Spring and summer 2019 seston, excretion, and tissue C:N:P data for quagga mussels (Dreissena rostriformis bugensis) in Lakes Michigan and Huron

Website: https://www.bco-dmo.org/dataset/922807
Data Type: Cruise Results
Version: 1
Version Date: 2024-03-19

Project
» Ecosystem-scale responses of coupled carbon and nutrient cycles to dramatic shifts in benthic communities: The Upper Great Lakes (Great Lakes CNP cycles)

Contributors	Affiliation	Role
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Abstract
Data include quagga mussel food, tissue, and excretion C, N, and P concentrations from sites throughout Lakes Huron and Michigan (including Green Bay) in the spring and summer of 2019. Samples were taken along trophic status and depth gradients. Site characteristics analyzed include site depth, seston C, N, and P concentrations, chlorophyll a concentration, water temperature, dissolved oxygen concentration, and mussel biomass.

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Coverage

Location: Great Lakes Michigan and Huron
Spatial Extent: **N**:46.986949 **E**:-82.024474 **S**:41.748073 **W**:-92.086815
Temporal Extent: 2019-05-24 - 2019-08-07

Dataset Description

Data files for this dataset are made available through the University of Minnesota Libraries Digital Conservancy at the following link (https://doi.org/10.13020/A6M5-HD07). Data files at the University of Minnesota Library include:

- Dreissenid (quagga) mussel tissue and excretion C, N, and P data for spring/summer 2019 in Lakes Michigan and Huron - Mussel_Data.csv (63.61Kb)
- Site characteristics and location data - Site_Characteristics.csv (9.459Kb)

Methods & Sampling

Study Location

We sampled 25 locations in Lakes Michigan (17 sites) and Huron (8 sites) during spring (May 24 – 29) and summer (July 31 – August 7) of 2019 (Figure 1, Table S1). Sites ranged from 20m to 130m deep. To account for differences in water chemistry between lake depth regions, sites were designated as 'shallow' (30 – 45m), 'mid-depth' (46m – 90m), or 'deep' (> 90m). Green Bay, with sites ranging 25 – 35m deep, was also considered a separate lake region due to consistent differences in trophic status compared to other locations.

Site Characterization

At each site we collected water samples from five meters below the surface ("surface") and two meters above the sediment-water interface ("near-bottom"). Water samples were collected using 12-L Niskin bottles on a Seabird 32 Carousel Rosette sampler. We filtered water samples through GF/F filters to determine particulate organic matter (POC, PON, and PP) concentrations and 0.45µm cellulose nitrate filters for chlorophyll a measurements. Filters for particulate phosphorus (PP) measurements were rinsed with 15 – 20mL 1% HCl and 50mL MilliQ water. All filters were frozen until analysis. We also collected chlorophyll a fluorescence and temperature profiles at each site using a SeaBird Model 911 plus CTD. We measured average dreissenid biomass (g/m2) at our sites using underwater video surveys and Ponar grab sampling (see Zalusky 2021 for more detail on mussel survey methods).

Mussel Collection

We used Ponar grabs to collect mussels for excretion experiments and tissue composition analysis. To minimize stress and damage, we carefully separated mussels from sediment by hand. Mussels were also gently cleansed using a soft-bristled toothbrush to ensure removal of adhering biofilm that might impact respiration and dissolved nutrient measurements. To mimic environmental conditions close to those insitu, we stored mussels in unfiltered near-bottom lake water during processing. Mussels were rinsed with ultrapure MilliQ water before we placed them in incubation chambers for excretion and respiration rate measurements.

Excretion and Respiration Rate Measurements

Mussel respiration and nutrient (N and P) excretion rates were measured using shipboard incubations. To test for the influence of body size on metabolic rate, at each site we incubated up to 12, 5, and 3 small (< 15.5mm), medium (15.5mm – 25mm), and large (> 25mm) mussels, respectively. Incubations were conducted in acid-cleaned vials with 0.7µm GF/F filtered near-bottom lake water. We used five replicates of each mussel size class (small, medium, large) and incubated three containers without mussels to act as controls (18 vials total). We mostly used 40mL amber glass vials as experimental containers, although a small number of incubations were performed in 60mL falcon tubes when working with very large mussels. Before each incubation began, we determined initial DO concentration and took initial dissolved nutrient samples in duplicate, which we syringe filtered (0.22µm polyethersulfone filter) and froze for later analysis. We then added mussels to the experimental containers, sealed the containers with no headspace for gas exchange, and incubated them for three hours in the dark at 4°C (Ozersky and others 2015; Mosley and Bootsma 2015; Tyner and others 2015; Vanderploeg and others 2017; Zalusky 2021). After three hours, we determined final DO concentrations for each vial and syringe filtered incubation water from each vial (0.22µm polyethersulfone filter) then froze samples for later analysis. We measured DO concentration using a WTW Optical IDS dissolved oxygen sensor (FDO® 925, precision = 0.01mg DO ±1.5%, Wilheim, Germany), paired with a multi-parameter portable meter (MultiLine® Multi 3510 IDS). The DO sensor was rinsed with cold MilliQ water between each measurement. DO concentration did not go below 327µmol O2/L in the incubation vials, indicating no instances of hypoxia. Finally, we froze mussels from all incubations for later analysis.

Laboratory Methods

Water Chemistry

Total seston POC and PON concentrations of water samples were determined using a Vario EL cube elemental analyzer (Elementar, Langenselbold, Germany). We dried sample filters for 24 hours at 60°C and then encased them in tin capsules for analysis. Water PP was then determined using a SEAL Analytical AQ400 discrete

analyzer (Mequon, Wisconsin). We combusted PP sample filters for two hours (550°C) and then digested them using sulfuric acid (10N H2SO4). PP samples were then reacted with acidic molybdate and antimony and reduced by ascorbic acid to form phosphomolybdenum blue, which was measured photometrically (880nm) (modification of US EPA 119-A method, Murphy and Riley 1962). Water column chlorophyll a filters were extracted into 10mL of 90% acetone for 24 hours (Welschmeyer, 1994) and analyzed using a UV-Visible spectrophotometer (Turner Designs, 10-AU, Sunnyvale, CA) at an excitation wavelength of 436nm and 680nm emission. We ran these and other nutrient samples (see below) in duplicate. We measured dissolved N and P (as NH3 + -N and SRP) concentrations in incubation water from mussel excretion experiments using a SEAL Analytical AQ400 discrete analyzer (Mequon, Wisconsin) (alkaline phenate method for NH4 + - EPA-103, acidic molybdate method for SRP - EPA-155). Respiration and excretion rates were determined by normalizing final incubation concentrations to control values, mussel biomass (as SFDM, see next section), and volume of incubation chambers. Values were then divided by the length of incubation time, yielding rates as µmol/g SFDM/h.

Mussel Biomass and Tissue Composition Analysis

Mussels were removed from their shells, dried for 24 – 48 hours in a drying oven at 60°C, and weighed to determine total biomass as shell-free dry mass (SFDM) for each incubation replicate. We then combined replicates for each size class at each site and analyzed them in duplicate (C and N) or triplicate (P). Dried tissue was homogenized using a mortar and pestle and stored in a desiccator until we weighed and analyzed them. We then weighed samples of homogenized tissue for POC and PON (target weight 0.6mg) and PP (target weight 1mg) analyses and processed them the same way as our seston samples (see above).

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Related Publications

Huff, A., Zalusky, J., Katsev, S., & Ozersky, T. (2023). Variable Tissue Stoichiometry Influences Nutrient Recycling by Invasive Freshwater Mussels in Nutrient-Poor Lakes. Ecosystems, 26(7), 1543–1555. https://doi.org/10.1007/s10021-023-00849-x

Results

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Parameters

Parameter	Description	Units
Lake	Lake where sampling occurred (note: Green Bay (GB) is considered separately from Lake Michigan)	unitless
Season	Season sampling occurred	unitless
Year	Year sampling occurred	unitless
Date	Date sampling occurred	unitless
Station_ID	Name of location where sampling occurred	unitless
Vial_ID	Sample identification number	unitless
Vial_Size	Volume of incubation container used in incubation experiment	millileters (mL)
Mussel_Size	Size of mussel included in incubation experiment (initial = initial water sample (no fauna, not incubated), control = water sample after incubation (no fauna))	unitless
Individuals	Number of individual mussels in incubation vial	count
SFDM	Shell-Free Dry Mass of fauna included in incubation vial	grams (g)

tissue_P	Amount of phosphorus in dried mussel tissue (SFDM) (umol P/mg SFDM)	micromole per milligram (umol/mg)
tissue_N	Amount of nitrogen in dried mussel tissue (SFDM) (umol N/mg SFDM)	micromole per milligram (umol/mg)
tissue_C	Amount of carbon in dried mussel tissue (SFDM) (umol C/mg SFDM)	micromole per milligram (umol/mg)
SRP	Soluble reactive phosphorus (SRP) in incubation water at end of incubation (umol P/L)	micromole per liter (umol/L)
SRP_flux	Soluble reactive phosphorus (SRP) in incubation water at end of incubation normalized to control values, mussel SFDM, sample volume, and incubation time	micromole per gram per hour (umol/g*h)
NH3	Ammonia in incubation water at end of incubation (umol N/L)	micromole per liter (umol/L)
NH3_flux	Ammonia in incubation water at end of incubation normalized to control values, mussel SFDM, sample volume, and incubation time (umol N/g SFDM*h)	micromole per gram per hour (umol/g*h)
DO_initial	Dissolved oxygen concentration in incubation water at start of incubation (mg O2/L)	miligram per liter (mg/L)
DO_final	Dissolved oxygen concentration in incubation water at end of incubation (mg O2/L)	miligram per liter (mg/L)
Resp_Rate	Amount of CO2 respired during the incubation. Calculated from DO consumption by subtracting initial water column DO concentration from final water column DO concentration and assuming a 1:1 ratio of O2:CO2. Normalized to control values, mussel SFDM, sample volume, and incubation time (umol C/g SFDM*h)	micromole per gram per hour (umol/g*h)

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Deployments

BH18-09

Website	https://www.bco-dmo.org/deployment/920899
Platform	R/V Blue Heron
Start Date	2018-07-30
End Date	2018-08-08

BH19-16

Website	https://www.bco-dmo.org/deployment/922811
Platform	R/V Blue Heron
Start Date	2019-08-08
End Date	2019-08-11
Description	Project: Sediment geochem Chief: Ozersky, Ted Start date: Sault St. Marie, Michigan End port: Duluth, Minnesota

BH19-15

Website	https://www.bco-dmo.org/deployment/922814
Platform	R/V Blue Heron
Start Date	2019-07-31
End Date	2019-08-08
Description	Project: Sediment geochem Chief: Ozersky, Ted Start port: Sault St. Marie, Michigan End port: Sault St. Marie, Michigan

BH19-05

Website	https://www.bco-dmo.org/deployment/922820
Platform	R/V Blue Heron
Start Date	2019-05-30
End Date	2019-06-02
Description	Project: Sediment geochem Chief: Ozersky, Ted Start Port: Sault St. Marie, Michigan End Port: Duluth, Minnesota

BH19-04

Website	https://www.bco-dmo.org/deployment/922817
Platform	R/V Blue Heron
Start Date	2019-05-21
End Date	2019-05-30
Description	Project: Sediment geochem Chief: Ozersky, Ted Start Port: Duluth, Minnesota End Port: Sault St. Marie, Michigan

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Project Information

Ecosystem-scale responses of coupled carbon and nutrient cycles to dramatic shifts in benthic communities: The Upper Great Lakes (Great Lakes CNP cycles)

Coverage: Upper Laurentian Great Lakes (Lakes Superior, Michigan, Huron)

NSF Award Abstract:
This project will study the effects of invasive zebra and quagga mussels on the biology and chemistry of the Great Lakes. These mussels have caused unprecedented changes to lake ecosystems, including large shifts in

water quality, altered fisheries and diminished recreational opportunities. The mechanisms by which the invasion has affected ecologically important aspects of lake chemistry remain uncertain, making it difficult to predict future changes. This project will quantify how mussels affect sediment and water nutrient chemistry in Lakes Michigan and Huron. Important missing data on altered chemical exchange between sediments and water will be collected to quantify the processes controlling nutrient cycles in the Great Lakes as water moves to the coastal ocean. Development of improved numerical models from this work will allow evaluation of other freshwater and marine systems affected by similar mussel invasions and other stressors. The project will train a post-doctoral researcher and several graduate and undergraduate students in highly interdisciplinary research. Educators and the public at large will be served through creation of freely available, online multimedia content, as well as outreach events at the Duluth Great Lakes Aquarium, the Shedd Aquarium in Chicago, and the Discovery World Science Museum in Milwaukee.

Benthic communities can have large impacts on benthic-pelagic chemical exchanges, but the ecosystem-scale effects of benthos on coupled transformations of carbon, nitrogen, and phosphorus (C-N-P) are rarely addressed and virtually unquantified in freshwaters. The recent invasion of the Laurentian Great Lakes, the world's largest freshwater ecosystem, by dreissenid (zebra and quagga) mussels coincided with massive changes to ecology and water chemistry. Consequences of the invasion include a large and unexplained decline in phosphorus levels, enigmatic reversal of past trends in nitrate levels, and the near-disappearance of native bioturbating Diporeia amphipods. Modeling suggests that nutrient fluxes from sediments could have been strongly affected by shifts in benthic community. Mechanisms explaining these changes, however, remain obscure and thus hamper model predictions of future ecosystem trajectories. Researchers from the Large Lakes Observatory - University of Minnesota Duluth will determine the effects of established dreissenid populations on sediment geochemistry and nutrient dynamics in the Great Lakes by conducting detailed studies in dreissenid-invaded Lakes Michigan and Huron and dreissenid-free Lake Superior. A team of biologists and geochemists will (1) obtain field data to characterize sediment geochemistry of C-N-P, asses rates of biogeochemical processes, and dreissenid effects on chemical and physical properties of sediments, (2) conduct lab experiments to determine how functional traits of sessile dreissenids vs. burrowing Diporeia affect sediment characteristics and chemical fluxes, and (3) use reactive-transport and mass-balance models to understand the whole-lake geochemistry of carbon and nutrients in dreissenid-invaded lakes. This work will advance understanding of the ecology of the great lakes and generally improve models of sediment - water column interactions in aquatic ecosystems.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1737368

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