

Carbonate chemistry data from static and fluctuating pCO₂ x dissolved oxygen (DO) experiments on *Menidia menidia*

Website: <https://www.bco-dmo.org/dataset/777144>

Data Type: experimental

Version: 1

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Project

» [Collaborative research: Understanding the effects of acidification and hypoxia within and across generations in a coastal marine fish](#) (HYPOA)

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|--|---|------------------------------------|
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Abstract

Coastal ecosystems experience substantial natural fluctuations in pCO₂ and dissolved oxygen (DO) conditions on diel, tidal, seasonal and interannual timescales. Rising carbon dioxide emissions and anthropogenic nutrient input are expected to increase these pCO₂ and DO cycles in severity and duration of acidification and hypoxia. How coastal marine organisms respond to natural pCO₂ x DO variability and future climate change remains largely unknown. Here, we assess the impact of static and cycling pCO₂ x DO conditions of various magnitudes and frequencies on early life survival and growth of an important coastal forage fish, *Menidia menidia*. Static low DO conditions severely decreased embryo survival, larval survival, time to 50% hatch, size at hatch and post-larval growth rates. Static elevated pCO₂ did not affect most response traits, however, a synergistic negative effect did occur on embryo survival under hypoxic conditions (3.0 mg L⁻¹). Cycling pCO₂ x DO, however, reduced these negative effects of static conditions on all response traits with the magnitude of fluctuations influencing the extent of this reduction. This indicates that fluctuations in pCO₂ and DO may benefit coastal organisms by providing periodic physiological refuge from stressful conditions, which could promote species adaptability to climate change.

Table of Contents

- [Coverage](#)
- [Dataset Description](#)
 - [Methods & Sampling](#)
 - [Data Processing Description](#)
- [Data Files](#)
- [Related Publications](#)
- [Parameters](#)
- [Instruments](#)
- [Project Information](#)
- [Funding](#)

Coverage

Temporal Extent: 2017-05-09 - 2019-07-03

Dataset Description

Carbonate chemistry data from static and fluctuating pCO₂ x dissolved oxygen (DO) experiments on *Menidia*

menidia. Four separate experiments were conducted over two consecutive years to determine the effects of static and fluctuating pCO₂ x DO conditions on the early life survival and growth of the coastal forage fish, M. menidia.

See related datasets: [survival](#) and [growth](#).

Methods & Sampling

Wild adults were collected using a 30 x 2 m beach seine and strip-spawned in the laboratory the following day. 100 embryos were then placed in each replicate across 9 recirculating systems of different pCO₂ x DO conditions (control, intermediate, extreme) and cycling patterns (static, small diel fluctuation, large diel fluctuation and tidal fluctuation).

pCO₂ x DO conditions were measured every hour for each tank and adjusted to the pre-determined conditions via the injection of carbon dioxide, nitrogen gas and/or CO₂-stripped air. LabView software (National Instruments) was used to control sampling pumps and gas and water solenoids.

Seawater samples of each tank were collected three times throughout each experiment and stored in 4°C for subsequent alkalinity measurements up to two weeks after the experiment finished. For more details please see Cross et al. (submitted).

Data Processing Description

Data processing: CO2SYS version 2.1 was used to calculate pCO₂ in the carbonate chemistry tables.

[[table of contents](#) | [back to top](#)]

Data Files

| File |
|---|
| carbonate_chemistry.csv (Comma Separated Values (.csv), 8.73 KB) MD5:bfa079cefb84af7f9191fe4e0f837dce |
| Primary data file for dataset ID 777144 |

[[table of contents](#) | [back to top](#)]

Related Publications

Cross, E. L., Murray, C. S., & Baumann, H. (2019). Diel and tidal pCO₂ x O₂ fluctuations provide physiological refuge to early life stages of a coastal forage fish. *Scientific Reports*, 9(1). doi:[10.1038/s41598-019-53930-8](https://doi.org/10.1038/s41598-019-53930-8)
Results

[[table of contents](#) | [back to top](#)]

Parameters

| Parameter | Description | Units |
|--------------------|---|--|
| Experiment | Experiment number | unitless |
| Experiment_descrip | Description of experiment | unitless |
| Treatment | Experimental treatment/conditions | unitless |
| Cycling_Pattern | Experimental cycling pattern | unitless |
| Metric | Indicates whether values are mean, min, or max; applicable only to Measured_pH, Measured_DO, and pCO2 columns of experiments three and four | unitless |
| Measured_pH | Mean of hourly pH measurements from a computer-controlled pH/DO manipulation system using a Hach pH probe | pH scale, NIST |
| Measured_pH_SD | Standard deviation (S.D.) of Measured_pH | pH scale, NIST |
| Measured_DO | Mean of hourly dissolved oxygen measurements from a computer-controlled pH/DO manipulation system using a Hach DO probe | milligrams per liter (mg L ⁻¹) |
| Measured_DO_SD | Standard deviation (S.D.) of Measured_DO | milligrams per liter (mg L ⁻¹) |
| pCO2 | Mean of partial pressure of CO2 calculated from alkalinity and pH measurements in CO2SYS v2.1 | microatmospheres (uatm) |
| pCO2_SD | Standard deviation (S.D.) of pCO2 | microatmospheres (uatm) |
| AT | Mean of alkalinity measurements from a Metler Toledo G20 Potentiometric titrator | micromoles per kilogram (umol kg ⁻¹) |
| AT_SD | Standard deviation (S.D.) of AT | micromoles per kilogram (umol kg ⁻¹) |
| Temperature | Mean of hourly temperature measurements from a a computer-controlled pH/DO manipulation system using a Hach DO probe | degrees Celsius |
| Temperature_SD | Standard deviation (S.D.) of Temperature | degrees Celsius |
| Salinity | Mean of daily salinity measurements from a refractometer | psu |
| Salinity_SD | Standard deviation (S.D.) of Salinity | psu |

[[table of contents](#) | [back to top](#)]

Instruments

| | |
|---|---|
| Dataset-specific Instrument Name | Metler Toledo G20 Potentiometric Titrator |
| Generic Instrument Name | Automatic titrator |
| Dataset-specific Description | Alkalinity - Metler Toledo G20 Potentiometric Titrator calibrated with certified reference material from Dr. Andrew Dickson, University of California San Diego |
| 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 | Hach LDO Model 2 |
| Generic Instrument Name | Oxygen Sensor |
| Dataset-specific Description | Dissolved oxygen (DO) - Optical DO probe (Hach LDO Model 2) |
| Generic Instrument Description | An electronic device that measures the proportion of oxygen (O ₂) in the gas or liquid being analyzed |

| | |
|---|--|
| Dataset-specific Instrument Name | Hach pHD digital electrode |
| Generic Instrument Name | pH Sensor |
| Dataset-specific Description | pHNIST - Hach pHD digital electrode - calibrated twice weekly using NIST 2-point pH buffers |
| 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 | Aqualogic Deltastar |
| Generic Instrument Name | Water Temperature Sensor |
| Dataset-specific Description | Temperature - Aqualogic thermostats connected to submersible heaters and chillers (Deltastar) |
| Generic Instrument Description | General term for an instrument that measures the temperature of the water with which it is in contact (thermometer). |

[[table of contents](#) | [back to top](#)]

Project Information

Collaborative research: Understanding the effects of acidification and hypoxia within and across generations in a coastal marine fish (HYPOA)

Coverage: Eastern Long Island Sound, CT, USA

Description from NSF award abstract:

Coastal marine ecosystems provide a number of important services and resources for humans, and at the same time, coastal waters are subject to environmental stressors such as increases in ocean acidification and reductions in dissolved oxygen. The effects of these stressors on coastal marine organisms remain poorly understood because most research to date has examined the sensitivity of species to one factor, but not to more than one in combination. This project will determine how a model fish species, the Atlantic silverside, will respond to observed and predicted levels of dissolved carbon dioxide (CO₂) and oxygen (O₂). Shorter-term experiments will measure embryo and larval survival, growth, and metabolism, and determine whether parents experiencing stressful conditions produce more robust offspring. Longer-term experiments will study the consequences of ocean acidification over the entire life span by quantifying the effects of high-CO₂ conditions on the ratio of males to females, lifetime growth, and reproductive investment. These studies will provide a more comprehensive view of how multiple stressors may impact populations of Atlantic silversides and potentially other important forage fish species. This collaborative project will support and train three graduate students at the University of Connecticut and the Stony Brook University (NY), two institutions that attract

students from minority groups. It will also provide a variety of opportunities for undergraduates to participate in research and the public to learn about the study, through summer research projects, incorporation in the "Women in Science and Engineering" program, and interactive displays of environmental data from monitoring buoys. The two early-career investigators are committed to increasing ocean literacy and awareness of NSF-funded research through public talks and presentations.

This project responds to the recognized need for multi-stressor assessments of species sensitivities to anthropogenic environmental change. It will combine environmental monitoring with advanced experimental approaches to characterize early and whole life consequences of acidification and hypoxia in the Atlantic silverside (*Menidia menidia*), a valued model species and important forage fish along most of the US east coast. Experiments will employ a newly constructed, computer-controlled fish rearing system to allow independent and combined manipulation of seawater pCO₂ and dissolved oxygen (DO) content and the application of static and fluctuating pCO₂ and DO levels that were chosen to represent contemporary and potential future scenarios in productive coastal habitats. First CO₂, DO, and CO₂ × DO dependent reaction norms will be quantified for fitness-relevant early life history (ELH) traits including pre- and post-hatch survival, time to hatch, post-hatch growth, by rearing offspring collected from wild adults from fertilization to 20 days post hatch (dph) using a full factorial design of 3 CO₂ × 3 DO levels. Second, the effects of tidal and diel CO₂ × DO fluctuations of different amplitudes on silverside ELH traits will be quantified. To address knowledge gaps regarding the CO₂-sensitivity in this species, laboratory manipulations of adult spawner environments and reciprocal offspring exposure experiments will elucidate the role of transgenerational plasticity as a potential short-term mechanism to cope with changing environments. To better understand the mechanisms of fish early life CO₂-sensitivity, the effects of temperature × CO₂ on pre- and post-hatch metabolism will be robustly quantified. The final objective is to rear silversides from fertilization to maturity under different CO₂ levels and assess potential CO₂-effects on sex ratio and whole life growth and fecundity.

Related references:

Gobler, C.J. and Baumann, H. (2016) Hypoxia and acidification in ocean ecosystems: Coupled dynamics and effects on marine life. *Biology Letters* 12:20150976. doi:[10.1098/rsbl.2015.0976](https://doi.org/10.1098/rsbl.2015.0976)

Baumann, H. (2016) Combined effects of ocean acidification, warming, and hypoxia on marine organisms. *Limnology and Oceanography e-Lectures* 6:1-43. doi:[10.1002/loe2.10002](https://doi.org/10.1002/loe2.10002)

Depasquale, E., Baumann, H., and Gobler, C.J. (2015) Variation in early life stage vulnerability among Northwest Atlantic estuarine forage fish to ocean acidification and low oxygen *Marine Ecology Progress Series* 523: 145-156. doi:[10.3354/meps11142](https://doi.org/10.3354/meps11142)

[[table of contents](#) | [back to top](#)]

Funding

| Funding Source | Award |
|--|-----------------------------|
| NSF Division of Ocean Sciences (NSF OCE) | OCE-1536165 |

[[table of contents](#) | [back to top](#)]