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

Website: https://www.bco-dmo.org/dataset/777117
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)

Contributors	Affiliation	Role
Baumann, Hannes	University of Connecticut (UConn)	Principal Investigator
Cross, Emma L.	University of Connecticut (UConn)	Co-Principal Investigator, Contact
Murray, Christopher S.	University of Connecticut (UConn)	Co-Principal Investigator
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

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 × DO variability and future climate change remains largely unknown. Here, we assess the impact of static and cycling pCO2 × 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 × 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

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

Dataset Description

Survival 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: growth and carbonate chemistry.

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.

Newly hatched larvae were counted every day to determine embryo survival. Surviving larvae at 6 or 15 days post hatch were counted to obtain larvae. For more details please see Cross et al. (submitted).

Data Processing Description

Survival data was processed using R.

[table of contents | back to top]

Data Files

File
survival.csv (Comma Separated Values (.csv), 7.92 KB) MD5:e9fac0ee80bc826946962107a3ab76bd Primary data file for dataset ID 777117

[table of contents | back to top]

Related Publications

Cross, E. L., Murray, C. S., & Baumann, H. (2019). Diel and tidal pCO2 × 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
Results

[table of contents | back to top]

Parameters

Parameter	Description	Units
Experiment	Experiment number	unitless
Tank	Tank number	unitless
Bucket	Bucket	unitless
Target_Temperature	Target temperature	degrees Celsius
Cycling_pattern	Experimental cycling pattern	unitless
Target_pCO2_uatm	Target pCO2	microatmospheres (uatm)
Target_DO_mgL	Target dissolved oxygen (DO)	milligrams per liter (mg L-1)
Embryo_survival	Percent of embryos that hatched	unitless (percent)
Larval_survival_to_15dph	Percent of larvae that survived to 15 days post hatch (dph)	unitless (percent)
Larval_survival_to_6dph	Percent of larvae that survived to 6 days post hatch (dph)	unitless (percent)

[table of contents | back to top]

Instruments

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 (O2) 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	Metler Toledo G20 Potentiometric Titrator
Generic Instrument Name	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	Titrators are 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	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

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

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

[table of contents | back to top]

Funding

Funding Source	Award
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[table of contents | back to top]