Phenotypic responses of Eastern oyster in response to variable length OA exposure conducted in summer 2017 with oysters sampled in Plum Island.

Website: https://www.bco-dmo.org/dataset/887553
Data Type: experimental
Version: 1
Version Date: 2023-01-20

Project
» Collaborative Research: Does ocean acidification induce a methylation response that affects the fitness of the next generation in oysters? (Epigenetics to Ocean)

Contributors	Affiliation	Role
Lotterhos, Katie	Northeastern University	Principal Investigator
Ries, Justin B.	Northeastern University	Principal Investigator
Cameron, Louise	Northeastern University	Scientist
Downey-Wall, Alan	Northeastern University	Scientist
Soenen, Karen	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
These data include multiple phenotypic measures (including calcification calculated using a buoyant weight approach, extrapallial fluid pH collected using a micro-pH probe, and general morphology at the time of collection.) for oysters exposed to ocean acidification at multiple timepoints over an 80 day period. The experiment was conducted in the summer of 2017 at the Northeastern University's Marine Science Center. The data was collected as part of a larger study aimed at assessing the molecular response of adult Eastern oyster (C. virginica) to OA exposure over time. Specifically, the aim of this work was to investigate the association of these molecular responses with oysters' capacity to regulate internal chemistry and calcification.

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Coverage

Spatial Extent: **N**:42.751636 **E**:-70.813498 **S**:42.681764 **W**:-70.855022
Temporal Extent: 2017 - 2017

Dataset Description

Data have not been made public due to unanswered questions and data quality issues. Final review by the data submitter was not received after it was imported into the BCO-DMO data system.

Reason: the submitter did not provide enough metadata descriptions, context and details about data relations.

The data was collected as part of a larger study aimed at assessing the molecular response of adult Eastern oyster (*C. virginica*) to OA exposure over time. Specifically, the aim of this work was to investigate the association of these molecular responses with oysters' capacity to regulate internal chemistry and calcification. Please see the linked Dryad and Github respository for additional information about associated molecular data.

This data was collected by Alan Downey-Wall and other members of the Lotterhos and Ries Lab at Northeastern University.

Methods & Sampling

These data water quality readings for oysters exposed to ocean acidification at multiple timepoints over an 80 day period. The experiment was conducted in the summer of 2017 at the Northeastern University's Marine Science Center with a flow-through seawater system that draws water from Broad Sound in Nahant, Massachusetts (42.416884, −70.907564) using oysters collected from Plum Island Sound, Massachusetts, USA (Site 1, 42.751636, −70.837023; Site 2, 42.725186, −70.855022; Site 3, 42.681764, −70.813498) in late April.

Calcification Rate: Net calcification rate was calculated for oysters surviving to either 50 or 80 days (n = 35) by buoyantly weighing oysters prior to exposure (BW1) and on day 33 or 34 of the exposure (BW2) following the methods of Ries et al. (2009). Buoyant weight was measured in a 27.65 liter tank (48 cm long, 24 cm wide and 24 cm deep) filled with seawater from the flow-through system and was maintained at treatment temperature by an Aqua Euro USA Model MC-1/4HP aquarium chiller. Buoyant weight was measured by completely submerging the oyster on a flat platform suspended from a bottom-loading scale (Cole Parmer Symmetry S-PT 413E, precision = 0.001 g). Care was taken to ensure no bubbles were trapped inside oyster shells. Oysters were weighed three times in the weighing basket, removing the oyster from the basket between each measurement. If replicate measurements varied by more than 0.01 g, oysters were re-weighed. A standard of known weight was weighed every 20 oysters to ensure that no drift was occurring in the scale. To establish a relationship between buoyant weight and dry weight for the purpose of estimating net calcification rate, shells of oysters sampled for tissue within four days of a buoyant weight measurement were soaked in 10% ethanol to remove salts, dried, and weighed. The dry weight was then regressed against the buoyant weight measurement to establish an empirical dry-buoyant weight relationship:

$$DryWgtBWi(mg) = 1.87*BWi - 2.74$$

This empirical relationship was then used to calculate dry shell weight at each buoyant weight time point via linear regression. Calculated dry weights were then used to calculate daily calcification rate:

$$\text{calcification rate (\%)} = (DryWgtBW2 - DryWgtBW1)/n * 100/DryWgtBW1$$

where dry weight (DryWgtBWi) was calculated for each individual using the buoyant weight pre-exposure (BW1) and 33-34 days into the exposure (BW2) and n was the number of days between the two measurements. Lastly, the average daily change in dry weight was divided by initial dry weight to standardize calcification rate for allometric effects, and multiplied by 100 to convert that fraction into a percent.

Extrapallial Fluid: Oyster pHEPF was measured by removing each oyster from its tank, inserting a 5 mL syringe with a flexible 18-gauge polypropylene tip through the luer-lock port into the oyster's extrapallial cavity, and extracting ~0.5–2 mL of extrapallial fluid. Care was taken to avoid puncturing the mantle tissue and inadvertently sampling either the hemolymph or stomach fluid. The pHEPF was measured immediately after extraction with an Orion 91'10DJWP Double Junction micro-pH probe calibrated with pH 7.01 and 10.01 NBS buffers (for slope) and Dickson seawater Certified Reference Material (for intercept).

Data Processing Description

Link to data processing: https://github.com/epigeneticstoocean/AE17_Cvirginica_MolecularResponse

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Related Publications

Downey-Wall, A. M., Cameron, L. P., Ford, B. M., McNally, E. M., Venkataraman, Y. R., Roberts, S. B., Ries, J. B., & Lotterhos, K. E. (2020). Ocean Acidification Induces Subtle Shifts in Gene Expression and DNA Methylation in Mantle Tissue of the Eastern Oyster (Crassostrea virginica) - Scrips https://github.com/epigeneticstoocean/AE17_Cvirginica_MolecularResponse
Software

Downey-Wall, A. M., Cameron, L. P., Ford, B. M., McNally, E. M., Venkataraman, Y. R., Roberts, S. B., Ries, J. B., & Lotterhos, K. E. (2020). Ocean Acidification Induces Subtle Shifts in Gene Expression and DNA Methylation in Mantle Tissue of the Eastern Oyster (Crassostrea virginica). Frontiers in Marine Science, 7. https://doi.org/10.3389/fmars.2020.566419
IsRelatedTo

Pierrot, D. E. Lewis,and D. W. R. Wallace. 2006. MS Excel Program Developed for CO2 System Calculations. ORNL/CDIAC-105a. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee. doi: 10.3334/CDIAC/otg.CO2SYS_XLS_CDIAC105a.
Software

Ries, J. B., Cohen, A. L., & McCorkle, D. C. (2009). Marine calcifiers exhibit mixed responses to CO2-induced ocean acidification. Geology, 37(12), 1131–1134. https://doi.org/10.1130/g30210a.1 https://doi.org/10.1130/G30210A.1
Methods

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Related Datasets

IsRelatedTo

Downey-Wall, A. (2020). *Data from: Ocean acidification induces subtle shifts in gene expression and DNA methylation in mantle tissue of the Eastern oyster (Crassostrea virginica)* (Version 3) [Data set]. Dryad. https://doi.org/10.5061/DRYAD.8CZ8W9GNK https://doi.org//10.5061/dryad.8cz8w9gnk

Downey-Wall, A., Lotterhos, K., Ries, J. B., Cameron, L. (2023) **Water quality of experiment measuring phenotypic responses of Eastern oyster in response to variable length OA exposure conducted in summer 2017 with oysters sampled in Plum Island.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-01-19 http://lod.bco-dmo.org/id/dataset/887456 [view at BCO-DMO]
Relationship Description: Dataset is part of same experiment.

Lotterhos, K., Ries, J. B. (2023) **Shell Concentrations from an adult Eastern oyster ocean acidification exposure experiment on adult Eastern oysters from Plum Island Sound in 2017.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-02-02 doi:10.26008/1912/bco-dmo.888902.1 [view at BCO-DMO]

McNally, E., Lotterhos, K., Ries, J. B. (2023) **Seawater concentration data from an ocean acidification exposure experiment on adult Eastern oysters from Plum Island Sound in 2017.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-02-02 doi:10.26008/1912/bco-dmo.888887.1 [view at BCO-DMO]

IsReferencedBy

Lotterhos, K., Ries, J. B. (2023) **Molar Ratios from an adult Eastern oyster ocean acidification exposure experiment at the Northeastern University Marine Science Center in 2017.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-02-02 doi:10.26008/1912/bco-dmo.888911.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
ID	Oyster ID	unitless
Exposure_Extra	Oysters part of planned exposure (Exposure) compare to extra oysters at the end of exposure (Exposure-Extra)	unitless
shelf	Shelf in experimental array (1-6)	unitless
tank	Tank ID for each shelf in experimental array (1-3)	unitless
tankID	Unique tank ID across experiment (1-18)	unitless
pCO2	pCO2 treatment (categorical)	uatm
length	Length of oyster at collection	centimeter (cm)
width	Width of oyster at collection	centimeter (cm)
pop	Population collected from (Ipswich, Rowley, Rowley2)	unitless
sample_date	Sample date in ISO format (YYY-MM-DD), UTC time	unitless
Timepoint	Day collected (from start of exposure) in ISO format (YYY-MM-DD), UTC time	unitless
pHMeasured	EPF pH (Uncorrected value)	pH
pHNBS	EPF pH NBS Scale	pH
pHSW	EPF pH Seawater Scale	pH
pHTotal	EPF pH Total Scale	pH
PercentChangePerDayStandardized_Exposure	The percent change in buoyant weight over the first 34 days of experimental exposure to OA (see methods for details on this calculation). Percent delta dry weight per day divided by starting dry weight (Calcification Rate %)	percentage (%)

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Instruments

Dataset-specific Instrument Name	Aqua Euro USA Model MC-1/4HP aquarium chiller
Generic Instrument Name	Aquarium chiller
Generic Instrument Description	Immersible or in-line liquid cooling device, usually with temperature control.

Dataset-specific Instrument Name	VINDTA 3C coupled alkalinity gram titration and coulometric DIC analyzer system
Generic Instrument Name	Automatic titrator
Generic Instrument Description	Instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

Dataset-specific Instrument Name	YSI 3200 conductivity probe (precision = 0.1 ppt)
Generic Instrument Name	Conductivity Meter
Generic Instrument Description	Conductivity Meter - An electrical conductivity meter (EC meter) measures the electrical conductivity in a solution. Commonly used in hydroponics, aquaculture and freshwater systems to monitor the amount of nutrients, salts or impurities in the water.

Dataset-specific Instrument Name	Accumet solid state pH electrode (precision = 1mV)
Generic Instrument Name	pH Sensor
Generic Instrument Description	An instrument that measures the hydrogen ion activity in solutions. The overall concentration of hydrogen ions is inversely related to its pH. The pH scale ranges from 0 to 14 and indicates whether acidic (more H+) or basic (less H+).

Dataset-specific Instrument Name	Orion 91'10DJWP Double Junction micro-pH probe+
Generic Instrument Name	pH Sensor
Generic Instrument Description	An instrument that measures the hydrogen ion activity in solutions. The overall concentration of hydrogen ions is inversely related to its pH. The pH scale ranges from 0 to 14 and indicates whether acidic (more H+) or basic (less H+).

Dataset-specific Instrument Name	Bottom-loading scale (Cole Parmer Symmetry S-PT 413E, precision = 0.001 g)
Generic Instrument Name	scale
Generic Instrument Description	An instrument used to measure weight or mass.

Dataset-specific Instrument Name	NIST-standardized glass thermometer (precision = 0.1 °C)
Generic Instrument Name	Thermometer
Generic Instrument Description	A device designed to measure temperature.

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Project Information

Collaborative Research: Does ocean acidification induce a methylation response that affects the fitness of the next generation in oysters? (Epigenetics to Ocean)

Coverage: Coastal Massachusetts near Nahant: 42°25'06"N 70°54'14"W

NSF Award Abstract:
Marine ecosystems worldwide are threatened by ocean acidification, a process caused by the unprecedented

rate at which carbon dioxide is increasing in the atmosphere. Since ocean change is predicted to be rapid, extreme, and widespread, marine species may face an "adapt-or-die" scenario. However, modifications to the DNA sequence may be induced in response to a stress like ocean acidification and then inherited. Such "epigenetic" modifications may hold the key to population viability under global climate change, but they have been understudied. The aim of this research is to characterize the role of DNA methylation, a heritable epigenetic system, in the response of Eastern oysters (Crassostrea virginica) to ocean acidification. The intellectual merit lies in the integrative approach, which will characterize the role of DNA methylation in the intergenerational response of oysters to ocean acidification. These interdisciplinary data, spanning from molecular to organismal levels, will provide insight into mechanisms that underlie the capacity of marine invertebrates to respond to ocean acidification and lay the foundation for future transgenerational studies. Ocean acidification currently threatens marine species worldwide and has already caused significant losses in aquaculture, especially in Crassostrea species. This research has broader impacts for breeding, aquaculture, and the economy. Under the investigators' "Epigenetics to Ocean" (E2O) training program, the investigators will build STEM talent in bioinformatics and biogeochemistry, expose girls in low-income school districts to careers in genomics, and advance the field through open science and reproducibility.

This research will specifically test if intermittent exposure to low pH induces a methylation response with downstream beneficial effects for biomineralization. These methylation states could be inherited and confer a fitness advantage to larvae that possess them. Phase 1 of the project will use an exposure experiment to determine the degree to which DNA methylation is altered and regulates the response to OA. Data from this experiment will be used to test the hypotheses that (i) DNA methylation, induced in the tissue of shell formation (i.e., mantle tissue), is correlated with changes in transcription and regulation of pallial fluid pH (calcifying fluid pH, measured by microelectrode), and (ii) that methylation changes induced in the mantle tissue are also induced in the germline --indicating that such changes are potentially heritable. Phase 2 of the project will use a pair-mated cross experiment to test the hypothesis that parental exposure to OA alters larval traits (calcification rate, shell structure, and polymorph mineralogy). Larvae will be generated from parents exposed to OA or control seawater, and then raised under control or OA conditions. Results will be used to (i) characterize inheritance of induced methylation states, (ii) estimate the variance in larval traits explained by genotype, non-genetic maternal/paternal effects, adult OA exposure, larval OA exposure, and parental methylome, and (iii) test the hypothesis that adult exposure alters the heritability (a quantity that predicts evolutionary response) of larval traits. Since the effects of epigenetic phenomena on estimates of heritability are highly debated, the results would advance understanding of this important issue. Because the investigators could discover that DNA methylation is a mechanism for heritable plastic responses to OA, knowledge of this mechanism would significantly improve and potentially transform predictive models for how organisms respond to global change.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1635423

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