Biogeochemical data from sediment cores collected from a shallow, sandy subterranean estuary (STE) in Virginia USA from 2018 to 2019

Website: https://www.bco-dmo.org/dataset/886227
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
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Abstract

These data were collected during 2018-2019 from a sandy subterranean estuary (STE) located in Gloucester Point, Virginia, USA. Seasonal vibracores collected sediment from 0-100 centimeters (cm). Ten-centimeter core sections were used in isotope tracer incubations with 15N-labeled substrates to measure potential denitrification and anaerobic ammonium oxidation (anammox) rates. Extractable nutrient concentrations in potassium chloride extracts were also analyzed for each core section.

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Coverage

Spatial Extent: **Lat**:37.248884 **Lon**:-76.505324
Temporal Extent: 2018-04-10 - 2019-01-16

Methods & Sampling

These data were collected during 2018-2019 from a sandy subterranean estuary (STE) located in Gloucester Point, Virginia, USA (37.248884, -76.505324). In four seasons, a vibracore collected a sediment core roughly 100 centimeters (cm) in length from the mid-tide line of the beach during low tide. Cores were sectioned into ten-centimeter increments. Extractable nutrient concentrations in potassium chloride extracts were analyzed for NOx (nitrate + nitrite), nitrite, and ammonium with a Lachat autoanalyzer. Core sections were used in isotope tracer incubations with 15N-labeled substrates to measure potential denitrification and anaerobic ammonium oxidation (anammox) rates. Briefly, 1 gram (g) of the composited sediment from each 10 cm section was used in sediment slurry incubation experiments. Samples were incubated for 6, 12, or 24 hours in sealed, helium-flushed 12 milliliter (mL) exetainer vials (Labco) at the measured in situ temperature. Denitrification rate incubations were amended with 100 nanomoles $^{15}NO_3^-$ (99 atm%, Cambridge Isotope Laboratories, Inc.), and $^{29,30}N_2$ products were measured using a gas bench isotope ratio mass spectrometer (IRMS, Delta V Plus, Thermo Fisher Scientific, Waltham, MA). To measure potential anammox rates, 500 nanomoles of $^{15}NH_4^+$ (99 atm%, Cambridge Isotope Laboratories, Inc.) and 100 nmoles $^{14}NO_2^-$ were added to the sediment slurries; the production of $^{29}N_2$ was measured by IRMS. N_2 production rates were calculated using the methods described by (Song and Tobias, 2011). All incubations were conducted in duplicate.

Data Processing Description

BCO-DMO Processing:
- split the Location column into Latitude and Longitude columns;
- converted Longitude values from positive to negative (to indicate West direction);
- converted date to YYYY-MM-DD format;
- renamed fields to comply with BCO-DMO naming conventions.

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Data Files

File
sediment_cores.csv(Comma Separated Values (.csv), 3.85 KB) MD5:4187e475ec59a70ee0f2ffcf5e6e0c2b Primary data file for dataset ID 886227

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Related Publications

Song, B., & Tobias, C. R. (2011). Molecular and Stable Isotope Methods to Detect and Measure Anaerobic Ammonium Oxidation (Anammox) in Aquatic Ecosystems. Research on Nitrification and Related Processes, Part B, 63–89. https://doi.org/10.1016/b978-0-12-386489-5.00003-8 https://doi.org/10.1016/B978-0-12-386489-5.00003-8
Methods

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Parameters

Parameter	Description	Units
Latitude	Latitude of sampling location	degrees North
Longitude	Longitude of sampling location	degrees East
Depth_cm	Depth section of core denoted by the top of that section, e.g. 10 cm indicates the core section from 10-20cm.	centimeters (cm)
Season	Season in which the samples were collected (Spring, Summer, Fall, Winter)	unitless
Date	Date of sample collection	unitless
Tidal_Stage	The tidal stage during which cores were collected	unitless
Extractable_NOx	Concentration of NOx (nitrate + nitrite) measured in sediment KCl extract in umoles/L	uM (micromolar)
Extractable_NO2	Concentration of NO2 (nitrite) measured in sediment KCl extract in umoles/L	uM (micromolar)
Extractable_NH3	Concentration of NH4 (ammonium) measured in sediment KCl extract in umoles/L	uM (micromolar)
Anammox	Measured mean potential anammox rate in mmoles/m2/day in duplicate sediment slurry incubation	millimoles per square meter per day (mmoles m-2 d-1)
Anammox_std_dev	Anammox standard deviation of duplicate samples	millimoles per square meter per day (mmoles m-2 d-1)
Denitrification	Measured mean potential denitrification rate in mmoles/m2/day in duplicate sediment slurry incubation	millimoles per square meter per day (mmoles m-2 d-1)
Denitrification_std_dev	Denitrification standard deviation of duplicate samples	millimoles per square meter per day (mmoles m-2 d-1)

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Instruments

Dataset-specific Instrument Name	Delta V Plus, Thermo Fisher Scientific
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Gas bench isotope ratio mass spectrometer (IRMS) Delta V Plus, Thermo Fisher Scientific, Waltham, MA.
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	Lachat QuikChem 8000
Generic Instrument Name	Nutrient Autoanalyzer
Dataset-specific Description	Lachat QuikChem 8000 automated ion analyzer Lachat In- struments, Milwaukee, WI, USA; detection limits for NO3−, NH4+, and PO43− are 0.20, 0.36, and 0.16 µM, respectively.
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	vibracore
Generic Instrument Name	Vibracore
Generic Instrument Description	Vibracoring is a sediment sampling technology to obtain undisturbed cores of unconsolidated, sediment in saturated or nearly saturated conditions by driving sampling tubes with a high-frequency-low-amplitude vibrating device. During sediment coring, the high-frequency vibration transfers the energy to the sediment and aids in the liquefaction of the surrounding sediment. It greatly reduces the friction between the core tube and sediment and eases the core tube to penetrate into the sediment layer. Comparing to non-vibratory coring devices, such as box cores, gravity cores, and piston cores, vibracore has higher core sample recoveries. Vibracorers are effective in both shallow and deep environments. They retrieve core samples with different lengths depending on sediment lithology.

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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-1657801

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