Routine metabolic rate (RMR) and critical partial pressure (Pcrit) measurements of Salpa fusiformis collected aboard R/V Atlantic Explorer cruise AE2306 in the Sargasso Sea in March 2023

Website: https://www.bco-dmo.org/dataset/969488
Data Type: Cruise Results
Version: 1
Version Date: 2025-09-05

Project
» EMBRACE-OCE-Seed: Temperature and oxygen partial pressure effect on aerobic metabolism and carbon flux of vertically migrating salps (Metabolic physiology of Salps)

Contributors	Affiliation	Role
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Abstract
These data include the effect of temperature and oxygen partial pressure on the aerobic metabolism of Salpa fusiformis collected during a Bermuda Atlantic Time-series Study cruise (AE2306) in the Sargasso Sea from in March of 2023 aboard the R/V Atlantic Explorer. A Pryoscience Firesting optode and oxygen sensor spots were used to collect routine metabolic rate (RMR) and critical oxygen partial pressure (Pcrit). Understanding the drivers of metabolic sensitivity is critical as climate change is shifting the distributions of temperature- and oxygen-limited organisms. Given salps' key role in carbon cycling, it's crucial to understand how these changes affect them across different temperature and oxygen concentrations.

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Coverage

Location: Sargasso Sea near BATS Station (31° 40'N, 64° 10'W), Surface to 200m
Spatial Extent: **Lat**:31.667 **Lon**:-64.167
Temporal Extent: 2023-03-18 - 2023-03-26

Methods & Sampling

Sample collection
Salpa fusiformis were collected in March 2023 aboard the R/V Atlantic Explorer (AE2306) during the monthly Bermuda Atlantic Time Series (BATS) cruise (31°50'N, 64°10'W). From 2023-03-19 to 2023-03-26, nighttime tows were conducted using a 1 meter circular Reeve net with 150 µm mesh, a 20 L cod end, and a miniSTAR-ODDI pressure and depth sensor deployed to 200 m depth. Conductivity, Temperature, Density, and Dissolved Oxygen (CTD-DO) casts were conducted at the same location following BATS protocols.

Only pristine salps, actively swimming, filtering, transparent, and free of abrasions, were used. Individuals were held for 12 hours to acclimate and confirm viability before experiments.

Oxygen consumption
Measurements followed Trueblood (2019), using Firesting optodes (PyroScience GmbH, Aachen, Germany), 50 mL gas-tight syringes with 0.2 µm filtered seawater at 21°C (sea surface temperature) or 14°C (temperature at 200 m). Routine metabolic rate (RMR) was used, as spontaneous activity could not be controlled for salps in the respirometer. Background respiration, determined using blank syringes with the same filtered seawater, was subtracted from RMR.

Critical oxygen partial pressure measurement
Critical partial pressure (P_{crit}) was calculated using the calc_alpha and the calc_pcrit() function in the "respirometry" package in R (Birk, 2024) based on metabolic rate (R) as a function of PO_2 (Seibel et al., 2021).

All salps were placed in cryo-vials and stored at -80ºC at sea. Samples were thawed; wet and dry weights were measured on shore. After obtaining wet mass, individuals were dried for 72 hrs at 60 ºC and then weighed.

Data Processing Description

Critical partial pressure (P_{crit}) was calculated using the calc_alpha and the calc_pcrit() function in the "respirometry" package in R (Birk et al., 2021) based on metabolic rate (R) as a function of PO_2 (Seibel et al., 2021).

Statistical analysis
Log-log power regressions of oxygen consumption vs. body mass were conducted using KaleidaGraph (Synergy Software, USA). An ANCOVA (R Foundation, Austria) tested the effect of temperature on RMR, controlling for body mass. The resulting rates were used to establish Q_{10}, the effect of a 10°C change in temperature on metabolic rate.

BCO-DMO Processing Description

- Imported data from source files "2023 Bermuda Salp Masses v1.1.csv" and "Bermuda 2023 RMR data v1.1.csv" into the BCO-DMO data system.
- Joined the two data files into a single table
- combined the two columns for resting metabolic rate into a single column (RMR at 14 degrees C, RMR at 21 degrees C --> RMR), then added a new column for temperature
- Removed 'Mass Wet Weight(mg)' column from RMR data because it matched 'Net Wet Weight (mg)' column in Salp Masses data

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Data Files

File	
969488_v1_salp_mass_rmr_2023.csv	(Comma Separated Values (.csv), 2.88 KB) MD5:e809f81154de96c32ab4e6a3f21f4559
Species, life cycle, length, wet weight, and dry weight of Salpa fusiformis plus routine metabolic rates at 21 and 14 degrees C; Primary data file for dataset ID 969488, version 1	

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Related Publications

Birk, M. A. (2024). respirometry: Tools for Conducting and Analyzing Respirometry Experiments (R package

version 2.0.1). Retrieved from https://CRAN.R-project.org/package=respirometry http://cran.r-project.org/package=respirometry
Software

Seibel, B. A., Andres, A., Birk, M. A., Burns, A. L., Shaw, C. T., Timpe, A. W., & Welsh, C. J. (2021). Oxygen supply capacity breathes new life into critical oxygen partial pressure (Pcrit). Journal of Experimental Biology, 224(8). doi:10.1242/jeb.242210
Methods

Synergy Software. (2000). KaleidaGraph (Version 3.5) [Computer software]. Reading, PA: Synergy Software. Retrieved from https://www.synergy.com
Software

Trueblood, L. A. (2019). Salp metabolism: temperature and oxygen partial pressure effect on the physiology of Salpa fusiformis from the California Current. Journal of Plankton Research, 41(3), 281–291. https://doi.org/10.1093/plankt/fbz014
Methods

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Parameters

Parameter	Description	Units
Latitude	Latitude of general sampling location	decimal degrees
Longitude	Longitude of general sampling location	decimal degrees
Sample_ID	Sample identification	unitless
Species	Species	unitless
Form	Which salp form was sampled (blastozooid or oozooid)	unitless
Length	Body length down the centerline of the salp from anterior to posterior	millimeters (mm)
Weigh_boat_mass	Mass of the empty weigh boat	milligrams (mg)
Boat_plus_salp_mass	Mass of the weigh boat plus salp	milligrams (mg)
Net_Wet_Weight_salp	Wet weight of the salp only (total - boat)	milligrams (mg)
Dry_Weight_with_boat	Weight of weigh boat and salp after drying	milligrams (mg)
Net_Dry_Weight_salp	Dry weight of the salp	milligrams (mg)
Temperature	Temperature of the experimental incubation measured using the temperature probe on the Pyroscience Firesting optode	degrees Celsius (°C)
RMR	Routine metabolic rate	micromoles per grams body mass per hour (µmol/g/hr)
Notes	Lab comments	unitless

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Instruments

Dataset-specific Instrument Name	CTD with dissolved oxygen sensor
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Dataset-specific Description	Conductivity, Temperature, Density, and Dissolved Oxygen (CTD-DO) casts were conducted at the same location following BATS protocols.
Generic Instrument Description	The Sea-Bird SBE 911 plus is a type of CTD instrument package for continuous measurement of conductivity, temperature and pressure. The SBE 911 plus includes the SBE 9plus Underwater Unit and the SBE 11plus Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 plus and SBE 11 plus is called a SBE 911 plus. The SBE 9 plus uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 plus and SBE 4). The SBE 9 plus CTD can be configured with up to eight auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorescence, light (PAR), light transmission, etc.). more information from Sea-Bird Electronics

Dataset-specific Instrument Name	drying oven
Generic Instrument Name	Drying Oven
Dataset-specific Description	After obtaining wet mass, individuals were dried for 72 hrs at 60 ºC and then weighed.
Generic Instrument Description	a heated chamber for drying

Dataset-specific Instrument Name	Firesting optodes
Generic Instrument Name	Optode
Dataset-specific Description	Metabolic measurements used Firesting optodes (PyroScience GmbH, Aachen, Germany).
Generic Instrument Description	An optode or optrode is an optical sensor device that optically measures a specific substance usually with the aid of a chemical transducer.

Dataset-specific Instrument Name	miniSTAR-ODDI pressure and depth sensor
Generic Instrument Name	Pressure Sensor
Dataset-specific Description	A miniSTAR-ODDI pressure and depth sensor was used during nighttime tows along with a Reeve net
Generic Instrument Description	A pressure sensor is a device used to measure absolute, differential, or gauge pressures. It is used only when detailed instrument documentation is not available.

Dataset-specific Instrument Name	SeaGear Reeve net
Generic Instrument Name	Reeve Net
Dataset-specific Description	A circular Reeve net with 150 micron mesh with a 20 L cod end was used for collections. The Reeve net was manufactured by SeaGear, Melbourne FL, USA
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)

Dataset-specific Instrument Name	scale/balance
Generic Instrument Name	scale or balance
Dataset-specific Description	After obtaining wet mass, individuals were dried for 72 hrs at 60 ºC and then weighed.
Generic Instrument Description	Devices that determine the mass or weight of a sample.

Dataset-specific Instrument Name	50 mL gas-tight syringes
Generic Instrument Name	syringe
Generic Instrument Description	A device used to inject fluids into or withdraw them from something; consists of a hollow barrel fitted with a plunger and a hollow needle.

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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

EMBRACE-OCE-Seed: Temperature and oxygen partial pressure effect on aerobic metabolism and carbon flux of vertically migrating salps (Metabolic physiology of Salps)

Coverage: Temperate and subtropical waters including Sargasso Sea

NSF abstract:
Salps, a type of gelatinous zooplankton, play a significant role in the ocean’s ecosystems, particularly in food webs and carbon cycling. Found throughout the world’s oceans, salps can rapidly bloom, consuming vast amounts of local primary production and contributing substantially to carbon sequestration by transporting carbon to deep ocean layers. This project seeks to understand how changes in temperature and oxygen levels affect the metabolic rates and carbon export capabilities of salps. Understanding these impacts is crucial for accurate ocean carbon cycling models and can help predict future changes in marine ecosystems. This project will advance the field of marine biology by filling significant gaps in our understanding of salp physiology and their role in carbon cycling. It will also support the training and education of underrepresented groups in marine science by integrating undergraduate students, particularly from underrepresented communities, in hands-on research, thereby fostering the next generation of scientists.

Salps (subphylum Urochordata, class Thaliacea) are an often-overlooked lineage of zooplankton that play a major role in carbon sequestration exporting as much as 46% of net primary production via respiration and fecal pellet production out of the euphotic zone. Understanding salp physiology is critically important for building accurate ocean carbon cycling models. Yet, there is very limited data available on salp physiology, and almost none on the effect of temperature and oxygen concentration on rate processes such as routine aerobic metabolic rate (RMR). The proposed research will characterize changes in RMR of both blastozooids and oozooids of the three most dominant species of vertically migrating salps in the Sargasso Sea. Oxygen consumption will be measured at temperatures consistent with the surface and at 200 m depth. Individuals will be held in respirometers and allowed to breathe down oxygen to lowest detectable levels to examine the effect of oxygen partial pressure on RMR. The resulting data will be incorporated into previously published carbon flux models for Sargasso Sea salps to determine what effect temperature and oxygen have on their carbon flux. As ocean temperatures continue to change both temperature and oxygen concentration will become important constraints on aerobic capacity and will affect activity, growth, and reproduction. As these changes occur, a greater understanding of salp metabolic physiology will improve our ability to more accurately predict salp contributions to carbon flux, an area of priority research in the biological pump community. This study will benefit society by providing unprecedented insight into how salps’ metabolism and carbon flux are affected by changes in temperature and oxygen content during their daily vertical migrations as well as the impact that climate change may have on salp physiology.

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-2409078

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