ZooSCAN images of zooplankton collected during BATS MOCNESS tows during R/V Atlantic Explorer cruises AE1614, AE1712, AE1830, and AE1819 in the vicinity of the Bermuda Atlantic Time-series Study from 2016 to 2018

Website: https://www.bco-dmo.org/dataset/853440
Data Type: Cruise Results
Version: 1
Version Date: 2021-10-07

Project
» Collaborative Research: Diel physiological rhythms in a tropical oceanic copepod (Zooplankton Diel Rhythm)
» Quantifying the drivers of midwater zooplankton community structure (Zooplankton Gradients)
» Bermuda Institute of Ocean Sciences Simons Collaboration on Ocean Processes and Ecology (BIOSSCOPE)

Contributors	Affiliation	Role
Blanco-Bercial, Leocadio	Bermuda Institute of Ocean Sciences (BIOS)	Principal Investigator
Maas, Amy	Bermuda Institute of Ocean Sciences (BIOS)	Co-Principal Investigator
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Abstract
ZooSCAN images from BATS MOCNESS tows during R/V Atlantic Explorer cruises AE1614, AE1712, AE1830, and AE1819 in the vicinity of the Bermuda Atlantic Time-series Study (BATS) in July of 2016, 2017, and 2018 as well as October 2018 (eight casts in total, 63 discrete nets). These data were published in Maas et al. (2021).

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Coverage

Spatial Extent: **N**:32.3065 **E**:-64.0621 **S**:31.666 **W**:-64.7935
Temporal Extent: 2016-07-11 - 2018-10-30

Methods & Sampling

Methodology: To obtain samples, a 1 m Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS; Wiebe et al., 1985) equipped with 150 µm nets was deployed during the mid-day and mid-night on cruises carried out in the vicinity of the Bermuda Atlantic Time-series Study site (BATS) in July of 2016, 2017, and 2018 as well as October 2018 (eight casts in total, 63 discrete nets). The net sampling plan used adaptive profiling, modifying the depth of closure to capture eight distinct ecological zones from surface to 1000 m depth: e.g. the thermocline, deep chl-a maximum (DCM), above the O2 minimum, within the O2 minimum core, and below the

O2 minimum (Maas et al., 2014, Steinberg et al., 2008a). The actual tow depths were set on a cruise-by-cruise basis, using CTD profiles to determine the depths of each ecological zone. Upon retrieval, the catch from each of the eight discrete nets were divided into splits. Half were preserved in 95% undenatured ethanol and the remainder preserved in buffered 4% formalin in seawater.

A representative subsample of the zooplankton community from each net were imaged from the formalin-preserved samples, then measured, using a ZooSCAN ver. 3 at 4,800 dpi (following the methods in: Gorsky et al., 2010, Vandromme et al., 2012). In order to better represent all size classes in the images, the original sample was divided into three size categories. All individuals larger than 2 cm were selected by eye and scanned separately from all the others. The remainder of the sample was sieved through a 1-mm mesh sieve, and both size fractions were individually scanned. From these smaller size fractions, at least 1500 particles were scanned after subsampling using a Motoda splitter (Motoda, 1959), requiring generation of two separate scans for both size classes. This resulted in a total of five images per net.

Image names:

Image names include:
cruise#_mocnessID_net#_sizefraction_ and _a|b if a replicate and end in _1.tif

Multiple images of the same size fraction were sometimes taken to obtain a sufficient number of particles. These replicates are named a or b. If there is no replicate they don't have a letter in the image name. An a and b scan were always done for size classes d2 and d3. This was important because the split size is for the sum of a+b (e.g. if a is ¼ and b is ¼, the acq_sub_part will be 0.5).

Example of image names:

ae1830_m13_n4_d3_a_1.tif [a replicate]
ae1830_m13_n4_d3_b_1.tif [a replicate]
ae1830_m13_n5_d1_1.tif [no replicate]

Related Datasets may contain the "object_id" (the particle/organism id) which is constructed the same way as the image name except it as an additional _# at the end. This additional number in the object_id is added by the Zooprocess software (Hydroptic, 2016).
e.g.
object_id: ae1614_m3_n1_d2_a_1_**100**
image_name: ae1614_m3_n1_d2_a_1.tif

Problem report: During the July 2018 cruise the top net of the night cast failed, and consequently images from this net are absent.

Data Processing Description

BCO-DMO Data Manager Processing Notes:
* Images bundled for download in the Data Files section. A tar.gz file per cruise was made.
* "date" and "time" column converted to ISO 8601 format in image sample information which is time zone AST (UTC-4)/ADT (UTC-3).
* ISO_DateTime_UTC column added in ISO 8601 format in time zone utc.
* Image sample information attached as a supplemental file "image_sample_information.csv".

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Data Files

File
ZooSCAN Images BATS AE1614 filename: ZooSCAN_Images_BATS_AE1614.tar.gz (GZIP (.gz), 31.83 GB) MD5:cd660ed602d8e4b984f9f946e6d536d6 Images acquired using the ZooSCAN imaging system during R/V Atlantic Explorer cruise AE1614 in the vicinity of the Bermuda Atlantic Time-series Study (BATS). The tar.gz bundle of compressed files contains 80 images in .tif format.
ZooSCAN Images BATS AE1712 filename: ZooSCAN_Images_BATS_AE1712.tar.gz (GZIP (.gz), 27.60 GB) MD5:4f6129527733c836d3787fced696d9d6 Images acquired using the ZooSCAN imaging system during R/V Atlantic Explorer cruise AE1712 in the vicinity of the Bermuda Atlantic Time-series Study (BATS). The tar.gz bundle of compressed files contains 68 images in .tif format.
ZooSCAN Images BATS AE1819 filename: ZooSCAN_Images_BATS_AE1819.tar.gz (GZIP (.gz), 25.94 GB) MD5:bd233160391542cc3185a15f28530124 Images acquired using the ZooSCAN imaging system during R/V Atlantic Explorer cruise AE1819 in the vicinity of the Bermuda Atlantic Time-series Study (BATS). The tar.gz bundle of compressed files contains 65 images in .tif format.
ZooSCAN Images BATS AE1830 filename: ZooSCAN_Images_BATS_AE1830.tar.gz (GZIP (.gz), 31.88 GB) MD5:d69a94a74fbf7a1bf4e3828482f4ddbe Images acquired using the ZooSCAN imaging system during R/V Atlantic Explorer cruise AE1830 in the vicinity of the Bermuda Atlantic Time-series Study (BATS). The tar.gz bundle of compressed files contains 81 images in .tif format.

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Supplemental Files

File
Image Sample Metadata (ZooSCAN BATS M3 to M13) filename: image_sample_information.csv (Comma Separated Values (.csv), 30.56 KB) MD5:1954f230c158230d25e019f37d82c19a Image Sample Metadata for ZooSCAN images collected during R/V Atlantic Explorer cruises AE1614, AE1712, AE1819, AE1830 between 2016-2018. Parameters (column name, description, units): image_name,Image name, unitless cruise_id,Cruise identifier, unitless mocness_id,MOCNESS identifier,unitless net_id,Net identifier,unitless size_fraction,Size fraction (e.g. d3). See methodology,unitless replicate,Replicate (see methodology),unitless lat,Latitude,decimal degrees lon,Longitude,decimal degrees date, Date (local) in time zone AST (UTC-4)/ADT (UTC-3) in format YYYY-MM-DD,unitless time, Time (local) in time zone AST (UTC-4)/ADT (UTC-3) in format hh:mm:ss ISO_DateTime_UTC,Datetime in timezone UTC in ISO 8601 format YYYY-MM-DDThh:mm:ssZ

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Related Publications

Gorsky, G., Ohman, M. D., Picheral, M., Gasparini, S., Stemmann, L., Romagnan, J.-B., ... Prejger, F. (2010). Digital zooplankton image analysis using the ZooScan integrated system. Journal of Plankton Research, 32(3),

285–303. doi:10.1093/plankt/fbp124
Methods

Hydroptic (2016). ZooSCAN. Available at http://www.hydroptic.com/index.php/public/Page/product_item/ZOOSCAN. Accessed June 17th, 2021.
Software

Maas, A. E., Frazar, S. L., Outram, D. M., Seibel, B. A., & Wishner, K. F. (2014). Fine-scale vertical distribution of macroplankton and micronekton in the Eastern Tropical North Pacific in association with an oxygen minimum zone. Journal of Plankton Research, 36(6), 1557–1575. doi:10.1093/plankt/fbu077
Methods

Maas, A. E., Gossner, H., Smith, M. J., & Blanco-Bercial, L. (2021). Use of optical imaging datasets to assess biogeochemical contributions of the mesozooplankton. Journal of Plankton Research, 43(3), 475–491. doi:10.1093/plankt/fbab037
Results

Motoda, S. (1959) Devices of simple plankton apparatus. Memoirs of the Faculty of Fisheries Hokkaido University, 7, 73-94. Available from http://hdl.handle.net/2115/21829.
Methods

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

Steinberg, D. K., Cope, J. S., Wilson, S. E., & Kobari, T. (2008). A comparison of mesopelagic mesozooplankton community structure in the subtropical and subarctic North Pacific Ocean. Deep Sea Research Part II: Topical Studies in Oceanography, 55(14-15), 1615–1635. doi:10.1016/j.dsr2.2008.04.025
Methods

Vandromme, P., Stemmann, L., Garcìa-Comas, C., Berline, L., Sun, X., & Gorsky, G. (2012). Assessing biases in computing size spectra of automatically classified zooplankton from imaging systems: A case study with the ZooScan integrated system. Methods in Oceanography, 1-2, 3–21. doi:10.1016/j.mio.2012.06.001
Methods

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Related Datasets

IsRelatedTo

Blanco-Bercial, L., Maas, A., Gossner, H. (2021) **ZooSCAN output from of imaged zooplankton collected during BATS MOCNESS tows during R/V Atlantic Explorer cruises AE1614, AE1712, AE1830, and AE1819 in the vicinity of the Bermuda Atlantic Time-series Study from 2016 to 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-10-05 doi:10.26008/1912/bco-dmo.857891.1 [view at BCO-DMO]
Relationship Description: ZooScan output for the images in this dataset.

References

Blanco-Bercial, L., Maas, A., Gossner, H. (2021) **ZooSCAN biovolume to biomass from imaged zooplankton collected during MOCNESS tows during various R/V Atlantic Explorer cruises and small boat deployments in the Sargasso Sea betwen 2016 to 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-06-17 doi:10.26008/1912/bco-dmo.854077.1 [view at BCO-DMO]
Relationship Description: Biovolume:biomass conversion provides validation for the analysis of the ZooScan images.

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	1m MOCNESS
Generic Instrument Name	MOCNESS
Generic Instrument Description	The Multiple Opening/Closing Net and Environmental Sensing System or MOCNESS is a family of net systems based on the Tucker Trawl principle. There are currently 8 different sizes of MOCNESS in existence which are designed for capture of different size ranges of zooplankton and micro-nekton Each system is designated according to the size of the net mouth opening and in two cases, the number of nets it carries. The original MOCNESS (Wiebe et al, 1976) was a redesigned and improved version of a system described by Frost and McCrone (1974).(from MOCNESS manual) This designation is used when the specific type of MOCNESS (number and size of nets) was not specified by the contributing investigator.

Dataset-specific Instrument Name	ZooSCAN ver. 3
Generic Instrument Name	ZooSCAN
Dataset-specific Description	http://www.hydroptic.com/index.php/public/Page/product_item/ZOOSCAN
Generic Instrument Description	Description excerpt from Hydroptic website http://www.hydroptic.com/index.php/public/Page/product_item/ZOOSCAN The ZooSCAN (CNRS patent) system makes use of scanner technology with custom lighting and a watertight scanning chamber into which liquid zooplankton samples can be placed. The scanner recovers a high-resolution, digitial image and the sample can be recovered without damage. These digital images can then be investigated by computer processing. While the resolution of the digitized zooplankton images is lower than the image obtained using a binocular microscope this technique has proved to be more than adequate for large sample sets. Identification of species is done by automatic comparison of the image (vignette) of each individual animal in the scanned image with a library data set which may be built by the investigator for each individual survey or imported from a previous survey. The latest machine learning algorithm allows high recognition levels even if we recommend complementary manual sorting to achieve a high number of taxonomic groups.

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Deployments

AE1614

Website	https://www.bco-dmo.org/deployment/853444
Platform	R/V Atlantic Explorer
Report	https://datadocs.bco-dmo.org/docs/305/BIOSSCOPE/data_docs/AE1614_CS_narrative_FINAL.pdf
Start Date	2016-07-09
End Date	2016-07-12

AE1712

Website	https://www.bco-dmo.org/deployment/857372
Platform	R/V Atlantic Explorer
Report	https://datadocs.bco-dmo.org/docs/305/BIOSSCOPE/data_docs/AE1712_CS_narrative.pdf
Start Date	2017-07-08
End Date	2017-07-11
Description	Project BIOS-SCOPE

AE1830

Website	https://www.bco-dmo.org/deployment/857780
Platform	R/V Atlantic Explorer
Start Date	2018-10-27
End Date	2018-10-31
Description	Cruise DOI: 10.7284/908188

AE1819

Website	https://www.bco-dmo.org/deployment/857784
Platform	R/V Atlantic Explorer
Report	https://datadocs.bco-dmo.org/docs/305/BIOSSCOPE/data_docs/AE1819_CS_narrative_v1.pdf
Start Date	2018-07-03
End Date	2018-07-06
Description	Project BIOS-SCOPE

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Project Information

Collaborative Research: Diel physiological rhythms in a tropical oceanic copepod (Zooplankton Diel Rhythm)

Coverage: Bermuda

NSF Award Abstract:
The daily vertical migration (DMV) of zooplankton and fish across hundreds of meters between shallow and

deep waters is a predominant pattern in pelagic ecosystems. This migration has consequences for biogeochemical cycling as it moves a substantial portion of fixed carbon and nitrogen (an estimated 15 to 40 % of the total global organic export) from the surface directly to depth where it feeds the midwater food chain and sequesters nutrients away from atmospheric mixing. Estimates and predictions of these fluxes are, however, poorly understood at present. New observations have shown that one source of uncertainty is due to the assumption that metabolic rates and processes do not vary over the course of the day, except based on changes in temperature and oxygen availability. Rates are, however, also driven by differences in feeding, swimming behavior, and underlying circadian cycles. The objective of this project is to improve the ability of scientists to understand and predict zooplankton contributions to the movement of carbon and nitrogen in the ocean by detailing daily changes in physiological processes of these organisms. By producing a set of respiration and excretion measurements over a daily time series, paired with simultaneously collected gene and protein expression patterns for an abundant vertically migratory species, the investigators will provide unprecedented and predictive insight into how changes in the environment affect the contribution of zooplankton to biogeochemical fluxes. The sampling design of the project will advance discovery and understanding by providing hands-on training opportunities to at least two undergraduate researchers. The project will broaden dissemination of the research via development of an educational module, focusing on rhythms in the ocean. The module will initially be piloted with the Bermuda Institute of Ocean Sciences (BIOS) summer camp students and then disseminated through the BIOS Explorer program, the Teacher Resources Page on the BIOS website, and published in a peer-reviewed educational journal.

This project will characterize the metabolic consequences of daily physiological rhythms and DVM for a model zooplankton species, the abundant subtropical copepod Pleuromamma xiphias. Flux processes (oxygen consumption, carbon dioxide production, production of ammonium and fecal pellet production) will be interrogated using directed experiments testing the effects of temperature, feeding and circadian cycle. Circadian cycling will further be examined using transcriptomic and proteomic profiling. These experiments will be related to field samples taken at 6-h intervals over the course of the diel migration using an integrated suite of molecular and organismal metrics. Combined organismal, transcriptomic and proteomic profiles will provide an understanding of which metabolic pathways and associated flux products vary in relation to particular environmental variables (food, light cycle, temperature). Diel variation in metabolic rates will also be assessed across seasons and species using other important migratory groups (pteropod, euphausiid, and another copepod). The metabolic data will then be contextualized with abundance estimates from archived depth-stratified tows to allow scaling to community-level patterns and will be used to improve calculations of zooplankton contribution to particulate organic carbon, nitrogen and respiratory active flux. The results of this study will both improve our flux estimates and provide predictive insight into how various environmental variables influence the underlying physiological pathways generating carbon and nitrogen flux.

Cruise reports are available from the completed cruises:
SD031019
AE1910
AE1918

Quantifying the drivers of midwater zooplankton community structure (Zooplankton Gradients)

Website: https://www.nsf.gov/awardsearch/showAward?AWD_ID=1948162

Coverage: North Atlantic and North Pacific

NSF Award Abstract:

Processes in the midwater region below 200 m depth, also known as the twilight zone, represent a major unknown for the biology and chemistry of the ocean. Studies of animals drifting in the oceans, known as zooplankton, are scarce due to the difficulty and associated time and costs of sampling deep waters. The advent of automated image analysis and genetic tools is leading to a rapid increase in our knowledge of the diversity, abundances and size distribution of communities in shallow waters. However, our understanding of the deeper layers of the ocean is still in its infancy, and there are few studies that combine these three facets of the ecology of the zooplankton. The objective of this project is to leverage existing samples, obtained from previously NSF-funded research in the North Pacific and North Atlantic, to study how the abundances, diversity, and size distribution of zooplankton in the midwater vary with latitude and environmental factors. Automated image analyses provide information on abundance and size, and genetic analyses give

unprecedented data on the diversity of the midwater community for the North Atlantic and the North Pacific, from subtropical to subarctic environments. This project provides high quality hands-on training opportunities for at least two undergraduate researchers and generates material for undergraduate and graduate courses. Two workshops train educators on the classroom use of the NSF-funded Biological and Chemical Oceanography Data Management Office (BCO-DMO) open access oceanographic data.

Recent advances in image analysis and metabarcoding of zooplankton communities via new data tools are an opportunity to generate quantitative and predictive relationships between environmental drivers and zooplankton diversity, abundances and size distribution. While this information is available for plankton in epipelagic regions, the focus of this study is on midwater communities, which remain poorly characterized. Obtaining these data is the first step towards a quantitative analysis that assesses the impact of the midwater community on biogeochemical cycles. The project uses archived samples from two cruises conducted in the N. Atlantic and N. Pacific to test hypotheses about how temperature, midwater hypoxia, primary productivity and biogeographic province shape the size class structure, biodiversity and behavior (diurnal vertical migration) of zooplankton communities. These newly-generated image and metabarcoding datasets of the mesozooplankton community from 0-1000 m are cross-comparable with other ocean regions. These data describe how migratory and midwater resident zooplankton communities are structured by environmental variables and demonstrate how this influences their biogeochemical contributions (specifically active flux and midwater attenuation of flux). Data tools generated for the image analysis in combination with metabarcoding has broad application in plankton ecology and allows metanalysis of other datasets. The project is complementary to ongoing national and international projects that seek to describe the function and structure of the midwater. In contrast to existing modeling and process projects, this project covers a moderately large geographic area and thus provides a strong comparative foundation for broader community-wide assessment of the function of zooplankton in the twilight zone.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Bermuda Institute of Ocean Sciences Simons Collaboration on Ocean Processes and Ecology (BIOSSCOPE)

Website: http://scope.bios.edu/

Coverage: North Atlantic Subtropical Gyre, Bermuda Atlantic Time Series (BATS) site

The aim of BIOS-SCOPE is to expand knowledge about the BATS ecosystem and achieve a better understanding of ocean food web sources, sinks and transformations of DOM. Advances in knowledge and technology now poise us to investigate the specific mechanisms of DOM incorporation, oxidation and transformation by zooplankton and the distinct microbial plankton communities that have been discovered at BATS.

The overarching goal of the BIOS-SCOPE is to form and foster collaborations of cross disciplinary science that utilize a broad suite of genomic, chemical, ecological, and biogeochemical approaches to evaluate microbial process, structure and function on various scales. These scales will range from organism-compound and organism-organism interactions to large biogeochemical patterns on the ecosystem scale. For this purpose we have assembled a cross-disciplinary team including microbial oceanographers (Carlson and Giovannoni), a chemical oceanographer (Kujawinski), biological oceanographer / zooplankton ecologists (Maas and Blanco-Bercial) and microbial bioinformatician (Temperton) with the expertise and technical acuity that are needed to study complex interactions between food web processes, microbes and DOM quantity and quality in the oligotrophic ocean. This scientific team has a vision of harnessing this potential to produce new discoveries that provide a mechanistic understanding of the carbon cycle and explain the many emergent phenomenon that have yet to be understood.

For additional details:

- ***BIOS-SCOPE Narrative***: *https://datadocs.bco-dmo.org/docs/302/BIOSSCOPE/data_docs/BIOS-SCOPE_Narrative_FINAL.pdf*
- ***Physical Framework***: *https://datadocs.bco-dmo.org/docs/302/BIOSSCOPE/data_docs/Physical_Framework.pdf*

BIOSSCOPE I: November 1st, 2015 through October 31st, 2020
Current: November 1st, 2020 to October 31st, 2025

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Funding

Funding Source	Award
Simons Foundation (Simons)	unknown SCOPE Simons
NSF Division of Ocean Sciences (NSF OCE)	OCE-1829318
NSF Division of Ocean Sciences (NSF OCE)	OCE-1948162

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