2015 Annual Progress Report

Reporting Period: 2/1/2014 - 1/31/2015

Project

R/HCE-02-10 - Alteration of Nutrient Cycling and Food Web Structure by Profundal Quagga Mussels in Lake Michigan

Activities & Results

Most field work for this project was completed in 2013. In 2014, emphasis was given to analyzing remaining samples from sediment traps and sediment cores, analyzing data, and publication of results. In addition, a lab experiment was conducted to directly measure phosphorus release from sediments in cores, and compare sediment phosphorus flux rates with mussel P recycling rates. Data analysis has focused on three primary topics: 1) Phosphorus grazing and recycling by profundal mussels; 2) The influence of mussels on near-bottom turbulence and the flux of particles to the lake bottom; 3) Physical and biogeochemical dynamics in the water column. Most data analyses were completed in 2014, and results have been presented at several scientific and general public meetings. Several papers have been published, with several more in preparation. Two graduate students who participated in this project have completed their degrees. One undergraduate member of this project presented his findings at the Summer Undergraduate Research Fellowship (SURF) Symposium (Purdue University), where he received an award for the best undergraduate oral presentation. The project was completed on December 2014 (see project completion report below).

Journal Articles & Other Publications

Title

Determining the coefficient of the small scale eddy model for gas transfer over air-water interface

Publication Type

Journal Article or Book Chapter

Author(s)

Wang, B., Q. Liao, J.H. Fillingham, and H.A. Bootsma

Citation

Wang, B., Q. Liao, J.H. Fillingham, and H.A. Bootsma. 2015. In press. Determining the coefficient of the small scale eddy model for gas transfer over air-water interface. J. Geophys. Res.-Oceans, DOI:10.1029/.

Title

On the coefficients of small eddy and surface divergence models for the air-water gas transfer velocity

Publication Type

Journal Article or Book Chapter

Author(s)
Liao, Q., B. Wang, J.H. Fillingham, and H.A. Bootsma

Citation
Liao, Q., B. Wang, J.H. Fillingham, and H.A. Bootsma. In press. On the coefficients of small eddy and surface divergence models for the air-water gas transfer velocity. J. Geophys. Res.- Oceans.

Title
Phosphorus cycling and grazing by profund quagga mussels in Lake Michigan

Publication Type
Journal Article or Book Chapter

Author(s)
Mosley, C.M., and H.A. Bootsma

Citation
Mosley, C.M., and H.A. Bootsma. In press. Phosphorus cycling and grazing by profund quagga mussels in Lake Michigan. J. Great Lakes Res.

Title
Deep-Water Near-Bottom Turbulence in Lake Michigan: An Underwater Investigation

Publication Type
Proceedings or Symposium

Author(s)
Cannon, D.J., and C. Troy

Citation
Cannon, D.J., and C. Troy. 2013. Deep-Water Near-Bottom Turbulence in Lake Michigan: An Underwater Investigation. The Summer Undergraduate Research Fellowship (SURF) Symposium. Paper 16. http://docs.lib.purdue.edu/surf/2013/presentations/16/

Traditional or Social Media Mentions

Headline/Title
Waters in Transition

Media Name
WI Sea Grant Podcast. http://www.seagrant.wisc.edu/home/Default.aspx?tabid=601&AudioGroupID=47#

Meetings and Workshops

...you organized using project funding.
0 Attendees

Description such as purpose, intended audience, location, and date
No description reported.

Presentations
8 Presentations
400 Presentation Attendees

Volunteer Hours
Estimated number of hours that citizens volunteered to help you accomplish your project goals.
0 Hours

Other
0 Models developed
0 Resource agencies that adopted models
0 Businesses that adopted models
0 Meetings with policy makers
0 Patents/Copyrights pending or received
0 Awards or other recognition

Description (optional)
No description reported.

Graduate Students

Name
Binbin Wang

Affiliation
University of Wisconsin-Milwaukee

Degree
PhD

Graduation
August 2013

Employment related to degree
Yes

Name
Caroline Mosley

Affiliation
University of Wisconsin-Milwaukee

Degree
Masters

Graduation
December 2014

Employment related to degree
Yes

Name
David Cannon

Affiliation
Other

Degree
Masters

Graduation
May 2016

Undergraduate Students
0 New
0 Continuing
1 Graduating

Education Projects Only
Estimated number of students who attended a Sea Grant-sponsored workshop or teachers who received training.
0 K-12 students reached
0 Teachers reached
0 Others reached

Curricula Developed
List curricula developed with Sea Grant support, assistance or influence. Include formal education courses, school or university instructional materials, lesson plans, audio-visual materials, teach guides and textbooks.
No curricula reported.

Project Completion Report
The primary objective of this project was to quantify the flux of carbon and phosphorus through the profundal quagga mussel community, and to determine the effect of these mussel-mediated fluxes on ecosystem-scale nutrient dynamics and energy flow. This was done using a multi-disciplinary approach that included three main tasks: 1) Measuring the rate at which profundal quagga mussels consume suspended particulate carbon and phosphorus, and determining the proportions of this consumed material that are allocated to growth, biodeposits, and excretion; 2) Comparing mussel grazing an excretion / egestion of particulate phosphorus with sedimentation rates as measured with sediment traps; 3) Measuring vertical mixing in the water column, and its influence on food delivery to profundal mussels and the fate of nutrients excreted by mussels. Mussel excretion / egestion experiments resulted in several key findings: 1) Due to constantly low temperatures and low food supply, phosphorus grazing and recycling by profundal mussels is less, on both an individual basis and areal basis, than that by nearshore mussels; 2) A significant portion (~40%) of phosphorus grazed by mussels is released in the form of particulate biodeposits. Therefore, mussel grazing may represent a significant nutrient sink; 3) Mussel grazing rates of phosphorus are several times greater than passive settling rates. This finding suggests that mussel grazing is supported to a large degree by delivery of particulate material to the lake bottom through vertical mixing

processes, rather than passive settling. Hence vertical mixing is a strong modulator of mussel impact on Lake Michigan carbon and phosphorus dynamics. Near-bottom profiles of temperature and currents suggest that weak near-bottom stratification is of sufficient strength to limit turbulence within the near-bottom boundary layer, which may in turn limit delivery of material to the lake bed. Hence any processes that increase near-bottom turbulence will likely result in an even greater capacity of profundal mussels to graze phytoplankton from the water column. There is evidence that, under calm conditions, mussel pumping activity is sufficient to affect near-bottom turbulence, which may accelerate food delivery. The fact that mussel grazing rates are greater than what can be supported by passive settling suggests that profundal quagga mussels have dramatically increased the flux of particulate material from the water column to the benthos, thereby decreasing the water column residence time of phosphorus and the water column concentration of phosphorus. While this effect is greatest in the mixing period, even in the stratified period mussel grazing rates are greater than particulate flux rates from the surface mixed layer to the hypolimnion. Hence mussel grazing reduces food availability to zooplankton and higher trophic levels. While some of the material grazed by profundal mussels is returned directly to the water column in dissolved form, a significant portion is converted to feces and pseudofeces that are deposited on the lake bottom. Lab experiments indicate that, over the short term (< 1 month), these biodeposits actually serves as a phosphorus sink rather than a phosphorus source, possibly due to bacterial growth on this organic-rich material. The long-term fate of these biodeposits (permanent burial versus recycling into the water column) remains uncertain. In summary, the key findings of this project are that quagga mussels inhabiting the deeper strata (hypolimnion) of Lake Michigan represent a significant sink for particulate carbon and phosphorus, reducing food availability to zooplankton and higher trophic levels. Both biogeochemical and food web models need to account for the influence of these filter feeders on energy flow and nutrient dynamics.