Fecal pellet elemental composition (CHN), production rates, and morphometrics from zooplankton incubation experiments collected during R/V Atlantic Explorer cruise AE2306 at the Bermuda Atlantic Time-series Study (BATS) site in Mar 2023

Website: https://www.bco-dmo.org/dataset/998152
Data Type: Cruise Results, Other Field Results
Version: 2
Version Date: 2026-07-20

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

Contributors	Affiliation	Role
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Abstract
This dataset reports the elemental composition of individual fecal pellets measured during a targeted experiment during the March 2023 BATS cruise (AE2306) aboard the R/V Atlantic Explorer in the Sargasso Sea near Bermuda. The elemental composition of individual fecal pellets (carbon density and C:N ratios) are reported, along with fecal pellet production rates derived from CHN data and experiment metadata. Supplemental files include zooplankton dry and wet weights for individuals used in elemental analyses, enabling organism-level scaling of elemental fluxes (CHN_Zooplankton.csv), and individual fecal pellet morphometrics and summed volumes for pellets collected for CHN analysis (CHN_Fecal_Pellets.csv). Together with the related datasets, these data provide integrated measurements linking zooplankton identity, size, fecal-pellet production, pellet elemental composition, and aggregate formation, supporting process-based analyses of zooplankton roles in particle production and vertical carbon transfer at BATS. The data were collected aboard the R/V Atlantic Explorer through the collaborative efforts of the laboratories of Dr. Susanne Neuer, Dr. Amy Maas, and Dr. Leocadio Blanco-Bercial, affiliated with Arizona State University and the Bermuda Institute of Ocean Sciences.

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Coverage

Location: Bermuda Atlantic Time-series Study (BATS) site, Sargasso Sea in the Western North-Atlantic. 31 50'N 64 10'W. Depths 0-300m.
Spatial Extent: **Lat**:31.6492 **Lon**:-64.0824
Temporal Extent: 2023-03

Methods & Sampling

Zooplankton Collection

Live zooplankton were collected during the March 2023 cruise (AE2306) using a 1-m², 150-µm mesh Reeve net for fecal pellet elemental analysis experiments.

Fecal Pellet Incubation and Collection

Target zooplankton taxa were incubated individually in 1-L acid-washed plastic containers ("Copepotties") filled with 0.2-µm filtered seawater. Each container included an inner insert constructed from a 1-mm mesh-bottomed plastic cup to allow separation of fecal pellets from the zooplankton. Incubations were conducted in the dark at approximately 20°C for 8–12 hours. Following incubation, fecal pellets were collected under a dissection microscope using glass pipettes and rinsed three times with nuclease-free water. Pellets were imaged at 63× magnification under a stereomicroscope, and morphometric measurements were obtained using INFINITY ANALYZE 7 software (Teledyne Technologies, Inc).

Fecal Pellet Elemental Analysis

Individual fecal pellets were placed onto pre-combusted, pre-weighed GF/F filters (0.7-µm pore size). Filters were dried, and changes in mass were used to estimate pellet dry weight. Filters containing fecal pellets were acidified by exposure to concentrated HCl fumes for 16 hours to remove inorganic carbon and then dried prior to analysis. Carbon, hydrogen, and nitrogen content was quantified using a Costech ECS 4010 elemental combustion system. Pellet carbon density and C:N ratios were calculated using measured pellet dimensions and elemental data.

Data Processing Description

Raw zooplankton sample metadata (cruise ID, station, date, time, depth interval, and diel period) were recorded at sea during each cruise. Zooplankton taxa used in fecal pellet elemental analysis experiments were identified to the lowest practical taxonomic level using stereomicroscope images and standard taxonomic references.

Fecal pellet morphometric measurements (length, width, and projected area) were obtained from stereomicroscope images using INFINITY ANALYZE 7 software (Teledyne Technologies, Inc). Pellet volumes were calculated from measured dimensions assuming cylindrical geometry. Individual fecal pellet production rates were calculated by dividing the total number of pellets produced per individual by the incubation duration (hours).

Dry weight values for zooplankton individuals used in elemental analyses were determined from measured mass after drying.

For elemental analysis, GF/F filter tare weights were subtracted from post-sample weights to obtain fecal pellet dry mass. Carbon, hydrogen, and nitrogen values output by the elemental analyzer were blank-corrected using pre-combusted filter blanks. Carbon density and C:N ratios were calculated from measured elemental content and pellet volume.

All data were compiled, quality-checked for transcription errors, and formatted into standardized tables for submission. No statistical analyses, model-based flux calculations, or graphical processing are included in the submitted datasets.

BCO-DMO Curation Notes

- Loaded data from "998152_v1_chn_results_submitter_email.csv" as table "res1-1" with empty strings and "nd" treated as missing values
- Converted the "Date" column from format "%m/%d/%Y" (UTC) to ISO format "%Y-%m-%d" (UTC datetime)
- Extracted non-numeric values from "StDev_Average_Animal_Dry_Weight" into a new column "StDev_Average_Animal_Dry_Weight_flag" (with suffix "_flag")
- Applied find-and-replace on "StDev_Average_Animal_Dry_Weight_flag": replaced "<0.005" with "True"
- Applied conditional find-and-replace on "StDev_Average_Animal_Dry_Weight_flag": replaced missing values with "False" where the flag column was NULL
- Reordered columns: Date, Cruise, Trawl, Start_Time, End_Time, Min_Depth, Max_Depth, Experiment, GFF_filter_num, Zooplankton_Groups, Zooplankton_Taxa, num_Zooplankton, Total_Hours, num_Fecal_pellet, ug_N, ug_C, C_N, Blank_Corrected_mg_C_from_CHN, Total_Volume, Carbon_Density, FPP_using_CHN_Exp_rate, FPP_using_CHN_Exp, Average_Animal_Dry_Weight, StDev_Average_Animal_Dry_Weight, StDev_Average_Animal_Dry_Weight_flag, Datetime_Start_UTC
- Converted Datetime_Start_UTC from "%Y-%m-%dT%H:%M" to "%Y-%m-%dT%H:%MZ" datetime format (UTC)
- Output written to "998152_v2_chn_results.csv"

** Version 2 **

Submitter provided a new file for each file published in this dataset. The files included corrected CHN values and corrected spelling in some Zooplankton_Taxa labels. A new flag field was created in the primary data file to reflect some values that were less than "<0.005" for the standard deviation of average animal dry weight.

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Data Files

File
998152_v2_chn_results.csv (Comma Separated Values (.csv), 3.14 KB) MD5:f72924f9b91f6f0e4440efdbe4764944 Primary data file for dataset ID 998152, version 2

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Supplemental Files

File

998152_v2_chn_fecal_pellets.csv (Comma Separated Values (.csv), 77.21 KB)
MD5:138de07c842959256266c06cd25e1e4c

Fecal pellet data from the CHN experiment. All night-time Reeve net trawl with latitude and longitude being 31.6492, -64.0824.

Date,Calendar date of experiment start or sample collection (MM/DD/YYYY)
Cruise,R/V Atlantic Explorer (AE) cruise ID number
Trawl,Net tow identifier associated with sample collection
Start_Time,Time when experiment or deployment started in HH:MM (Atlantic Standard Time GMT-4)
End_Time,Time when experiment or deployment ended in HH:MM (Atlantic Standard Time GMT-4)
Total_Time,Duration of experiment, incubation, or deployment in hours (h) and minutes (min)
Hour,Represents the total deployment duration expressed as whole hours. It is calculated by rounding the Total_Time (hh:mm) up to the nearest hour
Min_Depth_(m),Minimum depth of sampling or incubation., Units: meters (m)
Max_Depth_(m),Maximum depth of sampling or incubation., Units: meters (m)
Experiment,Experimental treatment or experiment identifier
Zooplankton_Groups,Broad taxonomic or functional group of zooplankton
Zooplankton_Taxa,Lowest identified taxonomic classification of zooplankton
GFF_filter#,Identifier for glass fiber filter used for CHN analysis
#_of_Zooplankton_At_Beginning,Number of live zooplankton individuals at experiment start
#_Zooplankton_Alive,Number of zooplankton alive or present at end of experiment or analysis
File_name_of_Image,Filename of microscopy image used for measurements
Area_(µm^2),Two-dimensional projected area of fecal pellet or organism., Units: square micrometers (µm²)
Area_(mm^2),Two-dimensional projected area of fecal pellet or organism., Units: square millimeters (mm²)
Volume_(mm^3),Calculated volume of fecal pellet or organism., Units: cubic millimeters (mm³)
Classification,Morphological classification of fecal pellet type
Color_of_Fecal_Pellet,Observed color of fecal pellet under microscopy
Sum_FP_(mm^3),total summed fecal pellet volume per experiment or sample., Units: cubic millimeters (mm³)
Sum_FP_(µm³),Total summed fecal pellet volume converted to micrometer scale., Units: cubic micrometers (µm³)
Notes,Qualitative observations on animal condition, pellet structure, or anomalies

998152_v2_chn_zooplankton.csv (Comma Separated Values (.csv), 11.46 KB)
MD5:e64db67d932aac75ca2df1f403930bb8

Zooplankton data from the CHN experiment. All night-time Reeve net trawl with latitude and longitude being 31.6492, -64.0824.

Date,Calendar date of experiment start or sample collection (MM/DD/YYYY)
Cruise,R/V Atlantic Explorer (AE) cruise ID number
Trawl,Net tow identifier associated with sample collection
Start_Time,Time when experiment or deployment started in HH:MM (Atlantic Standard Time GMT-4)
End_Time,Time when experiment or deployment ended in HH:MM (Atlantic Standard Time GMT-4)
Total_Time,Duration of experiment, incubation, or deployment in hours and minutes
Hour,Represents the total deployment duration expressed as whole hours. It is calculated by rounding the Total_Time (hh:mm) up to the nearest hour
Min_Depth_(m),Minimum depth of sampling or incubation., Units: meters (m)
Max_Depth_(m),Maximum depth of sampling or incubation., Units: meters (m)
Experiment,Experimental treatment or experiment identifier.
Zooplankton_Groups,Broad taxonomic or functional group of zooplankton.
Zooplankton_Taxa,Lowest identified taxonomic classification of zooplankton.
GFF_filter#,Identifier for glass fiber filter used for CHN analysis.
Image_Name,Filename of microscopy image used for measurements.
Dry_Weight, Mass of the sample after drying for 3–4 days in a desiccator, with the tin capsule mass subtracted, Units: miligrams (mg)
Wet_Weight, Mass of the sample prior to drying (wet weight), with the tin capsule mass subtracted, Units: milligrams (mg)
Notes,Qualitative observations on animal condition, pellet structure, or anomalies

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Related Publications

Alldredge, A. L., & Gotschalk, C. C. (1990). The relative contribution of marine snow of different origins to biological processes in coastal waters. Continental Shelf Research, 10(1), 41–58. https://doi.org/10.1016/0278-4343(90)90034-j
Methods

Durkin, C. A., Buesseler, K. O., Cetinić, I., Estapa, M. L., Kelly, R. P., & Omand, M. (2021). A Visual Tour of Carbon Export by Sinking Particles. Global Biogeochemical Cycles, 35(10). Portico.

https://doi.org/10.1029/2021gb006985
Methods

Niimi et. al. "Understanding the Seasonal Contributions of Key Zooplankton Fecal Pellet Production in the Sargasso Sea" (in preparation).
Results

Silver, M. W., & Bruland, K. W. (1981). Differential feeding and fecal pellet composition of salps and pteropods, and the possible origin of the deep-water flora and olive-green "Cells" Marine Biology, 62(4), 263–273. https://doi.org/10.1007/bf00397693
Methods

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Related Datasets

IsRelatedTo

Brenner, A., Maas, A., Blanco-Bercial, L., Noyes, K., Neuer, S. (2025) **Measurements of sinking particle types from deployed Particle Interceptor Trap System (PITS) at the Bermuda Atlantic Time-series Study (BATS) site from Jul 2021 to Mar 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-10-08 doi:10.26008/1912/bco-dmo.982170.1 [view at BCO-DMO]
Relationship Description: Roller tank and fecal pellet production experiments used zooplankton collected during the same cruises and from the same depth strata associated with the PITs aggregate collections.

Maas, A., Blanco-Bercial, L. (2024) **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.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-07-11 doi:10.26008/1912/bco-dmo.932236.1 [view at BCO-DMO]
Relationship Description: ZooSCAN images were generated from zooplankton community samples collected during these cruises to characterize zooplankton abundance, size structure, and taxonomy associated with aggregate formation and particle flux processes.

Neuer, S., Blanco-Bercial, L., Maas, A. E., Baird, K., Niimi, Y. J. (2026) **Quantification of zooplankton fecal-pellet production by on-board incubation experiments during seven Bermuda Atlantic Time-series Study (BATS) cruises aboard the R/V Atlantic Explorer from Jul 2021 to Mar 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2026-05-07 doi:10.26008/1912/bco-dmo.997926.1 [view at BCO-DMO]
Relationship Description: On board fecal-pellet production incubation experiment where samples originated.

Neuer, S., Blanco-Bercial, L., Maas, A. E., Baird, K., Niimi, Y. J. (2026) **Zooplankton-mediated aggregate formation was measured during seven Bermuda Atlantic Time-series Study (BATS) cruises aboard the R/V Atlantic Explorer Jul 2021 to Mar 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 2) Version Date 2026-05-14 doi:10.26008/1912/bco-dmo.998220.2 [view at BCO-DMO]
Relationship Description: Roller tank and fecal pellet production experiments used zooplankton collected during the same cruises and from the same depth strata associated with the PITs aggregate collections.

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Parameters

Parameter	Description	Units
Date	Date of experiment start or sample collection (Atlantic/Bermuda timezone (GMT-4))	unitless

Cruise	R/V Atlantic Explorer (AE) cruise ID number	unitless
Trawl	Net tow identifier associated with sample collection	unitless
Start_Time	Time when experiment or deployment started (Atlantic/Bermuda timezone (GMT-4))	unitless
End_Time	Time when experiment or deployment ended (Atlantic/Bermuda timezone (GMT-4))	unitless
Min_Depth	Minimum depth of sampling or incubation	meters (m)
Max_Depth	Maximum depth of sampling or incubation	meters (m)
Experiment	Experimental treatment or experiment identifier	unitless
GFF_filter_num	Identifier for glass fiber filter used for CHN analysis	unitless
Zooplankton_Groups	Broad taxonomic or functional group of zooplankton	unitless
Zooplankton_Taxa	Lowest identified taxonomic classification of zooplankton	unitless
num_Zooplankton	Number of zooplankton alive or present at end of experiment or analysis	unitless
Total_Hours	Duration of experiment, incubation, or deployment	hours
num_Fecal_pellet	Number of fecal pellets produced or analyzed	unitless
ug_N	nitrogen mass measured on filters via CHN analyzer	micrograms (µg)
ug_C	carbon mass measured on filters via CHN analyzer	micrograms (µg)
C_N	Carbon to nitrogen molar ratio	unitless
Blank_Corrected_mg_C_from_CHN	Carbon mass corrected for procedural blanks	milligrams (mg C)
Total_Volume	Total fecal pellet volume collected on filter	cubic micrometers (μm^3)

Carbon_Density	Carbon content per unit fecal pellet volume	mg C µm³
FPP_using_CHN_Exp_rate	Individual fecal pellet carbon production rate derived from CHN analysis	mg C individual^{-1} h^{-1}
FPP_using_CHN_Exp	Total fecal pellet carbon production per individual from CHN data	mg C individual^{-1}
Average_Animal_Dry_Weight	Mean dry weight of zooplankton individuals	milligrams (mg)
StDev_Average_Animal_Dry_Weight	Standard deviation of zooplankton dry weight	milligrams (mg)
StDev_Average_Animal_Dry_Weight_flag	The standard deviation of average animal dry weight was less than 0.005 mg as TRUE or FALSE	unitless
Datetime_Start_UTC	Datetime of experiment start (UTC)	unitless

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Instruments

Dataset-specific Instrument Name	Costech ECS 4010 elemental analyzer
Generic Instrument Name	Costech International Elemental Combustion System (ECS) 4010
Dataset-specific Description	Carbon, hydrogen, and nitrogen (CHN) content of fecal pellets were measured using a Costech ECS 4010 elemental analyzer.
Generic Instrument Description	The ECS 4010 Nitrogen / Protein Analyzer is an elemental combustion analyser for CHNSO elemental analysis and Nitrogen / Protein determination. The GC oven and separation column have a temperature range of 30-110 degC, with control of +/- 0.1 degC.

Dataset-specific Instrument Name	dissection microscope
Generic Instrument Name	Microscope - Optical
Dataset-specific Description	Following incubation, fecal pellets were collected under a dissection microscope using glass pipettes and rinsed three times with nuclease-free water.
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

Dataset-specific Instrument Name	stereomicroscope
Generic Instrument Name	Microscope - Optical
Dataset-specific Description	Pellets were imaged under a stereomicroscope, and morphometric measurements were obtained using INFINITY ANALYZE 7 software.
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

Dataset-specific Instrument Name	Reeve net
Generic Instrument Name	Reeve Net
Dataset-specific Description	Live zooplankton were collected during the March 2023 cruise (AE2306) using a 1-m², 150-µm mesh Reeve net for fecal pellet elemental analysis experiments.
Generic Instrument Description	A Reeve Net is a conventional ring net with a very large acrylic cylindrical cod-end (30 liters) designed to collect fragile gelatinous animals. The net is lowered to a particular depth and then hauled slowly back to the surface (5-10 m/min). Reeve (1981) also described a double net system with no bridle and flotation at the net mouth that is attached to a roller mechanism that rides on a tow wire. The roller system is locked in place by a pressure release device. Once below a set pressure, the roller and nets are released and they float slowly up the wire, gently collecting the zooplankton, without being influenced by the motion of the vessel and associated vertical wire movements. (from Wiebe and Benfield, 2003)

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Deployments

AE2306

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

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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.

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Funding

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

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