Benthic flux data from sediment cores collected in the York River Estuary, VA in 2020

Website: https://www.bco-dmo.org/dataset/854297
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Project
» Alteration of carbon fluxes by intense phytoplankton blooms in a microtidal estuary (LYRE)

Contributors	Affiliation	Role
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Abstract
Sediment cores were collected bimonthly and before/after summer intensive phytoplankton blooms in the York River Estuary. Flux parameters were measured during dark/light core incubations under in situ conditions.

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Coverage

Spatial Extent: **N**:37.4847 **E**:-76.3975 **S**:37.2217 **W**:-76.762
Temporal Extent: 2020-01-29 - 2020-10-28

Acquisition Description

Benthic Fluxes:
In January, June, August, and October of 2020, triplicate sediment cores (5.7 cm diameter, 10 cm height) were collected from three shoal stations and three channel stations during bimonthly cruises of the York River Estuary (YRE) on 24ft Carolina skiffs. In July and September 2020, triplicate sediment cores of the same parameters were collected from three shoal and three channel stations in the lower YRE before and after the occurrence of intense phytoplankton blooms. Depths at which the sediment cores were sampled were about 1m at the shoal stations and 10m at the channel stations. After collection, the sediment cores were stored in coolers on ice. As sampling at all of the stations took six hours, the cores were stored in

coolers for one to five hours depending on when a particular station was sampled. After transport, the sediment cores were placed in an environmental chamber under *in situ* conditions of temperature in buckets filled with ambient YRE water with constant stirring. The cores were left in the dark overnight to equilibrate. The following day, the overlying water in the cores was replaced with filter-sterilized (0.2 µm) site water and capped. The cores were then incubated for seven hours (three hours in the dark, followed by 1 hour for equilibration with light, followed by three hours in the light). Ambient light conditions were simulated by high-intensity UV/ VIS lamps. Dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), dissolved inorganic nitrogen and phosphorus (DIN), and dissolved organic nitrogen (DON) samples were collected every hour throughout the six-hour incubation. DOC, DIN, and DON samples were filtered through 0.45 µm polysulfone filters. For DIC, 12 mL of water were collected and preserved with 0.1 µL of mercuric chloride. Dissolved oxygen (DO) concentrations were monitored every hour using a PreSens OXY-4 SMA (G2) oxygen sensor. Water was simultaneously replaced during sampling with filter sterilized (0.2 µm) site water.

One additional sediment core (5 cm diameter) was taken at each shoal and channel station for sediment characterization (Anderson et al. 2003) and benthic chlorophyll-a analysis. After collection, one of the cores from each site was sectioned at 0-2cm and 2-5 cm. Half of each section was collected in whirlpak bags filled with a volume of KCl equal to 2x the volume of the sediment (35mL for 0-2cm section, 50mL for 2-5cm section), shaken for one hour, centrifuged, filtered (0.45 µm polysulfone), and analyzed for ammonium (NH_4^+), nitrate (NO_3^-), and nitrite (NO_2^-) on a QuikChem FIA+ 8000 Series Latchet autoanalyzer. The other half of each section (0-2cm and 2-5cm) was used to calculate bulk density, water content, and organic content via measurement of wet weights, dry weights, and combusted weights of the sediment sample. To determine benthic chlorophyll-a concentrations, sediment from each site was sampled *in situ* at 0-3mm and 3-10mm and frozen until analysis. For analysis, acetone extractant (10 mL) was added to the samples, each sample was sonicated for 30 seconds, and the sonicated samples were placed in a freezer for 24 hours before analysis on a spectrophotometer (Lorenzen 1967, Pinckney et al. 1995; Jeffrey and Welchmeyer 1997).

Benthic N Cycling Rates:
Actual rates of denitrification and DNRA were determined via the isotope pairing technique (IPT) (Murphy et al. 2016). IPT relies on using added $^{15}NO_3^-$ to water overlying sediments to distinguish between direct, coupled, and actual vs. potential rates of denitrification and DNRA. At the time of core collection, an additional set of two cores (5.7 cm diameter, 10 cm height) were collected from each station and kept in the same conditions as the flux cores to serve as T0 cores for IPT. After the flux experiment described above, the cores were uncapped and left in the dark overnight in buckets filled with ambient YRE water with constant stirring. The following morning, each core was spiked with 5.37 mL of 10 mM 98 atom% $^{15}NO_3^-$ to bring the concentration of nitrate within the cores to 100 µM. A water sample was collected from each core and analyzed for total NO_3^- ($^{14}NO_3^-$ + $^{15}NO_3^-$). The DO concentrations were measured in each core using a PreSens OXY-4 SMA (G2) oxygen sensor. The T0 cores were left uncapped in the environmental chamber and the remaining cores (TF) were capped and placed in buckets of ambient YRE water for one hour to allow the $^{15}NO_3^-$ to diffuse to the active zone of denitrification and DNRA. The overlying water in the T0 cores was then be sampled for total NO_3 - and the cores were slurried and sampled for $^{29}N_2$ and $^{30}N_2$ (12 mL of slurry preserved with 0.1 mL of saturated zinc chloride) and KCl-extractable NH_4^+ (60 mL of slurry placed in whirlpak bags filled with 17.7 g of powdered KCl). The NH_4^+ was reduced by the OX/MIMS method (Yin et al. 2014) and $^{29}N_2$ and $^{30}N_2$ measured by the MIMS. The DO concentrations in the TF cores were monitored using the PreSens OXY – 4 SMA (G2) oxygen sensor) every 30 to 60 minutes until DO concentrations reached no less than 70% of initial concentrations (or a 30% drop). Each core was then uncapped and the overlying water sampled and analyzed for total NO_3^-. The cores were slurried sampled and analyzed for $^{29}N_2$, $^{30}N_2$, and $^{15}NH_4^+$ concentrations as described above.

Instruments:
Nutrient analyses (NO_3, NO_2, NH_4) were performed with a Lachat QuikChem 8000 automated ion analyzer (Lachat Instruments, Milwaukee, WI, USA); detection limits for NO_3, and NH_4, are 0.20 and 0.36 µM, respectively). DIC was analyzed on an Apollo, model AS-C3 (Apollo SciTech, Newark DE); DOC on a Shimadzu TOC-VCSN combustion analyzer, and extracted chlorophyll-a on a Beckman Coulter DU800 Spectrophotometer. $^{29}N_2$ and $^{30}N_2$ measured by the membrane inlet mass spectrometer (MIMS, Balzers Prisma).

Processing Description

BCO-DMO Processing:
- changed date format to YYYY-MM-DD;
- corrected single longitude value that was positive;
- renamed fields.

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Related Publications

Anderson, I. C., Brush, M. J., Piehler, M. F., Currin, C. A., Stanhope, J. W., Smyth, A. R., … Whitehead, M. L. (2013). Impacts of Climate-Related Drivers on the Benthic Nutrient Filter in a Shallow Photic Estuary. Estuaries and Coasts, 37(S1), 46–62. doi:10.1007/s12237-013-9665-5
Methods

Jeffrey, S.W. & Welschmeyer, N.A. (1997). Spectrophotometric and fluorometric equations in common use in oceanography. p. 597–615. In: [Jeffrey SW, RFC Mantoura, and SW Wright, eds.] Phytoplankton pigments in oceanography: Guidelines to modern methods. UNESCO, Paris, France.
Methods

Lorenzen, C. J. (1967). Determination of chlorophyll and phaeopigments: spectrophotometric equations. Limnology and Oceanography, 12(2), 343–346. doi:10.4319/lo.1967.12.2.0343
Methods

Murphy, A. E., Anderson, I. C., Smyth, A. R., Song, B., & Luckenbach, M. W. (2016). Microbial nitrogen processing in hard clam (Mercenaria mercenaria) aquaculture sediments: the relative importance of denitrification and dissimilatory nitrate reduction to ammonium (DNRA). Limnology and Oceanography, 61(5), 1589–1604. doi:10.1002/lno.10305
Methods

Pinckney, J., Papa, R., & Zingmark, R. (1994). Comparison of high-performance liquid chromatographic, spectrophotometric, and fluorometric methods for determining chlorophyll a concentrations in estaurine sediments. Journal of Microbiological Methods, 19(1), 59–66. doi:10.1016/0167-7012(94)90026-4
Methods

Yin, G., Hou, L., Liu, M., Liu, Z., & Gardner, W. S. (2014). A Novel Membrane Inlet Mass Spectrometer Method to Measure 15NH4+ for Isotope-Enrichment Experiments in Aquatic Ecosystems. Environmental Science & Technology, 48(16), 9555–9562. doi:10.1021/es501261s
Methods

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Parameters

Parameter	Description	Units
Survey_Type	bimonthly or intensive cruise	unitless
Date	date when the survey took place; format: YYYY-MM-DD	unitless
Station	numerical station number to differentiate sample locations	unitless
Station_Type	station type to differentiate between channel and shoal stations	unitless

Depth	depth at which cores were collected	meters
Lat	latitude of sample location	decimal degrees North
Long	longitude of sample location	decimal degrees East
Salinity	Salinity measured in situ	unitless
Temp	Temp measured in situ	degrees Celsius
NOx_1	sediment nitrate/nitrate concentrations	micromolar
NO3_1	sediment nitrate concentrations	micromolar
NH4_1	sediment ammonium concentrations	micromolar
Chl_a	sediment chlorphyll-a concentrations	milligrams per square meter (mg/m2)
Bulk_Denisty	bulk density of sediment	grams dry weight per milliliter (g/mL)
Percent_OM	sediment percent organic matter	unitless (percent)
NH3_1	flux of ammonium in dark	millimoles per square meter per hour (mmol/m2/hour)
NO3_2	flux of nitrate in dark	millimoles per square meter per hour (mmol/m2/hour)
DIC_1	flux of dissolved inorganic carbon in dark	millimoles per square meter per hour (mmol/m2/hour)
DO_1	flux of dissolved oxygen in dark	millimoles per square meter per hour (mmol/m2/hour)
DOC_1	flux of dissolved inorganic carbon in dark	millimoles per square meter per hour (mmol/m2/hour)
TDN_1	flux of total dissolved nitrogen in dark	millimoles per square meter per hour (mmol/m2/hour)
NH3_2	flux of ammonium in light	millimoles per square meter per hour (mmol/m2/hour)
NO3_3	flux of nitrate in light	millimoles per square meter per hour (mmol/m2/hour)
DIC_2	flux of dissolved inorganic carbon in light	millimoles per square meter per hour (mmol/m2/hour)
DO_2	flux of dissolved oxygen in light	millimoles per square meter per hour (mmol/m2/hour)
DOC_2	flux of dissolved organic carbon in light	millimoles per square meter per hour (mmol/m2/hour)
TDN_2	flux of total dissolved nitrogen in light	millimoles per square meter per hour (mmol/m2/hour)
DNRA	actual rate of dissimilatory nitrate reduction to ammonium	micromoles per square meter per hour (micromole/m2/hour)
DNF	actual rate of denitrification	micromoles per square meter per hour (micromole/m2/hour)
NEM	calculated rate of benthic net ecosystem metabolism	millimoles oxygen per square meter per day (mmol/m2/day)

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Instruments

Dataset-specific Instrument Name	Shimadzu TOC-VCSN
Generic Instrument Name	Shimadzu TOC-V Analyzer
Dataset-specific Description	DOC was analyzed on a Shimadzu TOC-VCSN combustion analyzer.
Generic Instrument Description	A Shimadzu TOC-V Analyzer measures DOC by high temperature combustion method.

Dataset-specific Instrument Name	Lachat QuikChem 8000
Generic Instrument Name	Flow Injection Analyzer
Dataset-specific Description	Nutrient analyses (NO_3, NO_2, NH_4) were performed with a Lachat QuikChem 8000 automated ion analyzer (Lachat Instruments, Milwaukee, WI, USA).
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	Beckman Coulter DU800 Spectrophotometer
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	Extracted chlorophyll-a was analyzed on a Beckman Coulter DU800 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.

Dataset-specific Instrument Name	membrane inlet mass spectrometer (MIMS, Balzers Prisma)
Generic Instrument Name	Membrane Inlet Mass Spectrometer
Dataset-specific Description	$^{29}N_2$ and $^{30}N_2$ were measured by the membrane inlet mass spectrometer (MIMS, Balzers Prisma).
Generic Instrument Description	Membrane-introduction mass spectrometry (MIMS) is a method of introducing analytes into the mass spectrometer's vacuum chamber via a semipermeable membrane.

Dataset-specific Instrument Name	Apollo model AS-C3
Generic Instrument Name	Apollo SciTech AS-C3 Dissolved Inorganic Carbon (DIC) analyzer
Dataset-specific Description	DIC was analyzed on an Apollo, model AS-C3 (Apollo SciTech, Newark DE).
Generic Instrument Description	A Dissolved Inorganic Carbon (DIC) analyzer, for use in aquatic carbon dioxide parameter analysis of coastal waters, sediment pore-waters, and time-series incubation samples. The analyzer consists of a solid state infrared CO2 detector, a mass-flow controller, and a digital pump for transferring accurate amounts of reagent and sample. The analyzer uses an electronic cooling system to keep the reactor temperature below 3 degrees Celsius, and a Nafion dry tube to reduce the water vapour and keep the analyzer drift-free and maintenance-free for longer. The analyzer can handle sample volumes from 0.1 - 1.5 milliliters, however the best results are obtained from sample volumes between 0.5 - 1 milliliters. It takes approximately 3 minutes per analysis, and measurement precision is plus or minus 2 micromoles per kilogram or higher for surface seawater. It is designed for both land based and shipboard laboratory use.

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Project Information

Alteration of carbon fluxes by intense phytoplankton blooms in a microtidal estuary (LYRE)

Coverage: York River Estuary, Virginia

NSF Award Abstract:
Estuaries, coastal water bodies where rivers mix with ocean water, are hotspots for the processing of carbon and nutrients moving from land to the coastal ocean. Within estuaries land-based nutrient inputs can cause intense blooms of single-celled algae called phytoplankton, which can have significant impacts on the ecosystem. As blooms move down-estuary some of the phytoplankton material is buried on the bottom, and some is decomposed, resulting in low oxygen conditions (hypoxia), harmful to marine life, and production of carbon dioxide (CO2), the major greenhouse gas, which can exchange with the atmosphere. The remaining phytoplankton material can be exported to the ocean. The type and amount of carbon exported from the estuary depend both on its biological activity and physical factors such as fresh water discharge, temperature, and light availability. If phytoplankton production is greater than decomposition, the estuary will take up atmospheric CO2 and export phytoplankton carbon to the coastal ocean. On the other hand, if decomposition is greater than production the estuary will be a source of CO2 to the atmosphere and dissolved CO2 to the coastal ocean. The investigators expect that intense phytoplankton blooms will greatly amplify carbon exchanges with the atmosphere, coastal ocean, and bottom sediments. As intense phytoplankton blooms increase in the future due to increased nutrient inputs and temperature, low oxygen events may become more frequent with potential negative impacts on fisheries and increased export of carbon to the coastal ocean and atmosphere. This study will fill critical gaps identified by the Coastal Carbon Synthesis Program in knowledge of how microtidal estuaries transform and export C to the atmosphere, benthos, and coastal ocean. In addition, there will be a strong teaching and training component to this project, with support for graduate and undergraduate students. The graduate student will be partnered with secondary teachers to gain teaching experience and enrich the middle school educational programs. Summer undergraduate interns will be recruited for a summer

program from Hampton University, a historically Black college. There will be public outreach through participation in existing programs at VIMS.

Estuaries serve as critical hotspots for the processing of carbon (C) as it transits from land to the coastal ocean. Recent attempts to synthesize what is known about sources and fates of C in estuaries have noted large data gaps; thus, the role of estuaries, especially those that are microtidal, as important sources of carbon dioxide (CO2) to the atmosphere and total organic carbon (TOC) and dissolved inorganic carbon (DIC) to the coastal ocean, or as a C sink in bottom sediments, remains uncertain. Intensive phytoplankton blooms are becoming increasingly frequent in many estuaries and are likely to have important and yet unknown impacts on the C cycle. The trophic status of an estuary will determine in large part the species of C exported to the atmosphere, bottom sediments, and coastal ocean. The overarching objective of this project is to identify the impacts of intense phytoplankton blooms on C speciation, net C fluxes and exchanges in the Lower York River Estuary (LYRE), a representative mesotrophic, microtidal mid-Atlantic estuary. Metabolic processes are hypothesized to be spatially and temporally dynamic, driving the speciation, abundance, and fates of C in the LYRE. High spatiotemporal resolution sampling in the LYRE will capture rates of C cycling under both baseline conditions throughout most of the year, and during periods when the estuary is perturbed by widespread and intense, but patchy, late summer phytoplankton blooms. The short-term effects of physical drivers (wind, temperature, salinity, fresh water discharge, nutrient and organic carbon loads) and biological drivers (metabolic rates, bacterial and phytoplankton abundances and composition) on C transformations, speciation, and exchanges will be assessed. Expected longer term variations in the C cycle due to anthropogenic and natural disturbances will be predicted through use of modeling. In addition, laboratory manipulations will examine the impacts of specific organisms dominating intensive phytoplankton blooms on benthic metabolism, processing of organic C by the microbial community, and C fluxes to the water column.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1737258

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