Dissolved Macronutrient Concentrations from Depth Profiles and Incubation Experiments from STING I Cruise AE2305 on R/V Atlantic Explorer in the Gulf of Mexico from February to March 2023

Website: https://www.bco-dmo.org/dataset/929305
Data Type: Cruise Results
Version: 3
Version Date: 2026-04-27

Project
» Collaborative Research: Linking iron and nitrogen sources in an oligotrophic coastal margin: Nitrogen fixation and the role of boundary fluxes (West Florida Shelf DON and Fe)

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Abstract
Concentrations of inorganic dissolved macronutrients, including phosphate, nitrate plus nitrite (N+N), silicic acid, and nitrite, from phytoplankton shipboard incubation experiments and depth profiles collected on STING I cruise AE2305 on R/V Atlantic Explorer on the West Florida Shelf from February to March 2023. This project investigates how groundwater discharge delivers important nutrients to the coastal ecosystems of the West Florida Shelf. Preliminary studies had indicated that groundwater may supply both dissolved organic nitrogen (DON) and iron in this region. In coastal ecosystems like the West Florida Shelf that have very low nitrate and ammonium concentrations, DON is the main form of nitrogen available to organisms. Nitrogen cycling is strongly affected by iron availability because iron is essential for both photosynthesis and for nitrogen fixation. This study investigated the sources and composition of DON and iron, and their influence on the coastal ecosystem. The team sampled offshore groundwater wells, river and estuarine waters from shore, and conducted two expeditions across the West Florida Shelf in winter and summer for surface and depth profile sampling and for shipboard incubation experiments.

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Coverage

Location: Eastern Gulf of Mexico and West Florida Shelf
Spatial Extent: **N**:28.5 **E**:-82.5 **S**:26.3 **W**:-86.6
Temporal Extent: 2023-02-20 - 2023-03-05

Methods & Sampling

Water column samples were collected in February and March 2023 aboard the R/V Atlantic Explorer using a trace metal clean rosette (SeaBird) outfitted with 12-L Niskin-X samplers (Ocean Test Equipment), a trace metal clean pump, or a custom surface pump “towfish” system (Mellett and Buck, 2020). Seawater samples for macronutrient analysis were filtered through 0.2 µm Pall Acropak Super membrane filter capsules, collected in acid-cleaned and triple-rinsed 15-mL Falcon tubes, and stored in ziplock bags in the fridge until analyzed shipboard following recommended practices (Becker et al., 2020), typically within 24 hours of collection.

Samples were analyzed shipboard for phosphate, nitrate+nitrite, silicate, and nitrite on a QuAAtro39 AutoAnalyzer (SEAL Analytical) according to standard colorimetric methods (Strickland and Parsons, 1972). All reagents were prepared in dedicated labware with high purity Milli-Q (>18 MΩ cm) water. Working standards were prepared fresh daily in an artificial seawater (ASW; 35 g/L sodium chloride, 0.5 g/L sodium bicarbonate) matrix using calibrated volumetric pipettes.

Nine-point standard curves were analyzed at the beginning of each run with multiple reagent blanks. Quality control checks were analyzed every twelfth sample with ASW blanks and standards. The highest standard from the calibration curve was analyzed approximately every twenty samples to check for drift during the runs. Subsamples of reference material for nutrients in seawater (Konso) were measured in each run (see Table 1 below).

Detection limits for each parameter were determined from three times the standard deviation of replicate lowest standards. Limits of detection were 0.035 µM for phosphate, 0.048 µM for nitrate+nitrite, 0.051 µM for silicate, and 0.012 µM for nitrite. Values below detection are reported as 0 µM with accompanying QC Flag 6.

Data Processing Description

Data were flagged using the SeaDataNet quality flag scheme recommended by GEOTRACES (https://www.geotraces.org/geotraces-quality-flag-policy/) and described below. Notes specific to the application of these flags to this dataset are noted in brackets […].

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. [Not used].

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. [See Table 1 for blank and certified reference material values obtained in this study].

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. [Used when no replicate measurements were available to check the quality of the data].

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. [Used when all replicate measurements were too high to be consistent with real phenomena].

4: Bad Value: An obviously erroneous data value. [Not used].

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. [Not used].

6: Value Below Detection Limit: The level of the measured phenomenon was less than the limit of detection (LOD) for the method employed to measure it. The accompanying value is the detection limit for the technique or zero if that value is unknown. [Values below detection are reported as 0.00 µM in the data file. Detection limits for each parameter are listed in the “methods and sampling” section of this form].

7: Value in Excess: The level of the measured phenomenon was too large to be quantified by the technique employed to measure it. The accompanying value is the measurement limit for the technique. [Not used].

8: Interpolated Value: This value has been derived by interpolation from other values in the data object. [Not used].

9: Missing Value: The data value is missing. Any accompanying value will be a magic number representing absent data [When sample was not collected the notation ‘na’ for ‘not applicable’ was used; when sample collected but there is no result for this parameter, the notation ‘NDA’ for ‘no data available’ was used].

A: Value Phenomenon Uncertain: There is uncertainty in the description of the measured phenomenon associated with the value such as chemical species or biological entity. [Not used.]

BCO-DMO Curation Notes

- Spaces from column names replaced with underscores ("_").
- Special characters in column names replaced with plain text (i.e., "%" has been replaced with "percent").
- Date formats converted from %m/%d/%y to %Y-%m-%d.
- Column "ISO_DateTime_UTC" created by merging the DATE_UTC and TIME_UTC columns.

Version history notes:

Version 2 of this dataset contains corrections to version 1; the NO3+NO2 and PO4 values in Version 1 are swapped and incorrect. Version 2 also includes replicate count values.

Version 3 of this dataset contains dataset and metadata updates, including Cruise ID, Map station numbers, Map station coordinates, and Incubation bottle numbers, treatments and timepoints. No changes have been made to dataset values that existed in Version 2 of the data file.

Problem Description

Detection limits for each parameter were determined from three times the standard deviation of replicate lowest standards. Limits of detection were 0.035 µM for phosphate, 0.048 µM for nitrate+nitrite, 0.051 µM for silicate, and 0.012 µM for nitrite. Values below detection are reported as 0 µM with accompanying QC Flag 6.

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Data Files

File
929305_v3_sting_macronutrient_concentrations.csv (Comma Separated Values (.csv), 49.22 KB) MD5:a3f47a0bc664eb3aba5fc3157082510b Primary data file for dataset ID 929305, version 3

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Related Publications

Becker, S., Aoyama, M., Woodward, E. M. S., Bakker, K., Coverly, S., Mahaffey, C., & Tanhua, T. (2019/2020). GO-SHIP Repeat Hydrography Nutrient Manual: The Precise and Accurate Determination of Dissolved Inorganic Nutrients in Seawater, Using Continuous Flow Analysis Methods. Frontiers in Marine Science, 7. https://doi.org/10.3389/fmars.2020.581790
Methods

Mellett, T., & Buck, K. N. (2020). Spatial and temporal variability of trace metals (Fe, Cu, Mn, Zn, Co, Ni, Cd, Pb), iron and copper speciation, and electroactive Fe-binding humic substances in surface waters of the eastern Gulf of Mexico. Marine Chemistry, 227: 103891. doi:10.1016/j.marchem.2020.103891
Methods

Strickland, J. D. H. and Parsons, T. R. (1972). A Practical Hand Book of Seawater Analysis. Fisheries Research Board of Canada Bulletin 157, 2nd Edition, 310 p.
Methods

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Related Datasets

IsRelatedTo

Knapp, A. N. (2025) **Total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) of samples collected from rivers draining onto the West Florida Shelf and submarine groundwater wells on the Western coast of Florida from Nov 2022 to Mar 2024.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-12-12 doi:10.26008/1912/bco-dmo.989225.1 [view at BCO-DMO]
Relationship Description: These data are part of the same cruise and project.

Knapp, A. N. (2025) **Total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) of samples collected on the West Florida Shelf during STING I cruise AE2305 on R/V Atlantic Explorer from Feb 20 to Mar 05, 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-12-12 doi:10.26008/1912/bco-dmo.986688.1 [view at BCO-DMO]
Relationship Description: These data are part of the same cruise and project.

Knapp, A. N. (2025) **Total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) of samples collected on the West Florida Shelf during STING II cruise EN704 on R/V Endeavor from Jul 1 to Jul 12, 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-12-12 doi:10.26008/1912/bco-dmo.986861.1 [view at BCO-DMO]
Relationship Description: These data are part of the same cruise and project.

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Parameters

Parameter	Description	Units
STING_ID	Unique number assigned to each sampling event in STING project.	unitless
CRUISE_ID	Cruise ID number assigned to the cruise associated with sample collection.	unitless
EVTNBR	Event number; ‘nda’ for ‘no data available’ or missing information; ‘na’ for ‘not applicable’, used for incubation sampling events.	unitless

ISO_DateTime_UTC	UTC datetime when sample was collected.	unitless
DATE_UTC	UTC date when sample was collected.	unitless
TIME_UTC	UTC time when sample was collected; ‘nda’ for ‘no data available’ or missing information; ‘na’ for ‘not applicable’ to that sample.	unitless
DATE_EST	Local date, in Eastern Standard Time (EST) when sample was collected.	unitless
TIME_EST	Local time, in Eastern Standard Time (EST) when sample was collected; ‘nda’ for ‘no data available’ or missing information; ‘na’ for ‘not applicable’, used for incubation sampling events	unitless
LATITUDE_SHIP	Ship position when sample was collected, in decimal °N; ‘nda’ for ‘no data available’ or missing information.	decimal degrees
LONGITUDE_SHIP	Ship position when sample was collected, in decimal °E; ‘nda’ for ‘no data available’ or missing information.	decimal degrees
PLATFORM	Sampling system used. TMC CTD = trace metal CTD rosette. FISH = trace metal tow fish. TM PUMP = trace metal pump. INC = incubation.	unitless
CASTNBR	Cast number; ‘na’ for ‘not applicable’, used for TM pump sampling events.	unitless
STNNBR	Station number; ‘na’ for ‘not applicable’, used for incubation sampling events.	unitless
LATITUDE_MAP	Position of STN_MAP, in decimal °N; ‘nda’ for ‘no data available’ or missing information.	decimal degrees
LONGITUDE_MAP	Position of STN_MAP, in decimal °E; ‘nda’ for ‘no data available’ or missing information.	decimal degrees
STN_MAP	Station number assigned retroactively to orient data to map and repeat sampling across field efforts; ‘na’ for ‘not applicable’, used for incubation sampling events.	units
BTLNBR	CTD rosette bottle number; ‘na’ for ‘not applicable’ to that sample.	unitless
DEPTH	Sample collection depth below sea surface; ‘no data available’ or missing information; ‘na’ for ‘not applicable’ to that sample.	meters (m)

TREATMENT	Incubation treatment; ‘na’ for ‘not applicable’, used for non-incubation samples.	unitless
TIMEPOINT	Incubation timepoint; ‘na’ for ‘not applicable’, used for non-incubation samples.	unitless
PO4_CONC	Concentrations of dissolved phosphate.	Micromoles per liter (uM)
PO4_STDEV	Standard deviation of replicate phosphate concentration measurements. If only 2 replicates, the difference about the mean was used to calculate error.	Micromoles per liter (uM)
PO4_COUNT	Number of PO4 analytical replicaters performed.	count
PO4_FLAG	Quality flag for PO4 measurements. See the "Data Processing Description" section of the BCO-DMO metadata page for this dataset for full data quality flag details.	unitless
NO3_NO2_CONC	Concentrations of dissolved nitrate+nitrite.	Micromoles per liter (uM)
NO3_NO2_STDEV	Standard deviation of replicate nitrate+nitrite concentration measurements. If only 2 replicates, the difference about the mean was used to calculate error.	Micromoles per liter (uM)
NO3_NO2_COUNT	Number of nitrate+nitrite analytical replicaters performed.	count
NO3_NO2_FLAG	Quality flag for NO3_NO2. See the "Data Processing Description" section of the BCO-DMO metadata page for this dataset for full data quality flag details.	unitless
SiO4_CONC	Concentrations of dissolved silicate.	Micromoles per liter (uM)
SiO4_STDEV	Standard deviation of replicate silicate concentration measurements. If only 2 replicates, the difference about the mean was used to calculate error.	Micromoles per liter (uM)
SiO4_COUNT	Number of SiO4 analytical replicaters performed.	count
SiO4_FLAG	Quality flag for SiO4. See the "Data Processing Description" section of the BCO-DMO metadata page for this dataset for full data quality flag details.	unitless
NO2_CONC	Concentrations of dissolved nitrite.	micromoles per liter (uM)
NO2_STDEV	Standard deviation of replicate nitrite concentration measurements. If only 2 replicates, the difference about the mean was used to calculate error.	micromoles per liter (uM)

NO2_COUNT	Number of NO2 analytical replicaters performed.	count
NO2_FLAG	Quality flag for NO2. See the "Data Processing Description" section of the BCO-DMO metadata page for this dataset for full data quality flag details.	unitless

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Instruments

Dataset-specific Instrument Name	Towfish
Generic Instrument Name	Discrete water sampler
Dataset-specific Description	Seawater samples were collected with a custom surface sampling system, “towfish” (Mellett and Buck 2020), comprised of acid cleaned Bev-A-Line-IV tubing and an Almatec Double PTFE Diaphragm Pump.
Generic Instrument Description	A device that collects an in-situ discrete water sample from any depth and returns it to the surface without contamination by the waters through which it passes, such as a water bottle.

Dataset-specific Instrument Name	12-L X-Niskin bottles (Ocean Test Equipment)
Generic Instrument Name	Niskin bottle
Dataset-specific Description	12-L trace metal clean modified X-Niskin bottles (Ocean Test Equipment) mounted on a trace metal clean rosette with a programmable autofire module (Seabird) and deployed on 1/4” 12-strand Spectra synthetic line to collect depth profile seawater samples.
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.

Dataset-specific Instrument Name	QuAAtro39 AutoAnalyzer (SEAL Analytical)
Generic Instrument Name	Nutrient Autoanalyzer
Dataset-specific Description	QuAAtro39 AutoAnalyzer (SEAL Analytical) was used to measure macronutrient concentrations in seawater samples.
Generic Instrument Description	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.

Dataset-specific Instrument Name	TM Pump
Generic Instrument Name	Pump
Dataset-specific Description	Wilden Pro-Flo Series P100 PTFE Diaphram Pump was deployed on 1/4” 12-strand Spectra synthetic line to collect surface and depth profile seawater samples at stations with water depth
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

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Deployments

AE2305

Website	https://www.bco-dmo.org/deployment/929020
Platform	R/V Atlantic Explorer
Start Date	2023-02-18
End Date	2023-03-07
Description	Start and End port: St. Petersburg, Florida

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Project Information

Collaborative Research: Linking iron and nitrogen sources in an oligotrophic coastal margin: Nitrogen fixation and the role of boundary fluxes (West Florida Shelf DON and Fe)

Coverage: Gulf of Mexico/America, West Florida Shelf

NSF Award Abstract:
This project will investigate how groundwater discharge delivers important nutrients to the coastal ecosystems of the West Florida Shelf. Preliminary studies indicate that groundwater may supply both dissolved organic nitrogen (DON) and iron in this region. In coastal ecosystems like the West Florida Shelf that have very low nitrate and ammonium concentrations, DON is the main form of nitrogen available to organisms. Nitrogen cycling is strongly affected by iron availability because iron is essential for both photosynthesis and for nitrogen fixation. This study will investigate the sources and composition of DON and iron, and their influence on the coastal ecosystem. The team will sample offshore groundwater wells, river and estuarine waters, and conduct two expeditions across the West Florida Shelf in winter and summer. Investigators will participate in K-12 and outreach activities to increase awareness of the project and related science. The project will fund the work of six graduate and eight undergraduate students across five institutions, furthering NSF’s goals of education and training.

Motivated by preliminary observations of unexplained, tightly-correlated DON and dissolved iron concentrations across the West Florida Shelf (WFS), the proposed work will quantify the flux and isotopic signatures of submarine groundwater discharge (SGD)-derived DON and iron to the WFS, and evaluate the bioavailability of this temporally-variable source using four seasonal near-shore campaigns sampling offshore groundwater

wells, estuarine, and riverine endmembers and two cross-shelf cruises. The work will evaluate whether SGD stimulates nitrogen fixation on the WFS, and the potential for the stimulated nitrogen fixation to further modify the chemistry of DON and dissolved iron in the region. The cross-shelf cruises will investigate hypothesized periods of maximum SGD and Trichodesmium abundance (June), and reduced river discharge and SGD (February), thus comparing two distinct biogeochemical regimes. The concentrations and isotopic compositions of DON and dissolved iron, molecular composition of DON, and the concentration and composition of iron-binding ligands will be characterized. Nitrogen fixation rates and Trichodesmium spp. abundance and expression of iron stress genes will be measured. Fluxes of DON and iron from SGD and rivers will be quantified with radium isotope mass balances. The impacts of SGD on nitrogen fixation and DON/ligand production will be constrained with incubations of natural phytoplankton communities with submarine groundwater amendments. Two hypotheses will be tested: 1) SGD is the dominant source of bioavailable DON and dissolved iron on the WFS, and 2) SGD-alleviation of iron stress changes the dominant Trichodesmium species on the WFS, increases nitrogen fixation rates and modifies DON and iron composition. Overall, the work will establish connections between marine nitrogen and iron cycling and evaluate the potential for coastal inputs to modify water along the WFS before export to the Atlantic Ocean. This study will thus provide a framework to consider these boundary fluxes in oligotrophic coastal systems and the relative importance of rivers and SGD as sources of nitrogen and iron in other analogous locations, such as coastal systems in Australia, India, and Africa, where nitrogen fixation and SGD have also been documented.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2326719

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