ZooSCAN images of zooplankton collected with MOCNESS tows during six R/V Atlantic Explorer cruises in the northwest Atlantic (Sargasso Sea) from 2021 to 2023

Website: https://www.bco-dmo.org/dataset/932236
Data Type: Cruise Results
Version: 1
Version Date: 2024-07-11

Project
» Collaborative Research: Zooplankton mediation of particle formation in the Sargasso Sea (Zooplankton Mediation)

Contributors	Affiliation	Role
Maas, Amy	Bermuda Institute of Ocean Sciences (BIOS)	Principal Investigator
Blanco-Bercial, Leocadio	Bermuda Institute of Ocean Sciences (BIOS)	Co-Principal Investigator
Gossner, Hannah	Bermuda Institute of Ocean Sciences (BIOS)	Technician
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset consists of the raw ZooSCAN images taken of zooplankton caught in the upper 600m using Multiple Opening-Closing Net and Environmental Sensing System (MOCNESS) tows during day- and night-time. These samples were collected over two years, with three cruises a year to capture distinct seasons. The goal of this data was to assess high-resolution vertical distribution of zooplankton in order to distinguish diel vertical migrators from resident populations and to quantify contributions to particulate organic carbon flux via fecal pellet production. Project description: The oceanic biological carbon pump refers to the export of dissolved and particulate organic carbon to the deep ocean, and it is a significant driver of atmospheric carbon uptake by the oceans. Evidence from long-term research carried out at the Bermuda Atlantic Time-series Study (BATS) site suggests that the spectrum of particles collected by gel-traps below the euphotic zone changes drastically below 150 m, which is attributed to resident populations of zooplankton that feed on vertically migrating zooplankton as well as sinking particles. The goals of this study are to investigate the role of different zooplankton taxa on both particle aggregate formation and in particle transformation, and to compare and characterize the particles generated by the zooplankton communities with those collected by particle traps.

Table of Contents

Coverage

Location: BATS Sargasso Sea 31N 64W depth 0-600m
Spatial Extent: **N**:31.679467 **E**:-64.148983 **S**:31.509833 **W**:-64.342467

Temporal Extent: 2021-07-14 - 2023-03-24

Methods & Sampling

One pair of 1m^2 MOCNESS (Multiple Open Closing Nets with Environmental Sensor System) tows were performed during each cruise- one during the day, and one at night (MOCNESS, Wiebe et al, 1985). Nets with 150um mesh were used to better capture the smaller midwater zooplankton community in the region. Eight nets were fired in sequence along the upcast to capture spatially discrete zooplankton samples between 600m and the surface. While nets one, two, and three consistently targeted depths of 600-500m, 500m-400m, and 400-300m, depths for nets four through eight varied based on hydrographic features including the thermocline, deep chlorophyll maximum, and oxygen minimum zone (Maas et al, 2014, Steinberg et al, 2008). Once onboard, samples were split in two using a Motoda splitter (Motoda, 1959) with half preserved with sodium tetraborate buffered 4% formalin in seawater to be scanned with a ZooSCAN (Gorsky et al, 2010) and half placed in 95% undenatured ethanol for metabarcoding.

A representative subsample of the formalin-preserved zooplankton community from each net were imaged using a ZooSCAN ver. 4 at either 4,800 dpi or 2,400 dpi (following the methods in: Gorsky et al., 2010, Vandromme et al., 2012 as detailed in Maas et al. 2021). The change in resolution partway through the project was a result of recommendations from Hydroptic and loss of software support for 4800dpi imaging. 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 (fraction "d1"). The remainder of the sample was sieved through a 1-mm mesh sieve, and both size fractions were individually scanned ("d2" >1000um, "d3" 153-1000um). 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 _raw_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:

ae2112_m22_n4_d3_a_raw_1.tif [a replicate]
ae2112_m22_n4_d3_b_raw_1.tif [b replicate]
ae2204_m27_n5_d1_raw_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

Data Processing Description

Scans were processed using ZooProcess (version 8.22, ImageJ macro suite). The "Convert and process from RAW" function was used to separate particles into individual vignettes and generate a suite of measurements for each particle. "Doubles" (vignettes containing more than one particle) were manually separated in the software and reprocessed.

Processed scans and their corresponding metadata were then uploaded to Ecotaxa (Picheral et al, https://ecotaxa.obs-vlfr.fr/), where a training set was created using manually classified images from this project as well as existing validated images from other projects in the Sargasso Sea. Classification categories were chosen based on taxon of interest, identification level in previous projects, and known limitations of the

software. Generally, broader level taxonomic groups are used. Identification of all particles was predicted, then manually validated.

BCO-DMO Processing Description

Version 1:
* All raw scan images were bundled into zip files named by _.zip
* The filesize and md5 checksum was added to the image metadata table.
** After images were transferred to BCO-DMO, a file inventory was made containing the filename, filesize in bytes, and checksum (md5sum). This file inventory table was joined with the provided metadata table to verify the file collection is complete without any missing files.
* an additional supplemental file was added containing metadata for each file (including zips) which includes file access links to aid in programmatic download of all image bundles in the dataset once the dataset is released.
* two imagenames in the metadata table were changed to match the actual filenames. The data submitter was consulted and advised this was the correct course of action. The 3 was omitted in d3 of the imagename.
image_name ae2124_m24_n1_d_a_raw_1.tif -> ae2124_m24_n1_d3_a_raw_1.tif
image_name ae2124_m24_n1_d_b_raw_1.tif -> ae2124_m24_n1_d3_b_raw_1.tif

Problem Description

None

[table of contents | back to top]

Data Files

File	
ae2112_m22.zip	(ZIP Archive (ZIP), 64.78 GB) MD5:1571fbbcda4aac49c8e5a25cb2846f79 ZooSCAN images of zooplankton collected during MOCNESS tow m22 during R/V Atlantic Explorer cruise AE2112 in the northwest Atlantic in 2021. Images from this tow were bundled and compressed in a zip file bundle.
ae2112_m23.zip	(ZIP Archive (ZIP), 63.86 GB) MD5:e8f5018790acb6f10504e59a0929bca1 ZooSCAN images of zooplankton collected during MOCNESS tow m23 during R/V Atlantic Explorer cruise AE2112 in the northwest Atlantic in 2021. Images from this tow were bundled and compressed in a zip file bundle.
ae2124_m24.zip	(ZIP Archive (ZIP), 23.99 GB) MD5:7b0f827d258f9585d47e65321c773364 ZooSCAN images of zooplankton collected during MOCNESS tow m24 during R/V Atlantic Explorer cruise AE2124 in the northwest Atlantic in 2021. Images from this tow were bundled and compressed in a zip file bundle.
ae2124_m25.zip	(ZIP Archive (ZIP), 23.96 GB) MD5:7feb5e40c6961cc777d0e1225ebeb7a7 ZooSCAN images of zooplankton collected during MOCNESS tow m25 during R/V Atlantic Explorer cruise AE2124 in the northwest Atlantic in 2021. Images from this tow were bundled and compressed in a zip file bundle.
ae2204_m26.zip	(ZIP Archive (ZIP), 24.08 GB) MD5:946765045e7f4544efc41f584706668f ZooSCAN images of zooplankton collected during MOCNESS tow m26 during R/V Atlantic Explorer cruise AE2204 in the northwest Atlantic in 2022. Images from this tow were bundled and compressed in a zip file bundle.
ae2204_m27.zip	(ZIP Archive (ZIP), 24.07 GB) MD5:7a33893e3a7997407a76b393e0ade3cd ZooSCAN images of zooplankton collected during MOCNESS tow m27 during R/V Atlantic Explorer cruise AE2204 in the northwest Atlantic in 2022. Images from this tow were bundled and compressed in a zip file bundle.

File	
ae2214_m28.zip	(ZIP Archive (ZIP), 24.04 GB) MD5:2f1580d85c96082e101f841e721cad1a
ZooSCAN images of zooplankton collected during MOCNESS tow m28 during R/V Atlantic Explorer cruise AE2214 in the northwest Atlantic in 2022. Images from this tow were bundled and compressed in a zip file bundle.	
ae2214_m29.zip	(ZIP Archive (ZIP), 24.07 GB) MD5:9b2df23e76f4e35cc44cddd79b1aa321
ZooSCAN images of zooplankton collected during MOCNESS tow m29 during R/V Atlantic Explorer cruise AE2214 in the northwest Atlantic in 2022. Images from this tow were bundled and compressed in a zip file bundle.	
ae2224_m30.zip	(ZIP Archive (ZIP), 24.06 GB) MD5:28f8a8179b82be20e23986e4a3ecbbd6
ZooSCAN images of zooplankton collected during MOCNESS tow m30 during R/V Atlantic Explorer cruise AE2224 in the northwest Atlantic in 2022. Images from this tow were bundled and compressed in a zip file bundle.	
ae2224_m31.zip	(ZIP Archive (ZIP), 24.07 GB) MD5:9376fa90c08dd59f2e8ed7fc94cc44b8
ZooSCAN images of zooplankton collected during MOCNESS tow m31 during R/V Atlantic Explorer cruise AE2224 in the northwest Atlantic in 2022. Images from this tow were bundled and compressed in a zip file bundle.	
ae2306_m33.zip	(ZIP Archive (ZIP), 24.04 GB) MD5:39f766ebe91ad1172f804dd421be3a90
ZooSCAN images of zooplankton collected during MOCNESS tow m33 during R/V Atlantic Explorer cruise AE2306 in the northwest Atlantic in 2023. Images from this tow were bundled and compressed in a zip file bundle.	
ae2306_m35.zip	(ZIP Archive (ZIP), 24.01 GB) MD5:50421e45a9325a6e89046289bc9a8926
ZooSCAN images of zooplankton collected during MOCNESS tow m35 during R/V Atlantic Explorer cruise AE2306 in the northwest Atlantic in 2023. Images from this tow were bundled and compressed in a zip file bundle.	

[table of contents | back to top]

Supplemental Files

File
Dataset File Manifest filename: 932236_v1_file_manifest.csv (Comma Separated Values (.csv), 6.36 KB) MD5:cef845bd9cd54b51269b32a63ecc9b87 Manifest of all files attached to this dataset including the downloadURL for all 12 .zip files and image metadata table table (csv). Columns in manifest file: filename,FileType,downloadURL,mediatype,bytes,hash (md5 checksum),description,cruise_id,mocness_id,lat,lon,ISO_DateTime_UTC,first_image (within image .zip file) See additional metadata within the "description" column of this manifest table.
Image Sample Metadata filename: 932236_v1_zoo-med-agg_image_metadata.csv (Comma Separated Values (.csv), 83.41 KB) MD5:459a0e2e08184dae0735a6e1c0a979a7 Image sample metadata table for ZooSCAN images (raw scans). Images described in this table are contained within .zip files in this dataset (.zip file per cruise_id and mocness_id). Parameters (column name, description, units): image_name,Image name, unitless cruise_id,Cruise identifier, unitless mocness_id,MOCNESS tow 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 filesize_bytes, Filesize in bytes md5sum, checksum (md5) for the file. Can be used to verify the integrity of the file after transfers.

[table of contents | back to top]

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

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

Wiebe, P. H., Morton, A. W., Bradley, A. M., Backus, R. H., Craddock, J. E., Barber, V., … Flierl, G. R. (1985). New development in the MOCNESS, an apparatus for sampling zooplankton and micronekton. Marine Biology, 87(3), 313–323. doi:10.1007/bf00397811 https://doi.org/10.1007/BF00397811
Methods

[table of contents | back to top]

Related Datasets

IsRelatedTo

Blanco-Bercial, L., Maas, A., Gossner, H. (2024) **ZooProcess and Ecotaxa output from ZooSCANs of zooplankton collected with MOCNESS tows during six R/V Atlantic Explorer cruises from 2021 to 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-07-08 doi:10.26008/1912/bco-dmo.931883.1 [view at BCO-DMO]
Relationship Description: Data derived from analyzing these Zooscan images.

[table of contents | back to top]

Parameters

Parameters for this dataset have not yet been identified

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	MOCNESS (1m2 mouth size)
Generic Instrument Name	MOCNESS1
Dataset-specific 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). The MOCNESS used in this experiment is a 1m2 (mouth size) rigged with nine 150um mesh nets. One is flown open on the downcast to balance the net (Net 0- contents preserved but not analyzed), and the other eight (Net 1-8) are triggered on the upcast at desired depths. This particular MOCNESS was originally manufactured by Biological Environmental Sensor Systems (BESS), but was refit with new electronics from SIO/STS in 2017 (Net Interface Unit, Net Angle Sensor) to allow it to interface with Seabird instruments (SBE9Plus CTD, SBE3S Temperature, SBE4C Conductivity, SBE11 Deck Box).
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. The MOCNESS-1 carries nine 1-m2 nets usually of 335 micrometer mesh and is intended for use with the macrozooplankton. All nets are black to reduce contrast with the background. A motor/toggle release assembly is mounted on the top portion of the frame and stainless steel cables with swaged fittings are used to attach the net bar to the toggle release. A stepping motor in a pressure compensated case filled with oil turns the escapement crankshaft of the toggle release which sequentially releases the nets to an open then closed position on command from the surface. -- from the MOCNESS Operations Manual (1999 + 2003).

Dataset-specific Instrument Name	ZooSCAN ver. 4
Generic Instrument Name	ZooSCAN
Dataset-specific Description	A representative subsample of the formalin-preserved zooplankton community from each net were imaged using a ZooSCAN ver. 4 at either 4,800 dpi or 2,400 dpi (following the methods in: Gorsky et al., 2010, Vandromme et al., 2012 as detailed in Maas et al. 2021).
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.

[table of contents | back to top]

Deployments

AE2112

Website	https://www.bco-dmo.org/deployment/931891
Platform	R/V Atlantic Explorer
Start Date	2021-07-08
End Date	2021-07-16

AE2124

Website	https://www.bco-dmo.org/deployment/931893
Platform	R/V Atlantic Explorer
Start Date	2021-11-16
End Date	2021-11-19

AE2204

Website	https://www.bco-dmo.org/deployment/931895
Platform	R/V Atlantic Explorer
Start Date	2022-03-28
End Date	2022-04-04

AE2214

Website	https://www.bco-dmo.org/deployment/931897
Platform	R/V Atlantic Explorer
Start Date	2022-07-13
End Date	2022-07-18

AE2224

Website	https://www.bco-dmo.org/deployment/931899
Platform	R/V Atlantic Explorer
Start Date	2022-11-23
End Date	2022-11-30

AE2306

Website	https://www.bco-dmo.org/deployment/931901
Platform	R/V Atlantic Explorer
Start Date	2023-03-18
End Date	2023-03-26

[table of contents | back to top]

Project Information

Collaborative Research: Zooplankton mediation of particle formation in the Sargasso Sea (Zooplankton Mediation)

Coverage: Sargasso Sea/BATS area

NSF Award Abstract:
The purpose of this collaborative project is to advance understanding of the role of marine planktonic animals (or zooplankton) in the biological pump, or transport of carbon from surface to deeper ocean waters. This movement of carbon from surface to deep ocean water can ultimately affect carbon dioxide in the atmosphere, with implications for global climate. Many marine zooplankton, including species of copepods and krill, play a direct role in the biological pump both because they are abundant and because they can migrate from surface waters at night, where they feed, to depths of more than 500 m at night. At the same time, some organisms called flux feeders will remain at depth and do not migrate. Instead, they rely on particles produced by other zooplankton feeding in surface waters. In this project, the investigators are focusing on populations of flux feeders in the deeper ocean waters of the Sargasso Sea. They are leveraging an ongoing long-term research program, conducting field collections using specialized nets and particle traps, as well lab experiments, as a way to understand how these organisms modify the particles around them. This project is supporting a postdoctoral scientist and providing research experiences for undergraduates at two institutions. An education specialist is creating lesson plans for an award-winning Ask-A-Biologist website, designed for public and K-12 audiences. Images of zooplankton will be disseminated to the public and scientific community via EcoTaxa (a web platform devoted to plankton biodiversity, with images and taxonomic annotation) and physical samples will be archived as part of a teaching library.

The oceanic biological carbon pump refers to the export of dissolved and particulate organic carbon to the deep ocean, and it is a significant driver of atmospheric carbon uptake by the oceans. Evidence from long-term research carried out at the Bermuda Atlantic Time-series Study (BATS) site suggests that the spectrum of particles collected by gel-traps below the euphotic zone changes drastically below 150 m, which is attributed to resident populations of zooplankton that feed on vertically migrating zooplankton as well as sinking particles.

The goals of this study are to investigate the role of different zooplankton taxa on both particle aggregate formation and in particle transformation, and to compare and characterize the particles generated by the zooplankton communities with those collected by particle traps. The investigators are combining field collections with experiments onboard ship and in environmental chambers. They are collecting samples over two years, with three cruises a year to capture distinct seasons. They are assessing high-resolution vertical distribution of zooplankton in the upper 600 m using Multiple Opening-Closing Net and Environmental Sensing System (MOCNESS) tows during day- and night-time, to distinguish diel vertical migrators from resident populations and to quantify contributions to particulate organic carbon flux via fecal pellet production. On each cruise, sinking particles are being collected using gel trap tubes attached to the particle traps deployed monthly at BATS. In addition, roller tank experiments are determining how individual zooplankton mediate aggregate formation. Particle types and fecal pellets are being characterized using image analysis and DNA-based analysis of microbial communities. Finally, ongoing data collection from the long-term BATS program is providing invaluable environmental context and will ensure results from this study contribute to ongoing community efforts to observe and predict the fate of carbon in our global system.

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023621
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023372

[table of contents | back to top]