Particle image velocimetry (PIV) data for 6 representative cases of quagga mussel filter feeding activity collected during a benthic deployment from the R/V Neeskay on Aug. 2- Aug. 9, 2017.

Website: https://www.bco-dmo.org/dataset/729461
Data Type: Other Field Results
Version: 1
Version Date: 2018-03-06

Project
» Collaborative Research: Regulation of plankton and nutrient dynamics by hydrodynamics and profundal filter feeders (Filter Feeders Physics and Phosphorus)

Contributors	Affiliation	Role
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Coverage

Spatial Extent: **Lat**:43.09503 **Lon**:-87.77119
Temporal Extent: 2017-08-02 - 2017-08-09

Dataset Description

Instantaneous flow velocity distribution on a 2D (x-z) plane, where x and z denote the horizontal and vertical directions, respectively. The velocity field was measured by an underwater PIV system deployed in Lake Michigan to investigate turbulent flows and mixing above the lake bottom, as a result of interaction between lake currents and filter feeding activities of quagga mussels.

Please see supporting document Bio-mixing-PIV.pdf for a description of the data collection and preliminary results.

This dataset contains 6 of the 64 total image sets collected during the deployment. The 6 image sets are labeled as Cases A-F. The chosen sets represent a variety of hydrodynamic conditions. Sets A,B, and C represent the flow fields when the mussels were not actively feeding. Sets D,E, and F represent the flow fields when the mussels were actively feeding.

The datasets for each case are served with BCO-DMO as plain text files with fields for Case (A-F), Time (s), x coordinate (cm), z coordinate (z), u(m/s), and v (m/s). Each file is approximately 32.1 MB.

Links to the MatLab (2015b) version of these data are listed below. Each file is approximately 3.5 MB. Velocity measurements are listed in a 2D matrix format. Also listed are MatLab programs to read the data files and plot flow profiles.

Case A
Case B
Case C
Case D
Case E
Case F
MatLab file descriptions

Plot profiles
Plot velocity fields
Convert to CSV

Methods & Sampling

Excerpt from supporting document Bio-mixing-PIV.pdf:

"An underwater PIV system had been developed (Liao et al., 2009, 2014; Wang et al., 2013) and it was upgraded for this project to measure 2D velocity field immediately above the bottom of Lake Michigan at a mid-depth (latitude = 43.09503 and longitude = -87.77119, water depth = 55 meters) location, which is full covered by quagga mussels. The autonomous PIV (cf. Fig 1) is self-contained, including a laser unit that generated a light sheet by scanning the laser beam, a digital camera unit that captures images of particles illuminated by the laser “sheet”. Laser and camera are synchronized by a signal generator and images are captured by a single board computer that runs a Linux Arm OS. The system was programed to turn on 17 times per day and captures 6,000 image pairs in 10 minutes for each duty cycle. The battery capacity (15 AH 12V) allows 7 days of operation with this duty cycle configuration. The system was deployed untethered between Aug 2 and Aug 9 2017 for seven days. Image acquired covered an area of 8 × 9 cm2 (width × height). PIV interrogation resolved a 2D velocity field on a 41 × 35 mesh with a spatial resolution of 1.7 mm."

Data Processing Description

PIV interrogation analysis was conducted using a house-developed Matlab+C code. The interrogation algorithm followed that by Liao and Cowen (2005). PIV interrogation resolved the 2D velocity field on a 41 × 35 mesh with a spatial resolution of 1.7 mm. The interrogation sub-window was 64 × 64 pixels (3.4 × 3.4 mm), with a 50% overlap. PIV results were post-processed, including a local median filter (5 by 5 mesh grids) to remove strayed vectors and replaced with the local median value. Dissipation rate was estimated with a “direct” method based on PIV measurements (Wang and Liao, 2016)

References:

Liao, Q., Cowen, E. A. (2005). An efficient anti-aliasing spectral continuous window shifting technique for PIV. Experiments in Fluids, 38(2), 197-208. doi: 10.1007/s00348-004-0899-7

Wang B., and Liao, Q. (2016) Field observations of turbulent dissipation rate profiles immediately below the air-water interface. Journal of Geophysical Research: Ocean. 121(6), 4377-4391. doi: 10.1002/2015JC011512

Note: Files processed using MatLab 2015b.

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Data Files

File
729461.csv (Comma Separated Values (.csv), 182.67 MB) MD5:973fdcdeb60dbba6e8896202aaa179aa Primary data file for dataset ID 729461

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Related Publications

Liao, Q., Bootsma, H. A., Xiao, J., Klump, J. V., Hume, A., Long, M. H., & Berg, P. (2009). Development of an in situ underwater particle image velocimetry (UWPIV) system. Limnology and Oceanography: Methods, 7(2), 169–184. doi:10.4319/lom.2009.7.169
Methods

Liao, Q., Wang, B., & Wang, P.-F. (2015). In situ measurement of sediment resuspension caused by propeller wash with an underwater particle image velocimetry and an acoustic doppler velocimeter. Flow Measurement and Instrumentation, 41, 1–9. doi:10.1016/j.flowmeasinst.2014.10.008
Methods

Wang, B., Liao, Q., Xiao, J., & Bootsma, H. A. (2013). A Free-Floating PIV System: Measurements of Small-Scale Turbulence under the Wind Wave Surface. Journal of Atmospheric and Oceanic Technology, 30(7), 1494–1510. doi:10.1175/jtech-d-12-00092.1 https://doi.org/10.1175/JTECH-D-12-00092.1
Methods

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Parameters

Parameter	Description	Units
Time	500 measurements were made in 1 second increments	seconds
x	horizontal coordinate	cm
z	vertical coordinate	cm
u	instantaneous horizontal velocity field	cm/s
w	instantaneous vertical velocity field	cm/s

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Particle Image Velocimetry (PIV) system
Generic Instrument Description	Measures 2D velocity flow fields, usually by scanning particles with a laser beam and capturing images of the illuminated particles.

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Deployments

Neeskay_Cruises_2017-2020

Website	https://www.bco-dmo.org/deployment/730830
Platform	R/V Neeskay
Start Date	2017-05-11
End Date	2020-07-10
Description	Cruises associated with project "Collaborative Research: Regulation of plankton and nutrient dynamics by hydrodynamics and profundal filter feeders" (https://www.bco-dmo.org/project/670679) Multiple deployments of the small research vessel, R/V Osprey, in Lake Michigan at three locations northeast of Milwaukee Harbor, with bottom depths of 15 m (43.09577 N, 87.8611 W), 45 m (43.097983 N, 87.784033 W), and 75 m (43.097917 N, 87.7187 W). The vessel returned to port at end of each day. Both R/V/ Neeskay and R/V Osprey were used for sampling on this project. Sampling dates are as follows: 2017 Dates: May 11, 26; June 1, 8, 13, 23, 30; July 11, 18, 25; Aug. 1, 2, 9, 10, 16, 29; Sep. 12; Oct. 5, 9, 23; Nov. 13. 2018 Dates: May 10, June 12, June 27, July 17, July 19, July 31, Aug. 6, Aug. 23, Sep. 11, Sep. 13, Sep. 25, Oct. 18, Oct. 25. 2019 Dates: May 2, 14; June 5; July 1, 25; Aug. 19, 27; Sep. 11, 20, 23; Oct. 14; Nov. 4 2020 Dates: July 10.

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Project Information

Collaborative Research: Regulation of plankton and nutrient dynamics by hydrodynamics and profundal filter feeders (Filter Feeders Physics and Phosphorus)

Coverage: Lake Michigan

Overview:
While benthic filter feeders are known to influence plankton and nutrient dynamics in shallow marine and freshwater systems, their role is generally considered to be minor in large, deep systems. However, recent evidence indicates that profundal quagga mussels (Dreissena rostriformis bugensis) have dramatically altered energy flow and nutrient cycling in the Laurentian Great Lakes and other larges aquatic systems, so that conventional nutrient-plankton paradigms no longer apply. Observed rates of phosphorus grazing by profundal quagga mussels in Lake Michigan exceed the passive settling rates by nearly an order of magnitude, even under stably stratified conditions. We hypothesize that the apparently enhanced particle deliver rate to the lake bottom results from high filtration capacity combined with vertical mixing processes that advect phytoplankton from the euphotic zone to the near-bottom layer. However, the role of hydrodynamics is unclear, because these processes are poorly characterized both within the hypolimnion as a whole and within the near-bottom layer. In addition, the implications for phytoplankton and nutrient dynamics are unclear, as mussels are also important nutrient recyclers. In the proposed interdisciplinary research project, state-of-the-art instruments and analytical tools will be deployed in Lake Michigan to quantify these critical dynamic processes, including boundary layer turbulence, mussel grazing, excretion and egestion, and benthic fluxes of carbon and phosphorus. Empirical data will be used to calibrate a 3D hydrodynamic-biogeochemical model to test our hypotheses.

Intellectual Merit:
This collaborative biophysical project is structured around two primary questions: 1) What role do profundal dreissenid mussels play in large lake carbon and nutrient cycles? 2) How are mussel grazing and the fate of nutrients recycled by mussels modulated by hydrodynamics at scales ranging from mm (benthic boundary layer) to meters (entire water column)? The project will improve the ability to model nutrient and carbon dynamics in coastal and lacustrine waters where benthic filter-feeders are a significant portion of the biota. By so doing, it will address the overarching question of how plankton and nutrient dynamics in large, deep lakes with abundant profundal filter feeders differ from the conventional paradigm described by previous models. Additionally, the project will quantify and characterize boundary layer turbulence for benthic boundary layers in large, deep lakes, including near-bed turbulence produced by benthic filter feeders.

Broader Impacts:
The project will provide new insight into the impacts of invasive dreissenid mussels, which are now threatening

many large lakes and reservoirs across the United States. Dreissenid mussels appear to be responsible for a number of major changes that have occurred in the Great Lakes, including declines of pelagic plankton populations, declines in fish populations, and, ironically, nuisance algal blooms in the nearshore zone. As a result, conventional management models no longer apply, and managers are uncertain about appropriate nutrient loading targets and fish stocking levels. The data and models resulting from this project will help to guide those decisions. Additionally, the project will provide insight to bottom boundary layer physics, with applicability to other large lakes, atidal coastal seas, and the deep ocean. The project will leverage the collaboration and promote interdisciplinary education for undergraduate and graduate students from two universities (UW-Milwaukee and Purdue). The project will support 3 Ph.D. students and provide structured research experiences to undergraduates through a summer research program. The project will also promote education of future aquatic scientists by hosting a Biophysical Coupling Workshop for graduate students who participate in the annual IAGLR conferences, and the workshop lectures will be published for general access through ASLO e-Lectures and on an open-access project website.

Background publications are available at:
http://onlinelibrary.wiley.com/doi/10.1002/2014JC010506/full
http://link.springer.com/article/10.1007/s00348-012-1265-9
http://aslo.net/lomethods/free/2009/0169.pdf
http://www.sciencedirect.com/science/article/pii/S0380133015001458

Note: This is an NSF Collaborative Research Project.

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Funding

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