Microstructure profiles at Station AT55 in Lake Michigan from 2017, 2018 and 2019.

Website: https://www.bco-dmo.org/dataset/768011
Data Type: Other Field Results
Version: 2
Version Date: 2021-08-17

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

Contributors	Affiliation	Role
Troy, Cary	Purdue University	Principal Investigator, Contact
Bootsma, Harvey	University of Wisconsin (UW-Milwaukee)	Co-Principal Investigator
Cannon, David	Purdue University	Co-Principal Investigator
Liao, Qian	University of Wisconsin (UW-Milwaukee)	Co-Principal Investigator
Soenen, Karen	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Turbulent microstructure profiles were collected near Milwaukee, WI, during 2017 (August 1 - August 16), 2018 (April 5 – April 20), and 2019 (May 13 - May 14) at a 55m depth site. Microstructure measurements were collected using an RSI MicroCTD (Rockland Scientific International, Inc.), which measures velocity shear, temperature, turbidity, and chlorophyll concentrations. High resolution velocity shear (512 Hz) measurements were used to estimate turbulent kinetic energy dissipation throughout the water column. Microstructure profiles were collected during fair weather conditions on each day of sampling.

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Coverage

Spatial Extent: **Lat**:43.069917 **Lon**:-87.753217
Temporal Extent: 2017-08-01 - 2019-05-14

Dataset Description

Turbulent microstructure profiles were collected near Milwaukee, WI, during 2017 (August 1 - August 16), 2018 (April 5 – April 20), and 2019 (May 13 - May 14) at a 55m depth site. Microstructure measurements were collected using an RSI MicroCTD (Rockland Scientific International, Inc.), which measures velocity shear, temperature, turbidity, and chlorophyll concentrations. High resolution velocity shear (512 Hz) measurements were used to estimate turbulent kinetic energy dissipation throughout the water column. Microstructure profiles were collected during fair weather conditions on each day of sampling.

Methods & Sampling

Microstructure profiles were taken over 3 years:

- 2017: 176 microstructure profiles were collected over six days (August 1st, 2nd, 9th, 10th, 15th, and 16th).
- 2018: 129 microstructure profiles were collected over three days (April 5th, 12th, and 20th).
- 2019: 78 microstructure profiles were collected over three days (May 13th and 14th).

Measurements were collected using an RSI MicroCTD (Rockland Scientific International, Inc.) which sampled shear and temperature microstructure at 512Hz, free-falling at a velocity of 0.8 m/s (vertical resolution: ~1.5mm). Shear microstructure was analyzed to obtain turbulent kinetic energy dissipation (see data processing). Velocity shear was measured using two velocity shear probes (RSI; accuracy: 5%) oriented perpendicularly to collect orthogonal shear components. Microstructure temperatures were collected using 2 FP07 probes (accuracy: 0.005), with the resulting measurements averaged to produce the single temperature estimate included in the attached files. Turbidity (accuracy: 2%) and fluorescence (accuracy: 1%) measurements were collected using a JAC-CLTU sensor (JFE Advantech Co., Ltd).

Microstructure profiles were collected manually by letting the instrument free fall through the water column. Profiles were timed and manually stopped to prevent the instrument from crashing into the bed and damaging sensors.

Data Processing Description

Data were downloaded from the instrument and converted to physical units using Matlab software provided by the manufacturer. The energy spectra of vertical velocity shear were used to estimate turbulent kinetic energy dissipation using a combination of power spectral density function integration and Nasmyth empirical spectrum fitting (manufacturer-provided algorithms; see attached TN_028_Dissipation.pdf).

Energy spectra were calculated from 2s (1024 sample) measurement intervals overlapped by 50% (vertical resolution: 0.8m), with corrections for both instrument accelerations and probe-induced spatial averaging (see attached TN_028_Dissipation.pdf).

The mean absolute deviation (MAD) was used to identify and discard all observed spectra that were effected by anisotropy or deviated significantly from the shape of the model spectrum, with a rejection criteria of MAD>2(2/d)1/2, where d is degrees of freedom of the observed spectra.

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- added ISO_DateTime_UTC column with converted DOY_GMT into ISO 8601 format.
- added "profile_name" column to contain information about the name of the profile.
- added columns 'DOY_GMT', 'latitude', 'longitude' from supplementary file, using the "profile_name" column as the join key.

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Data Files

File
profiles_all.csv (Comma Separated Values (.csv), 3.57 MB) MD5:9d90ea1891a06b77510388781232a117 Primary data file for dataset ID 768011

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Supplemental Files

File
RSI Technical Note 028 filename: TN_028_Dissipation.pdf (Portable Document Format (.pdf), 1.02 MB) MD5:4d437a4886c702772472fce47ea0030e Calculating the Rate of Dissipation of Turbulent Kinetic Energy

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Related Publications

Cannon, D. J., Troy, C. D., Liao, Q., & Bootsma, H. A. (2019). Ice-Free Radiative Convection Drives Spring Mixing in a Large Lake. Geophysical Research Letters, 46(12), 6811–6820. doi:10.1029/2019gl082916
https://doi.org/https://doi.org/10.1029/2019GL082916
Results

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Parameters

Parameter	Description	Units
pressure	average pressure at measurement location	decibar (dbar)
temp	average temperature	degrees Celsius
S2	average total velocity shear (S2=[dU/dz]2+[dV/dz]2	1/s2
turb	average turbidity	FTU
chlor	average fluorescence	ppb
dissipation	turbulent kinetic energy dissipation calculated from shear signal	Watts per kilogram (W/kg)
profile_name	profile name extracted from submitted file name	unitless
DOY_GMT	time corresponding to each profile name. Times are taken as the average of measurement times for a given profile. Time units are days in GMT.	unitless
latitude	latitude with positive values northward	decimal degrees
longitude	longituide with positive values eastward	decimal degrees
ISO_DateTime_UTC	Date and time formatted following ISO8601 convention	unitless

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Instruments

Dataset-specific Instrument Name	RSI MicroCTD (Rockland Scientific International, Inc.)
Generic Instrument Name	CTD - profiler
Dataset-specific Description	Measurements were collected using an RSI MicroCTD (Rockland Scientific International, Inc.) which sampled shear and temperature microstructure at 512Hz, free-falling at a velocity of 0.8 m/s (vertical resolution: ~1.5mm).
Generic Instrument Description	The Conductivity, Temperature, Depth (CTD) unit is an integrated instrument package designed to measure the conductivity, temperature, and pressure (depth) of the water column. The instrument is lowered via cable through the water column. It permits scientists to observe the physical properties in real-time via a conducting cable, which is typically connected to a CTD to a deck unit and computer on a ship. The CTD is often configured with additional optional sensors including fluorometers, transmissometers and/or radiometers. It is often combined with a Rosette of water sampling bottles (e.g. Niskin, GO-FLO) for collecting discrete water samples during the cast. This term applies to profiling CTDs. For fixed CTDs, see https://www.bco-dmo.org/instrument/869934.

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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

Funding Source	Award
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