Global reconstructions of particle biovolume, size distribution, and carbon export flux from the seasonal euphotic zone and maximum winter time mixed layer from particle profiles conducted during cruises from 2008 to 2020

Website: https://www.bco-dmo.org/dataset/856942
Data Type: Other Field Results, model results
Version: 2
Version Date: 2023-02-02

Project
» Collaborative Research: Understanding the distribution and biogeochemical role of anaerobic microenvironments in the ocean (Ocean Particles and Microenvironments)

Contributors	Affiliation	Role
Bianchi, Daniele	University of California-Los Angeles (UCLA)	Principal Investigator
Clements, Daniel	University of California-Los Angeles (UCLA)	Co-Principal Investigator
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Global reconstructions of particle biovolume, size distribution, and carbon export flux from the seasonal euphotic zone and maximum winter time mixed layer.

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Coverage

Spatial Extent: **N**:90 **E**:180 **S**:-90 **W**:-180
Temporal Extent: 2008 - 2020

Methods & Sampling

Methodology:

This work is based on the compilation of over 6800 profiles of particulate matter observations from Underwater Vision Profilers (UVP5) (Rainer, 2021). The biovolume of the particle size distribution is calculated as the equivalent spherical volume of the particle size distribution (PSD), by summing the product of particle counts time particle volume in each size class. The slope of the PSD is calculated assuming a power law distribution for the particle abundance, by linear least square fit of the log of particle counts vs. the log of particle size. These quantities are estimated from two different depth horizons, the mixed layer depth (MLD_Export.nc) and the euphotic zone depth (Euphotic_Export.nc). To convert sparse observations to a global climatology, we trained 100 ensembles of regressions trees (Random Forests, RF) to predict biovolume and slope based on their relationship to well-sampled physical and biogeochemical predictors.

We calculate the particle sinking speed and carbon content by combining PSD reconstruction (biovolume and slope) with an empirical relationship between particle size, carbon content and sinking speed, the parameters of which are optimized to match in situ particle flux observations (Bisson et al. 2018). The flux values are calculated as the sum of the PSD time the sinking carbon parameters, for each grid cell. The error for reconstructed quantities is given by the standard deviation of 100 independent realizations of the RF reconstructions.

Sampling and analytical procedures:

This dataset contains a compilation of data from multiple sources. A list of all datasets and the associated information, including cruise name, is included.

Observations of Particle size and biovolume are made via the UVP5 camera, which is lowered in the water column on a CTD rosette. Images are captured at up to 30 images per second while the instrument is lowered at 1m/s. Images are analyzed and the pixel size of each particle is translated into a particle size, and the abundance calculated, following the method described by Picheral et al. (2010).

The data is compiled from multiple sources published and unpublished, and was accessed from EcoPart, the particle module of EcoTaxa https://ecotaxa.obs-vlfr.fr/part/ (Picheral et al., 2017).

Instruments:

Observations of particle abundance and biovolume were made with the Underwater Vision Profiler, version 5 (UVP5).

Data Processing Description

BCO-DMO Data Manager Processing Notes:
* Version 2 added to replace Version 1 on 2023-02-02.   The .nc files were changed after modifying the calculation of particle Flux from PSD, thus updated the flux fields to reflect the more robust estimates. Specifically, a Monte Carlo approach was used with injected randomness to robustly optimize the results.

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Data Files

File

Euphotic Zone Depth

filename: Euphotic_Export.nc

(NetCDF, 17.07 MB)
MD5:9da072d807b07c80f1df61ee038b9462

This file shows the reconstructed particles size distribution and particle flux from the base of the euphotic zone. All data are generated using a random forest machine learning model. Here we show the monthly climatological reconstructions of the PSD and resulting calculated flux.

File Parameters (Name,Description,Units,Missing data identifier):

latitude,cell-center latitude,degrees north,NaN

longitude,cell-center longitude,degrees east,NaN

time,month of reconstruction,month,NaN

area,cell area,m^2,NaN

Depth,Monthly export horizon,m,NaN

obs_bv,average observed particle biovolume,ppm,NaN

obs_slope,average observed particle size distribution slope,unitless,NaN

pred_bv,reconstructed particle biovolume,ppm,NaN

stdev_bbv,reconstructed particle biovolume standard deviation,ppm,NaN

pred_slope,reconstructed particle size distribution slope,unitless,NaN

stdev_slope,reconstructed particle size distribution slope standard deviation,unitless,NaN

flux,reconstructed particle carbon flux from the euphotic zone,mgC/m^2/dCocoaLigature1,NaN

stdev_flux,reconstructed particle carbon flux,mgC/m^2/d,NaN

Mixed-layer Depth

filename: MLD_Export.nc

(NetCDF, 16.01 MB)
MD5:cec7853036be1ac5efd322811b201f2e

This file shows the reconstructed particles size distribution and particle flux from the base of the maximum mixed layer. All data are generated using a random forest machine learning model. Here we show the monthly climatological reconstructions of the PSD and resulting calculated flux.

File Parameters:

Name,Description,Units,Missing data identifier

latitude,cell-center Latitude,degrees north,NaN

longitude,cell-center Longitude,degrees east,NaN

time,climatological month,month,NaN

area,cell surface area,m^2,NaN

depth,Monthly export horizon,M,NaN

obs_bv,average observed particle biovolume,ppm,NaN

obs_slope,average observed particle size distribution slope,unitless,NaN

pred_bv,reconstructed particle biovolume,ppm,NaN

stdev_bbv,reconstructed particle biovolume standard deviation,ppm,NaN

pred_slope,reconstructed particle size distribution slope,unitless,NaN

stdev_slope,reconstructed particle size distribution slope,unitless,NaN

flux,reconstructed particle carbon flux from the mixed layer,mgC/m^2/dCocoaLigature1,NaN

stdev_flux,reconstructed flux standard deviation,mgC/m^2/dCocoaLigature1,NaN

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Supplemental Files

File
Cruise List filename: cruise_list.csv (Comma Separated Values (.csv), 2.72 KB) MD5:d7697c97f905330988429eaf9dd1a136 A list of cruises during which the particle profiles were conducted. More information about these cruises can be found at EcoTaxa. Parameters (data column name, and description): "Cruise", Cruise identifier in EcoPart (EcoTaxa) "Year_of_cruise_start",Year of cruise start in format yyyy "Number_of_profiles", Number of profiles from the cruise

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Related Publications

Bisson, K. M., Siegel, D. A., DeVries, T., Cael, B. B., & Buesseler, K. O. (2018). How Data Set Characteristics Influence Ocean Carbon Export Models. Global Biogeochemical Cycles, 32(9), 1312–1328. doi:10.1029/2018gb005934 https://doi.org/10.1029/2018GB005934
Methods

Clements, D. J., Yang, S., Weber, T., Mcdonnell, A., Kiko, R., Stemmann, L., & Bianchi, D. (2021). Constraining the ocean's biological pump with in situ 1 optical observations and supervised learning. Part 2: 2 Carbon Flux. https://doi.org/10.1002/essoar.10509084.1
Results

Kiko, Rainer (2021): The global marine particle size distribution dataset obtained with the Underwater Vision Profiler 5 - version 1. PANGAEA, https://doi.pangaea.de/10.1594/PANGAEA.924375
IsDerivedFrom

Picheral M, Colin S, Irisson J-O (2017). EcoTaxa, a tool for the taxonomic classification of images. http://ecotaxa.obs-vlfr.fr
IsDerivedFrom

Picheral, M., Guidi, L., Stemmann, L., Karl, D. M., Iddaoud, G., & Gorsky, G. (2010). The Underwater Vision Profiler 5: An advanced instrument for high spatial resolution studies of particle size spectra and zooplankton. Limnology and Oceanography: Methods, 8(9), 462–473. doi:10.4319/lom.2010.8.462
Methods

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	nderwater Vision Profiler, version 5 (UVP5)
Generic Instrument Name	Underwater Vision Profiler
Dataset-specific Description	Observations of particle abundance and biovolume were made with the Underwater Vision Profiler, version 5 (UVP5).
Generic Instrument Description	A description of the UVP instrument can be found in the following publication: Picheral, M., L. Guidi, L. Stemmann, D. M. Karl, G. Iddaoud, and G. Gorsky. 2010. The Underwater Vision Profiler 5: An advanced instrument for high spatial resolution studies of particle size spectra and zooplankton. Limnol. Oceanogr. Meth. 8: 462-473. (access the PDF at URL: http://cmore.soest.hawaii.edu/cmoredata/LMO/Guidi/Picheral_2010.pdf)

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Project Information

Collaborative Research: Understanding the distribution and biogeochemical role of anaerobic microenvironments in the ocean (Ocean Particles and Microenvironments)

NSF Award Abstract:
Until recently, organic matter decomposition (respiration) was thought to occur primarily in oxygenated seawater; however, evidence has surfaced that respiration can occur under low oxygen conditions (anaerobic) similar to those found within microenvironments of suspended particles. As such, the possibility exists that these anaerobic reactions are more widespread than previously thought and could play a significant role in the cycling of sulfur, nitrogen, and some trace metals. Researchers from the University of California-Los Angeles and the University of Washington plan to study these reactions by developing a particle-redox model to simulate the biogeochemistry of anaerobic microenvironments and make predictions which can be tested against available ocean data (GEOTRACES program). The study is intended to understand the conditions needed to cycle nitrogen and sulfur in these particle microenvironments, the scavenging of trace metals during sulfide precipitations, and develop a tracer for particle bound denitrification (removal of nitrogen by microbes). This project will be the first funding support for two tenure-track faculty who are dedicated to education and public outreach to help broaden involvement in ocean sciences. One of the investigators will be involved as a youth educator in the "Students on Ice" program which conducts workshops that allows youth to gain experience at sea learning about oceanography, whereas the other would organize a series of workshops to engage students from the Rochester City School District in science.

This project seeks to investigate the evidence that has been coming out in recent years that anaerobic microenvironments within organic particles are widespread throughout the ocean and are a significant contributor to denitrification and sulfur reduction rates in otherwise oxygenated waters. To do so, the researchers plan to develop a new modeling framework to simulate the biogeochemistry of anaerobic microenvironments and make predictions which can be tested against available observations such as those from the GEOTRACES program. Overall the objectives of this research are to (1) understand the water column conditions and particle properties that lead to these anaerobic microenvironments, (2) test whether sulfate reduction rates are consistent with the metal precipitation signatures known for low oxygen water, and (3) predict the geochemical signature of particle bound denitrification and determine its rate from the large-scale distribution of nitrogen tracers. Understanding the anaerobic processes taking place within anaerobic microenvironments of organic particles in the water column is likely to update the biogeochemical cycles of nitrogen, sulfur, and trace metals.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1635632

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