Pelagic primary production and respiration in the York River Estuary sampled in 2018-2021.

Website: https://www.bco-dmo.org/dataset/962330
Data Type: Other Field Results
Version: 1
Version Date: 2025-09-23

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

Contributors	Affiliation	Role
Anderson, Iris C.	Virginia Institute of Marine Science (VIMS)	Principal Investigator
Brush, Mark J.	Virginia Institute of Marine Science (VIMS)	Co-Principal Investigator, Contact
Reece, Kimberly S.	Virginia Institute of Marine Science (VIMS)	Co-Principal Investigator
Song, Bongkeun	Virginia Institute of Marine Science (VIMS)	Co-Principal Investigator
Soenen, Karen	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
We measured pelagic primary production and respiration in the York River Estuary (YRE), a tributary of Chesapeake Bay, over two annual cycles (2018-19) and during two late-summer periods (2020-21) characterized by intense blooms of the dinoflagellates Margalefidinium polykrikoides and Alexandrium monilatum. During 2018-19, water was collected bimonthly from channel stations along the axis of the YRE. During 2020 and 2021, water was collected approximately weekly at stations inside and outside of bloom patches (n=3 each) in late summer in the lower YRE. Water was incubated across the full range of surface irradiance at in situ temperatures in a light gradient box. Metabolic rates were computed as the change in dissolved oxygen over the course of the incubations (1-3 hours in the light; overnight in the dark) as measured with Hach luminescent dissolved oxygen sensors. Data were used to construct photosynthesis-irradiance (P-I) curves that were combined with hourly surface irradiance, light attenuation, and estuarine bathymetry to compute vertically-integrated, daily rates. This dataset includes measured turbidity, extracted chlorophyll-a, and measured salinity, which were used to compute the vertical attenuation coefficient, statistically-determined P-I parameters normalized to measured chlorophyll-a, and vertically-integrated, daily rates of gross primary production and respiration.

Table of Contents

- Coverage
- Dataset Description
  - Methods & Sampling
  - Data Processing Description
  - BCO-DMO Curation Notes
  - Problem Description
- Data Files
- Related Publications
- Parameters
- Instruments
- Project Information
- Funding

Coverage

Location: York River Estuary, 37°20'53.99"N, 76°38'7.67"W
Spatial Extent: **N**:37.4841 **E**:-76.3863 **S**:37.2238 **W**:-76.7519

Temporal Extent: 2018-02-07 - 2021-09-07

Methods & Sampling

Data were collected on several single-day cruises on small privateers out of the Virginia Institute of Marine Science, Gloucester Point, VA. Dissolved oxygen concentrations were measured with a Hach HQ40d portable oxygen meter and LDO101 luminescent dissolved oxygen sensors. Sensors were calibrated in water-saturated air prior to each incubation, and re-checked post-incubation. Salinity and turbidity were measured with a YSI 6600V2 connected to a ship-board Dataflow system and calibrated using YSI calibration solutions. Chlorophyll-a concentrations were measured on a 10 AU Turner Designs fluorometer periodically calibrated to a stock solution of known concentration and checked before each run with a solid standard from Turner Designs.

During 2018-19, surface water was collected bimonthly from five fixed channel stations along the axis of the YRE. During 2020 and 2021, surface water was collected approximately weekly at stations inside and outside of bloom patches (n=3 each) in late summer in the lower YRE; station locations followed individual bloom patches which varied cruise to cruise. Water was held in blackened bottles at *in situ* temperatures until being returned to the lab.

Metabolic incubations followed the methods of Giordano et al. (2012, *Mar Ecol Prog Ser* 458: 21–38) and Lake et al. (2013, *Mar Ecol Prog Ser* 492:21–39). Unfiltered water was placed into 60 ml light and dark biological oxygen demand (BOD) bottles and incubated in the dark (n=4 bottles per station) and light (10 irradiance values, 1 bottle each per station) at *in situ* temperatures in a light gradient box with illumination provided by a metal halide lamp. Irradiance levels varied from approximately 30 to over 2,000 uE/m2/s photosynthetically active radiation. Light bottles were typically incubated for 1-3 hours while dark bottles were incubated overnight to obtain a measurable change in oxygen. Salinity and turbidity of the water samples were obtained from the associated Dataflow record on each cruise (measured with a YSI 6600V2 datasonde). Triplicate samples for chlorophyll-a determination at each station were filtered through 0.7 um glass fiber filters which were frozen prior to analysis following Arar and Collins (1997, EPA Method 445.0). Samples were extracted in the dark for 24 h in 8 ml of a 45:45:10 dimethyl sulfoxide : acetone: distilled water solution with 1% diethylamine (Shoaf and Lium 1976, *Limnol Oceanogr* 21: 926−928), and read on a 10 AU Turner Designs fluorometer before and after acidification to compute active chlorophyll-a.

Data Processing Description

Metabolic rates were computed as the change in dissolved oxygen over the course of the incubations (final minus initial) and expressed both as mgO2/l/h and normalized to chlorophyll-a (mgO2/mgChl-a/h). Photosynthesis-irradiance (P-I) curves were then statistically fit to the chlorophyll-a normalized data from each station using the Platt et al. (1980, *J Mar Res* 38: 687−701) function including photoinhibition:

$$P_B = P_{sB}*(1-EXP(-a_B*PAR/P_{sB}))*EXP(-b_B*PAR/P_{sB})+R_B$$

where P_B is the net photosynthetic rate (mgO2/mgChl-a/h), P_{sB} is the gross photosynthetic rate in the absence of photoinhibition (mgO2/mgChl-a/h), a_B is the initial slope of the P-I curve (mgO2/mgChl-a/h (uE/m2/s)$^{-1}$), PAR is photosynthetically active radiation (uE/m2/s), b_B is the negative slope characterizing photoinhibition (mgO2/mgChl-a/h (uE/m2/s)$^{-1}$), R_B is the rate of respiration (mgO2/mgChl-a/h), and the subscript B denotes that all parameters are normalized to chlorophyll-a biomass.

These P-I curves were then combined with hourly surface irradiance, light attenuation, and estuarine bathymetry to compute photosynthesis and respiration in 10 cm depth intervals each hour of the day, which were then vertically integrated and summed to obtain daily rates. Hourly PAR data were obtained from the Taskinas Creek meteorological station of the Chesapeake Bay National Estuarine Research Reserve in Virginia. To obtain representative rates and avoid biasing the data due to sampling on a particularly cloudy day, average hourly PAR was computed for each sampling date using the values from two weeks before and after the date; hourly values were converted to instantaneous PAR (uE/m2/s) to correspond to the units used in the P-I curves. Vertical attenuation coefficient for irradiance (m^{-1}) was computed from turbidity, chlorophyll-a, and salinity using the multiple linear regressions in Lake et al. (2015, *Estuaries and Coasts* 38: 2149-2171) developed for the York River. Vertically-integrated, daily rates were area-weighted to account for variations in estuarine bathymetry. For bimonthly cruises, stations were evenly spaced in five boxes along the axis of the

estuary; bathymetry within each box was used to area-weight the rates. For intensive cruises, area-weighting was based on the bathymetry of the lower YRE.

Calculation of vertically-integrated, daily rates assumed respiration was constant over each 24-hour period at the rate measured in the dark, and that chlorophyll-a concentrations were constant over depth for bimonthly cruises as well as at stations outside of bloom patches during intensive cruises. The two dinoflagellates that bloomed during intensive cruises are known to vertically migrate and aggregate near the surface at midday, so assumptions had to be made regarding the vertical distribution of chlorophyll-a at stations inside bloom patches during intensive cruises. We assumed that the observed chlorophyll-a at those stations occurred in the upper 1 m of the water column from 10 a.m. to 2 p.m. only based on vertical profiling. Below 1 m during the same four hours, chlorophyll-a was set at an average of the concentrations measured at stations outside of bloom patches. For the rest of the day when these species migrate to depth, surface chlorophyll-a (above 1 m) was set at the average of the non-bloom stations, and the high chlorophyll-a concentration measured at the surface was evenly distributed below 1 m.

BCO-DMO Curation Notes

* Converted Date column to ISO format (YYYY-MM-DD)
* Renamed parameters to comply with database requirements (no spaces, periods or special characters)
* Converted NaN values to blanks
* Served displayed excel values with exception to lat/lon values, after discussion with submitter were processed with a precision of 6 decimal numbers.

Problem Description

Daily integrated rates during intensive cruises are approximations only as they depend on assumptions related to the vertical distribution of chlorophyll-a throughout the day. Chlorophyll-a values on October 14, 2019 had to be estimated from the Dataflow YSI due to a problem with the Turner Designs fluorometer.

Certain dates have blank values because we could not sample at a few stations or because there were no bloom patches in the estuary.

[table of contents | back to top]

Data Files

File	
962330_v1_yre_csv.csv	(Comma Separated Values (.csv), 10.17 KB) MD5:ec5c500b9b912df6abdf864c18f58844
Primary data file for dataset ID 962330, version 1	

[table of contents | back to top]

Related Publications

Arar, E. J. & Collins, G. B. (1997). In vitro determination of chlorophyll a and phaeophtin a in marine and freshwater phytoplankton by fluorescence – USEPA Method 445.0. Revision 1.2. In: USEPA methods for determination of chemical substances in marine and estuarine environmental samples. Cincinnati, OH. URL: https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NERL&dirEntryId=309417
Methods

Giordano, J., Brush, M., & Anderson, I. (2012). Ecosystem metabolism in shallow coastal lagoons: patterns and partitioning of planktonic, benthic, and integrated community rates. Marine Ecology Progress Series, 458, 21–38. https://doi.org/10.3354/meps09719
Methods

Lake, S. J., & Brush, M. J. (2015). Contribution of Nutrient and Organic Matter Sources to the Development of

Periodic Hypoxia in a Tributary Estuary. Estuaries and Coasts, 38(6), 2149–2171. https://doi.org/10.1007/s12237-015-9954-2
Methods

Lake, S., Brush, M., Anderson, I., & Kator, H. (2013). Internal versus external drivers of periodic hypoxia in a coastal plain tributary estuary: the York River, Virginia. Marine Ecology Progress Series, 492, 21–39. https://doi.org/10.3354/meps10468
Methods

Platt, T., C. L. Gallegos, and W. G. Harrison. 1980. “Photoinhibition of Photosynthesis in Natural Assemblages of Marine Phytoplankton.” Journal of Marine Research, 16. https://elischolar.library.yale.edu/journal_of_marine_research/1525/
Methods

Shoaf, W. T., & Lium, B. W. (1976). Improved extraction of chlorophyll a and b from algae using dimethyl sulfoxide. Limnology and Oceanography, 21(6), 926–928. Portico. https://doi.org/10.4319/lo.1976.21.6.0926
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
Date	Cruise date	unitless
Station	Station number (fixed locations for bimonthly cruises; variable locations for intensive cruises).	unitless
Lat	Latitude	decimal degrees
Long	Longitude	decimal degrees
Cruise	Type of cruise. Bimonthly cruises characterized the entire estuary; intensive cruises were focused on the lower estuary.	unitless
Type	Type of station for intensive cruises. "bloom" stations were inside of intense bloom patches; "non-bloom" stations were outside these patches. Not applicable for bimonthly cruises.	unitless
Turbidity	Water turbidity measured by a YSI	(NTU or FNU depending on the instrument used)
Chla	Extracted active chlorophyll-a (ug/l)	micrograms per liter (ug/l)
Salinity	Salinity measured by a YSI	unitless
Calc_Kd	Vertical attenuation coefficient for irradiance	m-1

PsB	Biomass-specific gross photosynthetic rate in the absence of photoinhibition	mgO2/mgChl-a/h
aB	Initial slope of the biomass-specific photosynthesis-irradiance curve	mgO2/mgChl-a/h (uE/m2/s)-1
bB	Negative slope characterizing photoinhibition	mgO2/mgChl-a/h (uE/m2/s)-1
RB	Biomass-specific respiration rate	mgO2/mgChl-a/h
R2adjB	Adjusted R-squared value from fitting the biomass-specific photosynthesis-irradiance curve	unitless
GPP	Gross primary production	gO2/m2/d
Resp	Respiration	gO2/m2/d

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Hach LDO101
Generic Instrument Name	Oxygen Sensor
Dataset-specific Description	Dissolved oxygen concentrations were measured with Hach LDO101 luminescent dissolved oxygen sensors.
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O2) in the gas or liquid being analyzed

Dataset-specific Instrument Name	Hach HQ40d portable oxygen meter
Generic Instrument Name	Oxygen Sensor
Dataset-specific Description	Dissolved oxygen concentrations were measured with a Hach HQ40d portable oxygen meter.
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O2) in the gas or liquid being analyzed

Dataset-specific Instrument Name	10 AU Turner Designs
Generic Instrument Name	Turner Designs Fluorometer 10-AU
Dataset-specific Description	Chlorophyll-a concentrations were measured on a 10 AU Turner Designs fluorometer periodically calibrated to a stock solution of known concentration and checked before each run with a solid standard from Turner Designs.
Generic Instrument Description	The Turner Designs 10-AU Field Fluorometer is used to measure Chlorophyll fluorescence. The 10AU Fluorometer can be set up for continuous-flow monitoring or discrete sample analyses. A variety of compounds can be measured using application-specific optical filters available from the manufacturer (read more from Turner Designs, turnerdesigns.com, Sunnyvale, CA, USA).

Dataset-specific Instrument Name	YSI 6600V2
Generic Instrument Name	YSI Sonde 6-Series
Dataset-specific Description	Salinity and turbidity were measured with a YSI 6600V2 connected to a ship-board Dataflow system and calibrated using YSI calibration solutions.
Generic Instrument Description	YSI 6-Series water quality sondes and sensors are instruments for environmental monitoring and long-term deployments. YSI datasondes accept multiple water quality sensors (i.e., they are multiparameter sondes). Sondes can measure temperature, conductivity, dissolved oxygen, depth, turbidity, and other water quality parameters. The 6-Series includes several models. More from YSI.

[table of contents | back to top]

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 (CO_2) 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.

[table of contents | back to top]

Funding

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

[table of contents | back to top]