timepoint (T0). The remaining twenty-seven cubitainers were assigned treatments: nine were unamended (Ctrl), nine were amended with 5 nM FeCl2 (Fe), and nine were amended with 200 nM desferrioxamine B (DFB), a strong iron chelator that inhibits dissolved iron uptake. The cubitainers were placed in an on-deck incubator covered with neutral density screening to simulate 25% irradiance supplied with flow-through surface seawater to maintain ambient surface temperature. Three cubitainers from each treatment were harvested for each of the three subsequent timepoints: 48 hours (T1), 168 hours (T2), and 264 hours (T3) after incubation. This dataset includes dissolved iron concentrations from this incubation. (Physiological measurements from this incubation are in this dataset: https://www.bco-dmo.org/dataset/994607)

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Coverage

Location: Northern California Current System, off the southern coast of Oregon at 43°02'42.7"N, 124°33'07.2"W

Spatial Extent: **Lat**:43.0452 **Lon**:-124.552
Temporal Extent: 2023-05-29 - 2023-06-10

Methods & Sampling

Data collection took place on the R/V Sally Ride from May 29th to June 10th, 2023. To simulate upwelling conditions under different iron treatments, an onboard incubation experiment was conducted. Seawater for the incubation experiment was collected within the northern CCS, off the southern coast of Oregon at 43°02'42.7"N, 124°33'07.2"W. The collected seawater was deemed as freshly upwelled water and taken from a depth of 55 m – which corresponds to a depth slightly below the euphotic zone receiving less than 1% irradiance – using trace-metal clean techniques on May 30th, 2023, 13:30 GMT. The seawater was pumped and homogenized using trace metal clean techniques, then transferred into a total of thirty 20 L low-density polyethylene cubitainers. Three cubitainers were immediately harvested for the initial timepoint (T0). The remaining twenty-seven cubitainers were assigned treatments: nine were unamended (labeled Ctrl), nine were amended with 5 nM FeCl2 (labeled +Fe), and nine were amended with 200 nM desferrioxamine B, a strong iron chelator that inhibits dissolved iron uptake (labeled DFB). The cubitainers were placed in an on-deck incubator covered with two layers of neutral density screening to simulate 26% of incidence irradiance supplied with flow-through surface seawater to maintain ambient surface temperature. Three cubitainers from each treatment were harvested for each of the three subsequent timepoints: 48 hours (T1), 168 hours (T2), and 264 hours (T3) after incubation.

Iron Incubation Experimental Set-Up. The seawater for the iron incubation experiment was pumped into a positive pressure trace metal clean laboratory and then into 50-gallon acid-washed high-density polyethylene (HDPE) drums. Seawater in these drums was homogenized using a Wilden air-operated double diaphragm pump made of polytetrafluoroethylene and acid-washed HDPE tubing. The seawater was then transferred into a total of thirty 20 L low-density polyethylene cubitainers.

Dissolved Iron Sampling. Samples for measurement of dissolved iron were filtered directly from the cubitainer through an acid-cleaned Acropak supor membrane cartridge filter with 0.2 micrometer pore size. Filtered samples were collected in acid-cleaned LDPE bottles, which were rinsed three times with sample prior to filling. Samples were acidified at sea with Optima hydrochloric acid to a pH of ~1.8.

Dissolved Iron Analysis. Samples were analyzed post-cruise in a trace metal clean room using the methods of Lohan et al. (2006) with modifications as described in Biller et al. (2013). This method involves pre-concentrating iron on a chelating resin; we followed Biller et al. (2013) and used Toyopearl Chelate-650 resin, which recovers >93% of Fe(III) at pH 2. We added a small amount of Optima ammonium hydroxide to each sample before analysis to increase the pH from 1.8 to 2. We also added hydrogen peroxide (10 micromolar) to each sample ten minutes before analysis to ensure quantitative oxidation of all Fe(II) to Fe(III), which Lohan et al (2005) found to be effective. After pre-concentration, the iron is eluted into a reaction stream with the colorimetric agent N,N-dimethyl-p-phenylenediaminedihydrochloride (DPD), which turns deeper pink the more iron is present. The signal is detected with a flow-through spectrophotometer.

Standards were made by spiking low metal seawater with known amounts of added iron and creating a standard addition curve. Blanks were assessed by analyzing acidified MilliQ as a sample. Reference samples (Geotraces GSC and D1) measured in the same analytical runs as the samples were in line with consensus values.

Note about the DFB treatments: high concentrations (>10nM) of dissolved Fe were measured in the treatments with added DFB. We think this is likely because the strong chelator solubilized Fe. It is also possible there was some Fe in the DFB spike. Regardless, the dissolved Fe present in the DFB treatments was almost certainly not biologically available, as it was chelated with DFB.

Notes about methods papers cited:
* Lohan et al. (2005, doi: 10.1016/j.aca.2004.09.005) - This paper shows that 10 micromolar H2O2 and ten minutes is sufficient to quantitatively oxidize Fe(II) to Fe(III) in acidified seawater
* Lohan et al. (2006, doi: 10.4319/lom.2006.4.164) - The main methods paper, but we used some modifications as in Biller et al., 2013.
* Biller et al. (2023, doi: 10.1016/j.csr.2013.07.003) - The paper that has the modifications we used to Lohan et al 2006's method.

Data Processing Description

Data was processed in Microsoft Excel. Blanks were subtracted from the sample signals, and the slopes of the standard addition curves were used to convert from absorbance to concentration. Drift in sensitivity was adjusted for by running a quality control sample many times throughout a sequence: any changes to its signal were linearly extrapolated and applied to the samples throughout the sequence.

BCO-DMO Curation Notes

- Imported data from source file "dFe data Adrian's incubation for BCODMO.xlsx" into the BCO-DMO system.
- Renamed columns to conform with FAIR principles and BCO-DMO naming conventions. The only allowed characters are A-Z,a-z,0-9, and underscores. No spaces, hyphens, commas, parentheses, or Greek letters.
- Set types as string and numeric
- Exported data as CSV file titled "1004007_v1_iron_concentrations_pupcycle2.csv"

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Related Publications

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

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

Lohan, M. C., Aguilar-Islas, A. M., Franks, R. P., & Bruland, K. W. (2005). Determination of iron and copper in seawater at pH 1.7 with a new commercially available chelating resin, NTA Superflow. Analytica Chimica Acta, 530(1), 121–129. https://doi.org/10.1016/j.aca.2004.09.005
Methods

Pillai, S. V., Sezginer, Y., Marchetti, A., Till, C. P., Speciale, E. V., & Tortell, P. D. (2026). Hyperspectral optical signatures of iron-limitation in a coastal upwelling system. Limnology and Oceanography, 71(3). Portico. https://doi.org/10.1002/lno.70344
Results

Speciale, E. V., Lim, P., Jeong, Y., Cook, C. C. Z., Cohen, N. R., McClure, W., Schnetzer, A., Till, C. P., Till, R. C., & Marchetti, A. (n.d.). Mixotrophy as an alternative strategy under iron-limited upwelling conditions [Manuscript under review].
Results

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Related Datasets

IsRelatedTo

Speciale, E., Lim, P., Jeong, Y., Cook, C., Cohen, N., McClure, W., Schnetzer, A., Marchetti, A. (2026) **Physiological measurements from an iron incubation experiment using upwelled waters in the California Current System during the PUPCYCLE II cruise in May and June 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2026-08-12 http://lod.bco-dmo.org/id/dataset/994607 [view at BCO-DMO]
Relationship Description: Physiological data from the same incubation experiment.

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Parameters

Parameter	Description	Units
Time_Stamp	The timepoint of sampling the incubation: 48 hours (T1), 168 hours (T2), and 264 hours (T3).	unitless
Treatment	Experimental treatment where Ctrl = unamended control; plus Fe = amended with 5nM FeCl2; plus DFB (low Fe) = amended with 200 nM desferrioxamine B	unitless
Replicate	Each treatment at each timepoint was in triplicate. The three different cubitainers for the triplicate measurements are indicated with A, B, and C	unitless
Sample_Name	Incubation samples were identified with a Q number to unambiguously identify each sample by treatment, replicate and timepoint.	unitless
Fe_Conc	The concentration of dissolved iron (less than 0.2 micrometers)	nanomoles per kilogram (nmol/kg)

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Instruments

Dataset-specific Instrument Name	Wilden air-operated double diaphragm pump
Generic Instrument Name	Pump
Dataset-specific Description	A Wilden air-operated double diaphragm pump made of polytetrafluoroethylene and acid-washed HDPE tubing was used to homogenize the seawater in the drums
Generic Instrument Description	A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps

Dataset-specific Instrument Name	Varian model 340 UV-Vis detector
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	The flow through spectrophotometer used for these samples was a Varian model 340 UV-Vis detector at 514 nm.
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

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Deployments

SR2311

Website	https://www.bco-dmo.org/deployment/994610
Platform	R/V Sally Ride
Start Date	2023-05-29
End Date	2023-06-10
Description	California Current System, off the southern coast of Oregon at 43°02'42.7"N, 124°33'07.2"W, depth 55m

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Project Information

CAREER: An integrated molecular and physiological approach to examining the dynamics of upwelled phytoplankton in current and changing oceans (Upwelled Phytoplankton Dynamics)

Coverage: California Upwelling Zone

NSF Award Abstract:
Upwelling zones are hotspots of photosynthesis that are very dynamic in space and time. Microscopic algae, known as phytoplankton, bloom when deep, nutrient-rich waters are upwelled into sunlit surface layers of the ocean, providing nourishment that supports productive food webs and draws down carbon dioxide (CO2) from the atmosphere to the deep ocean. Photosynthetic microbes in these regions must constantly adapt to changes in their chemical and physical environments. For example, subsurface populations respond to changes in light as they approach the surface. When upwelled waters move offshore, cells sink out of the illuminated zone, establishing seed populations that remain inactive until the next upwelling event. This process is called the upwelling conveyor belt cycle (UCBC). How phytoplankton respond to these changes in environmental conditions and how they may influence their nutrient requirements remains unknown. With future ocean changes predicted to alter seawater chemistry, including ocean acidification and decreased iron availability, some phytoplankton groups may be more vulnerable than others. Accompanying educational activities provide learning experiences to enhance understanding and awareness of marine microbes. The development of a research hub at UNC aims to provide infrastructure and support for scientists and students conducting research on environmental genomics. A laboratory component for an upper-level undergraduate course focused on marine phytoplankton is being developed. Educational outreach activities to broader communities include creation of a lesson plan on phytoplankton in upwelling zones and a virtual research cruise experience for middle-school students, as well as a hands-on lab activity for a local museum focused on marine phytoplankton and the important roles they play in shaping our planet.

The project examines how phytoplankton respond at the molecular and physiological level to the different UCBC stages, which seed populations (i.e., surface versus subsurface) contribute most to phytoplankton blooms during upwelling events of varying intensity, how phytoplankton elemental compositions are altered throughout UCBC stages, and how future predicted ocean conditions will affect the phytoplankton responses to UCBC conditions. This project contains both laboratory and fieldwork. In the laboratory, phytoplankton isolates recently obtained from upwelling regions are exposed to simulated UCBC conditions to examine changes in gene expression, growth and photosynthetic characteristics and elemental composition. Cultures are subjected to both current and future ocean conditions, including reduced iron availability and higher CO2. In the field, research cruises within upwelling regions study the dynamics of natural phytoplankton communities (both surface and subsurface) experiencing upwelling and relaxation and within simulated upwelling incubation experiments. Knowledge of how phytoplankton are affected by UCBC conditions at an integrated molecular, physiological and elemental level under both current and future scenarios is imperative for the proper conservation and management of these critically important ecosystems.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1751805

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