Population fitness measurements collected for Acartia hudsonica during multigenerational exposure to ocean warming (OW), ocean acidification (OA), and combined ocean warming and acidification (OWA)

Website: https://www.bco-dmo.org/dataset/923960
Data Type: Other Field Results, experimental
Version: 1
Version Date: 2024-03-29

Project
» Collaborative Research: Response of marine copepods to warming temperature and ocean acidification (Copepod Response to Warming Temp and OA)

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Abstract
These data include population fitness measurements collected for Acartia hudsonica during multigenerational exposure to ocean warming (OW), ocean acidification (OA), and combined ocean warming and acidification (OWA) including a benign ambient condition temperature and CO2 control (AM).

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Coverage

Location: University of Connecticut, Avery Point campus
Spatial Extent: **Lat**:41.3 **Lon**:-72
Temporal Extent: 2017-07-02 - 2018-08-15

Methods & Sampling

Three hundred copepods were collected in April of 2018 from eastern Long Island Sound, Connecticut, USA (41.3°N, 72.0°W) and raised for one year (~12 generations) (14 degrees Celsius (°C), 400 microatmospheres (µatm) CO2, 30 ‰ salinity, 12:12 hours light:dark) as stock cultures to limit maternal effects (Falconer, 1989, *Introduction to Quantitative Genetics*). Three resulting stock cultures with >2,000 individuals each were combined and then split evenly into three groups for each of the four treatments. Groups were acclimatized within a generation to temperature (15°C or 13°C, 1°C per day) and pCO2 (1000 µatm, 100 µatm per day, OA treatments only). Groups seeded the F0 individuals for 7-10 days yielding ~15,000 eggs per treatment. Resulting F0 eggs and nauplii were combined for each treatment, redistributed among three replicate cultures, and returned to their respective experimental conditions. The experimental environmental conditions were: 1) Ambient control (AM): 13°C, 400 µatm CO2, pH = 8.2; 2) Ocean Acidification (OA): 13°C, 1000 µatm CO2, pH = 7.85; 3) Ocean Warming (OW): 15°C, 400 µatm CO2, pH = 8.2; 4) Combined warming and acidification (OWA): 15°C, 1000 µatm CO2, pH = 7.85. Copepods were fed equal proportions of the live phytoplankters *Tetraselmis* sp., *Rhodomonas* sp., and T*halassiosira weissflogii* every 48-72 hours to achieve food-replete conditions (≥600 micrograms (µg) Carbon per liter (L)) (Feinberg and Dam, 1998. *Marine Ecology Progress Series*), deliberately raised under ambient conditions to avoid confounding effects of possible food quality changes.

The population net reproductive rate, λ, was calculated as the dominant eigenvalue of an assembled projected age-structured Leslie matrix constructed from survival and fecundity data (Caswell, H. 2001. *Matrix Population Models: Construction, Analysis, and Interpretation*). Briefly, day-specific probabilities of survival are calculated from day-specific survival as Px = lx / (lx-1) where lx represents the proportion of individuals on day x and lx - 1 represents the proportion of individuals on day x - 1. Probabilities of survival on day 1 are assumed to be 100%, or a value of 1.0. Per capita EPR and HS are calculated as described in the preceding, with fecundity rates equalling the product of EPR and HS. Because only females produce offspring, total fecundity rates must be scaled to the sex ratio (proportion of females to males). To account for differences in individual development time for each treatment, fecundity rates are assigned to all days after the first matured adult is observed. We assume that surviving individuals represented by the survival experiments are equally as likely to experience any of the fecundity values observed in EPR experiments. Therefore, each mate-pair fecundity rate was paired with each survival beaker to construct a matrix. This yields a maximum of 120 matrices per treatment per generation (3 survival beakers × 4 replicate cultures × 10 mate pairs). Full methods for all traits can be found in: deMayo, et al. 2023. Simultaneous warming and acidification limit population and reveal phenotype costs for a marine phenotype. *Proc. R. Soc. B* 290: 20231033. doi.org/10.1098/rspb.2023.1033

Data Processing Description

All data analysis and processing were performed with R (v 4.0.2). Code for data analysis and visualization can be found at: https://zenodo.org/badge/latestdoi/505896789.

BCO-DMO Curation Notes

- Imported original file "lambda_results_devtime_surv_epr_hf_sex_w_f11.txt" into the BCO-DMO system.
- Renamed fields to comply with BCO-DMO naming conventions.
- Saved final file as "923960_v1_a_hudsonica_population_fitness.csv".

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Data Files

File	
923960_v1_a_hudsonica_population_fitness.csv	(Comma Separated Values (.csv), 57.24 KB) MD5:36af3b46a7840005e37fb59eb33ea31c
Primary data file for dataset ID 923960, version 1	

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Related Publications

R Core Team (2020). R: A language and environment for statistical computing. R v4.0.2. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/
Software

deMayo, J. A., Brennan, R. S., Pespeni, M. H., Finiguerra, M., Norton, L., Park, G., Baumann, H., & Dam, H. G. (2023). Simultaneous warming and acidification limit population fitness and reveal phenotype costs for a marine copepod. Proceedings of the Royal Society B: Biological Sciences, 290(2006). https://doi.org/10.1098/rspb.2023.1033
Results

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Related Datasets

IsRelatedTo

Dam, H. G., Baumann, H., Finiguerra, M., Pespeni, M., Brennan, R. (2024) **Body size measurements collected for Acartia hudsonica during multigenerational exposure to ocean warming (OW), ocean acidification (OA), and combined ocean warming and acidification (OWA).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-04-03 doi:10.26008/1912/bco-dmo.924236.1 [view at BCO-DMO]
Relationship Description: These datasets result from the same set of experiments.

Dam, H. G., Baumann, H., Finiguerra, M., Pespeni, M., Brennan, R. (2024) **Development (i.e. maturation) time measurements for Acartia hudsonica during multigenerational exposure to ocean warming (OW), ocean acidification (OA), and combined ocean warming and acidification (OWA).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-04-03 doi:10.26008/1912/bco-dmo.924206.1 [view at BCO-DMO]
Relationship Description: These datasets result from the same set of experiments.

Dam, H. G., Baumann, H., Finiguerra, M., Pespeni, M., Brennan, R. (2024) **Egg production rate (EPR) and egg hatching success (HS) data for Acartia tonsa during multigenerational exposure to ocean warming (OW), ocean acidification (OA), and combined ocean warming and acidification (OWA).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-04-02 doi:10.26008/1912/bco-dmo.924126.1 [view at BCO-DMO]
Relationship Description: These datasets result from the same set of experiments.

Dam, H. G., Baumann, H., Finiguerra, M., Pespeni, M., Brennan, R. (2024) **Population fitness measurements collected for Acartia tonsa during multigenerational exposure to ocean warming (OW), ocean acidification (OA), and combined ocean warming and acidification (OWA).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-03-28 doi:10.26008/1912/bco-dmo.923908.1 [view at BCO-DMO]
Relationship Description: These datasets result from the same set of experiments.

Dam, H. G., Baumann, H., Finiguerra, M., Pespeni, M., Brennan, R. (2024) **Survivorship measurements collected for Acartia hudsonica during multigenerational exposure to ocean warming (OW), ocean acidification (OA), and combined ocean warming and acidification (OWA).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-04-01 doi:10.26008/1912/bco-dmo.924088.1 [view at BCO-DMO]
Relationship Description: These datasets result from the same set of experiments.

Jamesdemayo, & Dam-Lab. (2023). *dam-lab/hudsonica_transgenerational_MS: Data and code for manuscript: Limited copepod adaptation to combined warming and acidification reveals cost of producing adaptive phenotypes* (Version 3.3) [Computer software]. Zenodo. https://doi.org/10.5281/ZENODO.6678641 https://doi.org/10.5281/zenodo.6678641

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Parameters

Parameter	Description	Units
Generation	The generation at which fitness was estimated	unitless
Treatment	The treatment that the orgnaisms were evaluated in, and where traits were measured and fitness was estimated. 1 = ambient (AM): temperature = 18 °C, pCO2 = 400 µatm. 2 = ocean acidification (OA): temperature = 18 °C, pCO2= 2000 µatm. 3 = ocean warming (OW): temperature = 22 °C, pCO2 = 400 µatm. 4 = ocean warming and acidification (OWA): temperature = 22 °C, pCO2 = 2,000 µatm.	unitless
Rep	The biological replicate associated with the population fitness estimates	unitless
lambda	The net reproductive rate estimates	per generation
surv	The corresponding survival probabilities	unitless
epr	The corresponding egg production rate measurements	eggs per female per day
hf	The corresponding hatching success rates	nauplii per number of eggs laid
sex	The corresponding sex ratio	females per total copepods
dev_time	The corresponding development time	days to adulthood

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Project Information

Collaborative Research: Response of marine copepods to warming temperature and ocean acidification (Copepod Response to Warming Temp and OA)

Coverage: North western Atlantic ocean; Gulf of Maine, coastal and estuarine habitats

NSF Award Abstract:
Over time, our oceans are becoming both warmer and higher dissolved carbon dioxide. The latter condition is called ocean acidification. The consequences of these simultaneous changes for populations of marine organisms are not well understood. For this project, the investigators will conduct a series of laboratory experiments to determine how two closely-related, common species of Acartia copepods will respond to the interactive effects of warming and acidification and also how well these species can adapt over multiple generations to changing ocean conditions. Since these copepods are key species in coastal food webs, results will have important implications for understanding and predicting how marine ecosystems may respond to future climate change. The investigators will share results from the research through traditional print media, case studies, and video mini lectures. The goal will be for educators of all levels to easily access material on climate change and ocean acidification to include in teaching curricula, in alignment with recommendations for universal design for learning. The project is a collaborative effort between an established professor at the University of Connecticut and an early-career female scientist at the University of Vermont. It will provide training and opportunities for collaborative, interdisciplinary research for two postdoctoral investigators, two

graduate students and an undergraduate student.

The project's main goals are: 1) to test the simultaneous effects of temperature and carbon dioxide under current and future conditions on life history traits throughout the life cycle for two key copepod species, warm-adapted Acartia tonsa and cold-adapted Acartia hudsonica; 2) to test for adaptive capacity of both copepod species to a warmer and carbon-dioxide-enriched ocean; 3) to measure the genetic and maternally-induced changes across multiple generations of experimental selection in future conditions in both copepod species, and to identify the genes and pathways responding to selection. The investigators will use experiments encompassing current and projected temperature and carbon-dioxide conditions, will determine the roles of each variable and their interaction on traits that affect the fitness of both copepod species. They will also determine which life stages are most sensitive to individual or simultaneous stress conditions. Through multigenerational selection experiments, the investigators will identify and characterize the mechanisms of copepod evolutionary adaptation. Finally, they will measure genomic changes across the generations under all four experimental conditions to quantify the relative contributions of genetic and maternally-induced change in the physiological and life history traits of copepods in response to near-future climate conditions.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1559075
NSF Division of Ocean Sciences (NSF OCE)	OCE-1559180

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