Lobster Larvae Respirometry Data

Website: https://www.bco-dmo.org/dataset/939782
Data Type: experimental
Version: 1
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Project
» RUI: Collaborative Research: Linking physiological thermal thresholds to the distribution of lobster settlers and juveniles (Lobster Thermal Thresholds)

Contributors	Affiliation	Role
Annis, Eric R.	Hood College	Principal Investigator
Frederich, Markus	University of New England - Marine Science Center (UNE-MSC)	Co-Principal Investigator
Rasher, Douglas B.	Bigelow Laboratory for Ocean Sciences	Co-Principal Investigator

Abstract
We used the American lobster (Homarus americanus) in the Gulf of Maine as a model system to define thermal tolerance in larvae and establish mechanistic linkages between thermal tolerance of the individual larva and the patterns of settlement in the field. We assessed and compared the thermal tolerances of larvae reared in the laboratory using conventional methods with larvae captured in the wild, and examined ontogenetic changes in thermal tolerance. The upper and lower thermal thresholds larval stages I-IV and the first juvenile stage were defined in part by oxygen consumption and scope for activity (defined as the difference in oxygen consumption between larvae at rest and larvae swimming actively). This data set includes the raw oxygen consumption data obtained through closed system microrespirometry and subsequently used to calculate scope for activity. These data were collected between 2021-2023 at Bigelow Laboratory for Ocean Sciences, led by Eric Annis.

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Coverage

Location: Bigelow Laboratory for Ocean Sciences
Temporal Extent: 2021-06-01 - 2023-09-01

Methods & Sampling

Microrespirometry trials were conducted on planktonic larval stages I, II, III, IV and benthic stage V at temperatures ranging from 4-32°C. We used a Unisense MicroRespiration System (https://unisense.com/products/microrespiration-system/), with SensorTrace Rate software and Oxygen MicroOptode MR optical oxygen sensors. Sensors were calibrated at 0 and 100% oxygen saturation at each treatment temperature prior to experimental trials. Larvae were held at held at 18°C until the time of the experiment when they were transferred to a 20 ml vial and placed in a water bath at the treatment temperature for a 10-minute acclimation period. Acclimated larvae were transferred to respiration chambers filled with 0.45 µm filtered sea water at treatment temperature and lowered into the water bath for a 20-minute respirometry trial. 4 ml respiration chambers were used for stages I-III and 40 ml for stages IV and V. Only

one larva was used in each chamber. Magnetic stir bars were used in all trials. In trials for resting oxygen consumption rate, a stainless steel mesh separated the larva from the stir bar. In the actively swimming trials the mesh was removed and movement of the stir bar prevented the larva from resting on the bottom. Controls were run using respiration chambers with 45 µm filtered sea water and no larva. The first 10 minute of data collected during the trial were discarded as it often required time to reach a linear rate of oxygen consumption. The rate of oxygen consumptions was determined for approximately the last 10 minutes of the trial using Unisense SensorTrace Rate software. After the trial was completed the larvae were rinsed with DI water, frozen individually, and subsequently dried at 60°C for 24 hours to obtain dry weight of individuals. When dry weight for an individual was not available and average values for the season was used. Oxygen consumption rate as normalized to dry weight of the individual larva.

Larvae were reared in lab under several different conditions. Most larvae were reared individually in an environmental control room at 18°C in 400 ml glass jars in 0.45 µm filtered seawater and fed fresh hatched brine shrimp ad libitum. Water changes were made every 2-3 days. Alternative rearing conditions included 14°C and fed fresh hatched brine shrimp, ambient seawater temperature (jars were held in a water bath of flow through seawater) fed fresh hatched brine shrimp, and 18°C and fed a diet of live freshly collected zooplankton from local waters. We also conducted trials on wild caught stage IV larvae. Larvae were collected using a neuston net (0-0.5 m depth) in the vicinity of Boothbay, Maine, USA. Wild larvae were held in individual jars at ambient sea water temperature until trials could be conducted.

Data Processing Description

SensorTrace Rate software (ver. 1.13) was used to manually select the portion of the oxygen consumption curve used to determine the rate. The slope of the line was recorded and transferred to an Excel spreadsheet. The rate (µmol/L/h) was multiplied by the chamber volume to determine the oxygen consumed per hour. The oxygen consumption rate in the controls were subtracted from the treatment rates. The resulting rate was then divided by the dry weight of the larva. All available control values were averaged for the season at each treatment temperature to provide more consistent values.

BCO-DMO Processing Description

- Removed units from column names
- Replaced blank spaces in column names with underscores ("_")
- Added column "Trial_Datetime_UTC" from columns "Trial_Date" and "Trial_Time_Local_EST"

Problem Description

Data have been checked and potentially problematic readings have been deleted.

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	Unisense MicroRespiration System
Generic Instrument Name	Respirometer
Dataset-specific Description	A Unisense MicroRespiration System, with SensorTrace Rate software and Oxygen MicroOptode MR optical oxygen sensors, was used during microrespirometry trials on planktonic larvae.
Generic Instrument Description	A device that measures the rate of respiration by a living organism or organic system by measuring its rate of exchange of oxygen and/or carbon dioxide.

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Project Information

RUI: Collaborative Research: Linking physiological thermal thresholds to the distribution of lobster settlers and juveniles (Lobster Thermal Thresholds)

Coverage: Gulf of Maine

NSF Award Abstract:
Temperature is one critical factor that determines the distribution of marine organisms. However, in many cases temperature ranges (thermal tolerances) are only known for adults, but not for the immature stages that transition from the plankton to the bottom. This study is testing how temperature affects where larvae are settling. The American lobster (Homarus americanus) in the Gulf of Maine is serving as a model system to measure the thermal tolerance of the larvae and link this to the distribution of young lobsters in the field. Presently, lobster larvae are more likely to experience relatively cold temperatures than heat stress and larval settlement appears to be restricted to warmer shallow waters by a sensitivity to temperatures below 12°C. As water temperature has increased, settlement and juvenile distribution have expanded into deeper waters suggesting a release from cold stress. This project is advancing the understanding of shifting species distributions in response to increasing ocean temperatures by exploring thermal sensitivity in wild-caught larvae for the first time. This information is providing thermal thresholds for modeling larval viability in response to climate change scenarios. Understanding the larvae?s responses to temperature is fundamental to predicting the impact of climate change on one of the most valuable commercial fisheries in North America. The project is supporting training of undergraduate interns and a master?s student from small colleges (Hood College and University of New England) and connecting them with a research institution (Bigelow Laboratory for Ocean Sciences). Teacher training is occurring in collaboration with the Marine Science Center at the University of New England. Results from this study are being shared with stakeholders and contributing to science-based management of the lobster fishery.

This project is the first to examine how thermal stress on a larval stage determines juvenile distributions using a combination of correlative and experimental approaches that includes measuring biochemical stress indicators in larvae deployed in natural field habitats. The central hypothesis is that the physiology of individual planktonic larvae controls meso-scale settlement patterns in the field. The goal is to ascertain if there is a causal relationship between the underlying physiology and thermal sensitivity of the organism and the distribution of early life stages. Larval supply, settlement and juvenile abundances will be assessed at different depths with temperatures above and below the proposed minimum temperature threshold of 12°C for larvae. Laboratory experiments using conventional methods are determining thermal tolerances in wild-caught larvae and how they change with ontogeny. The upper and lower thermal optima are being resolved using multiple physiological parameters such as measurements of oxygen consumption and aerobic scope, and biochemical assays of thermal stress (HSP70, AMPK, and SIRT). To link physiology to settlement patterns, caged stage IV larvae and V juveniles are being deployed in the field at sites with temperatures above and below 12°C. Lethal and sub-lethal effects on caged lobsters are being evaluated through measures of growth, mortality and biochemical markers of thermal stress. This is the first study to focus on the thermal tolerance of wild larvae,

which has broad implications for understanding settling in marine invertebrate larvae.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1948146
NSF Division of Ocean Sciences (NSF OCE)	OCE-1947639
NSF Division of Ocean Sciences (NSF OCE)	OCE-1948108

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