

Biogeochemical data collected from porewater profiles within a shallow, sandy subterranean estuary (STE) in Virginia USA, from 2018 - 2019

Website: <https://www.bco-dmo.org/dataset/807664>

Data Type: Other Field Results

Version: 1

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Project

» [Collaborative Research: Cryptic nitrogen cycling in the anoxic subterranean estuary](#) (Subsurface cryptic N cycle)

Contributors	Affiliation	Role
Song, Bongkeun	Virginia Institute of Marine Science (VIMS)	Principal Investigator
Anderson, Iris C.	Virginia Institute of Marine Science (VIMS)	Co-Principal Investigator
Wilson, Stephanie J.	Virginia Institute of Marine Science (VIMS)	Student, Contact
Kinkade, Danie	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract

These data were collected during 2018-2019 from a sandy subterranean estuary (STE) located in Gloucester Point, Virginia, USA. Porewater samples were collected from dedicated piezometers at depths ranging from 10 centimeters to 300 centimeters deep in the STE.

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Coverage

Spatial Extent: Lat:37.248884 Lon:-76.505324

Temporal Extent: 2018-04-09 - 2019-01-15

Acquisition Description

These data were collected during 2018-2019 from a STE located in Gloucester Point, Virginia, USA. Porewater samples were collected from dedicated piezometers at depths ranging from 10 centimeters to 300 centimeters deep in the STE. Each profile from the STE in each season was all collected at low tide.

Porewater samples were collected using a peristaltic pump to pull water from each piezometer. Temperature, salinity, and pH were collected using a flow-through cell and a YSI. Nutrient samples were filtered with a 0.45 μ M filter and kept on ice until frozen for later analysis. DIC samples were fixed using HgCl in exetainer tubes and kept under water until analysis. Sulfide samples were fixed with Zinc Acetate for later calorimetric analysis.

Processing Description

Nutrient samples were analyzed on a Lachat QuikChem 8000 automated ion analyzer Lachat Instruments, Milwaukee, WI, USA; detection limits for NO_3^- , NH_4^+ , and PO_4^{3-} are 0.20, 0.36, and 0.16 μM , respectively. Dissolved organic Carbon samples were analyzed using a Shimadzu TOC 5000 total organic carbon analyzer. Porewater sulfide were analyzed using a spectrophotometer.

BCO-DMO Processing Notes:

- Ran through Laminar processing software, and set data types.
- Location field was split into individual latitude and longitude fields with sign designations for direction, and added to data.
- Standardized ISODateTime field was constructed from supplied date and time fields and added to data
- Parameter names were edited to conform to BCO-DMO conventions (inserted underscores for spaces in parameter names)

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Parameters

Parameter	Description	Units
Location	geographic position of sampling site given in latitude and longitude	decial degrees
Depth	Depth of porewater collection	cm
Season	sampling season	unitless
Date	sampling date	unitless
Time	time of sample collection	unitless
Tidal_Stage	text description of stage of tidal cycle (i.e. low high)	unitless
Temperature	porewater temperature	degrees Celsius
Salinity	salinity	unitless
pH	porewater pH	unitless
DO	Porewater dissolved oxygen	uM
NO3	Porewater Nitrate	uM
NO2	Porewater Nitrite	uM
NH4	Porewater Ammonium	uM
DIP	Porewater Phosphate	uM
DIC	Porewater Dissolved Inorganic Carbon	uM
DOC	Porewater Dissolved Organic Carbon	uM
DON	Porewater Dissolved Organic Nitrogen	uM
H2S	Porewater Sulfide	uM
Latitude	latitude component of geographic location where positive is north	decimal degrees
Longitude	longitude component of geographic location where positive is east	decimal degrees
ISO_DateTime_UTC	Date and time (UTC) in ISO8601 format: YYYY-MM-DDThh:mm:ssZ	unitless

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Instruments

Dataset-specific Instrument Name	total organic carbon analyzer
Generic Instrument Name	Total Organic Carbon Analyzer
Dataset-specific Description	Shimadzu TOC 5000 total organic carbon analyzer
Generic Instrument Description	A unit that accurately determines the carbon concentrations of organic compounds typically by detecting and measuring its combustion product (CO ₂). See description document at: http://bcodata.whoi.edu/LaurentianGreatLakes_Chemistry/bs116.pdf

Dataset-specific Instrument Name	automated ion analyzer
Generic Instrument Name	Flow Injection Analyzer
Dataset-specific Description	Lachat QuikChem 8000 automated ion analyzer Lachat Instruments, Milwaukee, WI, USA; detection limits for NO ₃ ⁻ , NH ₄ ⁺ , and PO ₄ ³⁻ are 0.20, 0.36, and 0.16 μM, respectively
Generic Instrument Description	An instrument that performs flow injection analysis. Flow injection analysis (FIA) is an approach to chemical analysis that is accomplished by injecting a plug of sample into a flowing carrier stream. FIA is an automated method in which a sample is injected into a continuous flow of a carrier solution that mixes with other continuously flowing solutions before reaching a detector. Precision is dramatically increased when FIA is used instead of manual injections and as a result very specific FIA systems have been developed for a wide array of analytical techniques.

Dataset-specific Instrument Name	spectrophotometer
Generic Instrument Name	Spectrophotometer
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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Project Information

Collaborative Research: Cryptic nitrogen cycling in the anoxic subterranean estuary (Subsurface cryptic N cycle)

Coverage: Temperate (Mid-Atlantic), Sandy Beach along the York River Estuary, Gloucester Point, Virginia, USA (37.24884N/76.505324W)

NSF Award Abstract:

Nitrogen is an important nutrient that maintains high coastal ecosystem productivity. Yet excess nitrogen delivery can cause serious water quality deterioration including harmful algal blooms, fish kills, and oxygen free dead zones. Numerous nitrogen transformations regulate the balance between nitrogen delivery and nitrogen removal in coastal environments and the majority of these reactions occur in sediments where seawater passes through the subsurface and mixes with groundwater transported from uplands. This mixing zone, referred to as the subterranean estuary, is characterized by very different geochemistry than either the seawater above it or the groundwater below it. Thus, it has the potential to host a variety of unique reactions that affect nitrogen availability to the overlying water. Scientists from the College of William and Mary, Virginia Institute of Marine Science (VIMS), and the University of Connecticut (UConn) propose to examine the importance of a cryptic nitrogen cycle, a novel and potentially widespread nitrogen cycling process in the subterranean estuary. The cryptic nitrogen cycle comprises anoxic ammonium

oxidation to nitrite (anoxic nitrification) coupled with anaerobic ammonium oxidation (anammox) or denitrification producing harmless dinitrogen gas. The proposed project represents highly transformative science because it has the potential to change the current paradigm detailing operation of the biogeochemical nitrogen cycle in anoxic environments. Occurrence of the cryptic nitrogen cycle would have broad implications for the nitrogen budget of terrestrial and groundwater systems and the coastal ocean. Characterization of the cryptic nitrogen cycle will allow us to better understand interactions among the nitrogen, metals, and sulfur cycles, and potential impacts of ongoing human modification of coastal environments. Educational contribution of this project focuses on graduate and undergraduate student training. Two graduate students at VIMS and UConn will receive interdisciplinary training in microbiology, molecular ecology, and biogeochemistry while several undergraduates recruited through the VIMS REU (Research Experience for Undergraduates) Program and the UConn marine science programs will also participate in the project. In addition, three summer undergraduate interns will be recruited from Hampton University, a historically Black college, and trained to enhance minority education and research in marine science. Public outreach will be achieved through popular venues such as VIMS Marine Science Day, and the VIMS After Hours Public Lecture Series at VIMS. Tobias at UConn also provides educational contributions and outreach efforts through the UConn Marine Scholars and Early College Experience programs and an exhibit at Mystic Aquarium.

A cryptic nitrogen cycle is proposed as a new process coupling anoxic nitrification to microbial nitrogen removal pathways such as anammox and denitrification. Unlike anammox, which refers to the oxidation of ammonium by nitrite to form dinitrogen (N₂) gas, anoxic nitrification occurs by oxidation of ammonium in the absence of oxygen using other common chemical oxidants such as metal oxides (namely, Fe and Mn) or sulfate, abundant in many marine and coastal systems. The thermodynamic favorability of these reactions relies on coupling nitrite formed via these oxidants with anammox or denitrification. Due to the coupling, nitrite will not accumulate or be measurable in anoxic marine systems. Thus, a cryptic N cycle responsible for nitrite production can occur as a novel N transforming process in anoxic environments, serve as a vital link to N₂ production, and attenuate N loads discharging from a subterranean estuary (STE). Preliminary results from a STE in the York River Estuary located in Virginia showed substantial N₂ production, representing removal of 50-75% of the fixed groundwater N, in ferruginous and sulfidic zones where neither nitrite nor nitrate were detectable. Stable isotope incubation experiments using the ¹⁵N tracer and molecular analysis of microbial communities suggest that coupled anoxic nitrification and anammox processes are the dominant N₂ production pathways rather than canonical denitrification in the STE. Therefore, coupled anoxic nitrification-anammox in coastal groundwater may be a major unrecognized sink for fixed nitrogen at the land-sea interface. In addition to coastal groundwater, the cryptic N cycle has potential importance in anoxic zones and ocean basins. This proposal focuses on the STE because geochemical conditions there appear optimal for the proposed reactions to occur, and our preliminary data show strong evidence for a cryptic N cycle. The proposed work uses a combined geochemical, ¹⁵N isotope tracer and microbiological approach to evaluate environmental controls on the cryptic N cycle as well as to estimate its contribution to reduction of fixed N fluxes to the coastal ocean. Four approaches are proposed: (1) Field characterization of anoxic nitrification reactions and associated microbial communities in a subterranean estuary; (2) Laboratory incubation experiments to identify hotspots of the cryptic N cycle; (3) Controlled microcosm experiments to determine geochemical controls on anoxic nitrification; and (4) in situ assessment of anoxic nitrification to estimate the importance of the cryptic N cycle in a coastal aquifer.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1658135
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