Hydrography, nutrients, and nitrogen uptake rates from SPIROPA cruise TN368 in July 2019

Website: https://www.bco-dmo.org/dataset/927927
Data Type: Cruise Results
Version: 1
Version Date: 2024-05-20

Project
» Collaborative Research: Shelfbreak Frontal Dynamics: Mechanisms of Upwelling, Net Community Production, and Ecological Implications (SPIROPA)

Contributors	Affiliation	Role
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Abstract
Continental shelves contribute a large fraction of the ocean's new nitrogen (N) via N2 fixation; yet, we know little about how physical processes at the ocean's margins shape diazotroph biogeography and activity. This dataset includes N2 fixation rates and hydrographic measurements collected at the Mid-Atlantic Bight shelfbreak front in July 2019. Rates were measured using the 15N2 bubble release method on repeat cross-frontal transects. This study was coordinated with the SPIROPA ('Shelfbreak Productivity Interdisciplinary Research Operation at the Pioneer Array') Project (https://www.bco-dmo.org/project/748894). See Selden et al. (2024, JGR-Oceans) or contact Dr. Corday Selden (crselden@marine.rutgers.edu) for further information.

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Coverage

Location: Mid-Atlantic Bight shelfbreak front to the south of Massachusetts, USA. Multiple transects in the area of 70-71 degrees W longitude and 39-40.5 degrees N latitude. Sampling was restricted to waters above the 0.1% light level.
Spatial Extent: **N**:40.5 **E**:-70 **S**:39 **W**:-71
Temporal Extent: 2019-07-05 - 2019-07-18

Dataset Description

This dataset is derived from Selden et al. (2024) JGR Oceans Table S1, and McGillicuddy bottle data from TN368, the third SPIROPA cruise (https://www.bco-dmo.org/dataset/849340). The mean values of nitrogen fixation rates shown here are derived from nitrogen fixation incubation data (https://www.bco-dmo.org/dataset/928568)

Glossary of terms:
A = Atom-% enrichment
APN = Atom-% enrichment of the particulate nitrogen pool
BDL = Below detection limit
DNQ = Detectable but not quantifiable
LOD = Limit of detection
LOQ = Limit of quantification
N2 = Nitrogen gas
PETG = Polyethylene Terephthalate Glycol
PN = Particulate nitrogen
NFR = Nitrogen fixation rate
SUR = Specific uptake rate
t0 = time initial
tf = time final

Methods & Sampling

Nitrogen fixation rates and hydrographic data were measured in July 2019 in conjunction with the SPIROPA (Shelfbreak Productivity Interdisciplinary Research Operation at the Pioneer Array) project cruises (Chief Scientist Dr. Dennis McGillicuddy). This case study was conducted at the Mid-Atlantic Bight shelfbreak front to the south of Massachusetts, USA to examine whether significant N2 fixation occurs in the continental shelf region. On July 5th, 2019, the vessel R/V Thomas G. Thompson (cruise TN368) departed Woods Hole, MA and performed multiple transects in the area of 70 to 71 degrees West longitude and 39 to 40.5 degrees North latitude. Sampling was restricted to waters above the 0.1% light level.

Water was collected in 10L Niskin bottles on a 24-bottle rosette. Vertical conductivity, temperature, and depth profiles were measured concurrently using a Sea-Bird 911+ CTD profiler. Samples to determine nitrate, phosphate, and silicate concentrations were filtered (0.4 um, polycarbonate) directly from the Niskin bottles into acid-washed polyethylene bottles and stored frozen until analysis. Standard colorimetric methods were performed at the Woods Hole Oceanographic Institution's Nutrient Analytical Facility using a SEAL Analytical AA3 HR discrete chemistry analyzer. Detection limits for nitrate, phosphate, and silicate methods were 0.040, 0.030 and 0.009 µM, respectively.

This dataset presents hydrographic and nutrient data plus uptake rates and nitrogen fixation rates based on the mean values of replicate samples at each collection site and depth. For full incubation data (and methods) for all replicates, please refer to BCO-DMO dataset https://www.bco-dmo.org/dataset/928568.

Nitrogen fixation rates (NFR) were measured using the $^{15}N_2$ bubble release method on repeat cross-frontal transects. Bottles were incubated on-deck for approximately 24 hours in incubators that recirculated water through aquaria chillers to maintain approximate temperature conditions for shelf, frontal, and offshore waters. At the end of the incubation period, an aliquot was collected from each bottle for isotope analysis (see https://www.bco-dmo.org/dataset/928568). The remaining incubation volume was then filtered for initial particulate nitrogen (PN) samples.

Specific uptake rates were calculated following Montoya et al. (1996), with equations detailed below.

Data Processing Description

Specific N_2 uptake rates (SUR) were calculated following Montoya et al. (1996):

Equation 1: SUR = (APN_tf - APN_t0) / (AN2 - APN_t0)] x (1/time)

where A represents the atom-% enrichment of the initial (t=0) or final (t=f) particulate nitrogen (PN) pool, or the nitrogen (N_2) pool. Across all experiments, AN2 averaged 3.89 ± 2.0%. Experiments with <1% enrichment were excluded from downstream analysis. The specific uptake rate represents the relative contribution of diazotroph-derived N to PN turnover within a given sample. Absolute N_2 fixation rates (NFR) were calculated as:

Equation 2: NFR = SUR x [PN]

where [PN] indicates the particulate nitrogen concentration. Limits of detection and quantification were calculated per incubation by propagating the minimum detectable difference between initial and final ^{15}N atom-% enrichment of the PN pool (3σ and 10σ), three sigma and ten sigma respectively, n≥7, 12.5 µg N standards measured daily through Eqn. 2 (Ripp, 1996; White et al. 2020). A rate was only considered detectable if two of three replicate incubations yielded detectable rates.

BCO-DMO Processing Description

- Imported data from source file "Selden_JGR24_TableS1.xlsx" into the BCO-DMO data system.
- Changed date format from m/d/yyyy to yyyy-mm-dd (ISO Date 8601 format) and converted datetimes from EST to UTC.
- Converted latitude and longitude to decimal degrees.
- Added official cruise ID corresponding to the the provided deployment and cruise name
- Added cast number and replicate sample ids (from the incubations) based on datetime and depth.
- Rounded values according to the PI's/submitter's indicated precision
- Modified parameter (column) names to conform with 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.

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Related Publications

Montoya, J. P., Voss, M., Kahler, P., & Capone, D. G. (1996). A Simple, High-Precision, High-Sensitivity Tracer Assay for N(inf2) Fixation. Applied and Environmental Microbiology, 62(3), 986–993. https://doi.org/10.1128/aem.62.3.986-993.1996
Methods

Selden, C. R., Mulholland, M. R., Bernhardt, P. W., Widner, B., Macías-Tapia, A., Ji, Q., & Jayakumar, A. (2019). Dinitrogen Fixation Across Physico-Chemical Gradients of the Eastern Tropical North Pacific Oxygen Deficient Zone. Global Biogeochemical Cycles, 33(9), 1187–1202. doi:10.1029/2019gb006242 https://doi.org/10.1029/2019GB006242
Methods

Selden, C. R., Mulholland, M. R., Crider, K. E., Clayton, S., Macías-Tapia, A., Bernhardt, P., McGillicuddy, D. J., Zhang, W. G., & Chappell, P. D. (2024). Nitrogen Fixation at the Mid-Atlantic Bight Shelfbreak and Transport of Newly Fixed Nitrogen to the Slope Sea. Journal of Geophysical Research: Oceans, 129(4). American Geophysical Union (AGU). https://doi.org/10.1029/2023jc020651 https://doi.org/10.1029/2023JC020651
Results
,
Methods

White, A. E., Granger, J., Selden, C., Gradoville, M. R., Potts, L., Bourbonnais, A., Fulweiler, R. W., Knapp, A. N., Mohr, W., Moisander, P. H., Tobias, C. R., Caffin, M., Wilson, S. T., Benavides, M., Bonnet, S., Mulholland, M. R., & Chang, B. X. (2020). A critical review of the 15N2 tracer method to measure diazotrophic production in pelagic ecosystems. Limnology and Oceanography: Methods, 18(4), 129–147. Wiley. https://doi.org/10.1002/lom3.10353
Methods

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Related Datasets

IsDerivedFrom

McGillicuddy, D. J., Sosik, H. M., Zhang, W. G., Smith, W. O., Stanley, R., Turner, J., Petitpas, C. (2022) **Bottle sample data from CTD casts from the third cruise of SPIROPA project, R/V Thomas G. Thompson cruise TN368, to the New England Shelfbreak in July of 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 2) Version Date 2022-06-08 doi:10.26008/1912/bco-dmo.849340.2 [view at BCO-DMO]

IsSupplementedBy

Mulholland, M., Chappell, P. Dreux (2024) **Nitrogen fixation incubation data from cruise TN368 in July 2019 for SPIROPA project.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-05-23 http://lod.bco-dmo.org/id/dataset/928568 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
DateTime_EST	Datetime of sampling in Eastern Standard Time	unitless
Latitude	Latitude of sampling site	decimal degrees
Longitude	Longitude of sampling site	decimal degrees
Cruise_ID	Cruise ID	unitless
Cast	Cast identifier for cruise TN368 on R/V T.G. Thompson	unitless
Depth	Depth at which sample was collected	meters (m)
Salinity	Salinity (derived from CTD data)	psu
Temperature	Temperature in degrees Celsius (derived from CTD data)	degrees Celsius (°C)
SigmaTheta	Sigma theta potential density at sampling depth (derived from CTD data)	kilograms per cubic meter (kg/m3)
NO3	Nitrate concentration of sample water	micromolar
PO4	Phosphate concentration of sample water	micromolar
SiO4	Silicate concentration of sample water	micromolar
PN_mean	Mean particulate nitrate concentration of sample water	micromolar
PN_sd	Standard deviation of particulate nitrate concentrations of sample water	micromolar

Replicate_incubations	Number of replicate 15N2 incubations conducted	unitless
Repl_spl_ids	Sample ID of replicate samples in incubation	unitless
Flag	Flag for specific uptake rate/nitrogen (N2) fixation rate, where DNQ = Detected but not quantifiable; BDL = Below detection limit	unitless
SUR_mean	Mean specific N2 uptake rate calculated from replicate incubations	per day
SUR_sd	Standard deviation of specific nitrogen uptake rates	per day
NFR_mean	Mean nitrogen fixation rate calculated from replicate incubations	nanomoles nitrogen per liter per day (nmol N2/L/day)
NFR_sd	Standard deviation of nitrogen fixation rates	nanomoles nitrogen per liter per day (nmol N2/L/day)
NFR_LOD	Limit of detection for nitrogen fixation rate at given sampling location	nanomoles nitrogen per liter per day (nmol N2/L/day)
NFR_LOQ	Limit of quantification for nitrogen fixation rate at given sampling location	nanomoles nitrogen per liter per day (nmol N2/L/day)
SUR_LOD	Limit of detection for specific nitrogen uptake rate at given sampling location	per day
SUR_LOQ	Limit of quantification for specific nitrogen uptake rate at given sampling location	per day
ISO_DateTime_UTC_if_EST	Datetime of sampling in UTC (if original datetimes were EST or GMT-5)	unitless
ISO_DateTime_UTC_if_EDT	Datetime of sampling in UTC (if original datetimes were actually EDT or GMT-4)	unitless

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Instruments

Dataset-specific Instrument Name	AquaEuroUSA Aquaria chillers (MC-1/10HP)
Generic Instrument Name	Aquarium chiller
Dataset-specific Description	To avoid temperature-shocking the samples, three on-deck incubators recirculated water through aquaria chillers (MC-1/10HP, AquaEuroUSA) housed in custom casings.
Generic Instrument Description	Immersible or in-line liquid cooling device, usually with temperature control.

Dataset-specific Instrument Name	Sea-Bird 911 plus CTD
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Dataset-specific Description	Vertical conductivity, temperature, and depth profiles were collected concurrently using a Sea-Bird 911 plus CTD.
Generic Instrument Description	The Sea-Bird SBE 911 plus is a type of CTD instrument package for continuous measurement of conductivity, temperature and pressure. The SBE 911 plus includes the SBE 9plus Underwater Unit and the SBE 11plus Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 plus and SBE 11 plus is called a SBE 911 plus. The SBE 9 plus uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 plus and SBE 4). The SBE 9 plus CTD can be configured with up to eight auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorescence, light (PAR), light transmission, etc.). more information from Sea-Bird Electronics

Dataset-specific Instrument Name	incubator
Generic Instrument Name	Incubator
Dataset-specific Description	To avoid temperature-shocking the samples, three on-deck incubators recirculated water through aquaria chillers.
Generic Instrument Description	A device in which environmental conditions (light, photoperiod, temperature, humidity, etc.) can be controlled. Note: we have more specific terms for shipboard incubators (https://www.bco-dmo.org/instrument/629001) and in-situ incubators (https://www.bco-dmo.org/instrument/494).

Dataset-specific Instrument Name	Europa 20/20 isotope ratio mass spectrometer with automated nitrogen and carbon preparation module
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Initial and final PN isotopic composition and concentration were analyzed on a Europa 20/20 isotope ratio mass spectrometer with an automated N and carbon preparation module.
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	Niskin bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	A CTD rosette equipped with 24 10L Niskin bottles was used to sample water in the Mid Atlantic Bight
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	SEAL Analytical AA3 HR discrete chemistry analyzer
Generic Instrument Name	Seal Analytical AutoAnalyser 3HR
Dataset-specific Description	Samples to determine nitrate, phosphate, and silicate concentrations were filtered (0.4 µm, polycarbonate) directly from Niskin bottles into acid-washed polyethylene bottles and stored frozen until analysis via standard colorimetric methods at the WHOI Nutrient Analytical Facility using a SEAL Analytical AA3 HR discrete chemistry analyzer.
Generic Instrument Description	A fully automated Segmented Flow Analysis (SFA) system, ideal for water and seawater analysis. It comprises a modular system which integrates an autosampler, peristaltic pump, chemistry manifold and detector. The sample and reagents are pumped continuously through the chemistry manifold, and air bubbles are introduced at regular intervals forming reaction segments which are mixed using glass coils. The AA3 uses segmented flow analysis principles to reduce inter-sample dispersion, and can analyse up to 100 samples per hour using stable LED light sources.

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Deployments

TN368

Website	https://www.bco-dmo.org/deployment/848750
Platform	R/V Thomas G. Thompson
Start Date	2019-07-05
End Date	2019-07-18
Description	DOI: https://doi.org/10.7284/908710

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Project Information

Collaborative Research: Shelfbreak Frontal Dynamics: Mechanisms of Upwelling, Net Community Production, and Ecological Implications (SPIROPA)

Website: http://science.whoi.edu/users/olga/SPIROPA/SPIROPA.html

Coverage: Shelf break south of New England, OOI Pioneer Array

NSF award abstract:

The continental shelf break of the Middle Atlantic Bight supports a productive and diverse ecosystem. Current paradigms suggest that this productivity is driven by several upwelling mechanisms at the shelf break front. This upwelling supplies nutrients that stimulate primary production by phytoplankton, which in turn leads to enhanced production at higher trophic levels. Although local enhancement of phytoplankton biomass has been observed in some circumstances, such a feature is curiously absent from time-averaged measurements, both from satellites and shipboard sampling. Why would there not be a mean enhancement in phytoplankton biomass as a result of the upwelling? One hypothesis is that grazing by zooplankton prevents accumulation of biomass on seasonal and longer time scales, transferring the excess production to higher trophic levels and thereby contributing to the overall productivity of the ecosystem. However, another possibility is that the net impact of these highly intermittent processes is not adequately represented in long-term means of the observations, because of the relatively low resolution of the in-water measurements and the fact that the frontal enhancement can take place below the depth observable by satellite. The deployment of the Ocean Observatories Initiative (OOI) Pioneer Array south of New England has provided a unique opportunity to test these hypotheses. The combination of moored instrumentation and autonomous underwater vehicles will facilitate observations of the frontal system with unprecedented spatial and temporal resolution. This will provide an ideal four-dimensional (space-time) context in which to conduct a detailed study of frontal dynamics and plankton communities needed to examine mechanisms controlling phytoplankton populations in this frontal system. This project will also: (1) promote teaching, training and learning via participation of graduate and undergraduate students in the research , (2) provide a broad dissemination of information by means of outreach in public forums, printed media, and a video documentary of the field work, and (3) contribute to improving societal well-being and increased economic competitiveness by providing the knowledge needed for science-based stewardship of coastal ecosystems, with particular emphasis on connecting with the fishing industry through the Commercial Fisheries Research Foundation.

The investigators will conduct a set of three cruises to obtain cross-shelf sections of physical, chemical, and biological properties within the Pioneer Array. Nutrient distributions will be assayed together with hydrography to detect the signature of frontal upwelling and associated nutrient supply. The investigators expect that enhanced nutrient supply will lead to changes in the phytoplankton assemblage, which will be quantified with conventional flow cytometry, imaging flow cytometry (Imaging FlowCytobot, IFCB), optical imaging (Video Plankton Recorder, VPR), traditional microscopic methods, and pigment analysis. Zooplankton will be measured in size classes ranging from micro- to mesozooplankton with the IFCB and VPR, respectively, and also with microscopic analysis. Biological responses to upwelling will be assessed by measuring rates of primary productivity, zooplankton grazing, and net community production. These observations will be synthesized in the context of a coupled physical-biological model to test the two hypotheses that can potentially explain prior observations: (1) grazer-mediated control and (2) undersampling. Hindcast simulations will also be used to diagnose the relative importance of the various mechanisms of upwelling. The intellectual merit of this effort stems from our interdisciplinary approach, advanced observational techniques, and

integrated analysis in the context of a state-of-the-art coupled model. The project will address longstanding questions regarding hydrodynamics and productivity of an important ecosystem, leading to improved understanding of physical-biological interactions in a complex continental shelf regime. Given the importance of frontal systems in the global coastal ocean, it is expected that knowledge gained will have broad applicability beyond the specific region being studied.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1657803

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