Morphometrics of black sea bass reared at contrasting pCO2 conditions in laboratory experiments conduced with embryos from adults collected in Long Island Sound in 2022

Website: https://www.bco-dmo.org/dataset/927800
Data Type: experimental, Other Field Results
Version: 1
Version Date: 2024-09-16

Project
» Collaborative research: Understanding the effects of acidification and hypoxia within and across generations in a coastal marine fish (HYPOA)
» Collaborative research: The genomic underpinnings of local adaptation despite gene flow along a coastal environmental cline (GenomAdapt)

Contributors	Affiliation	Role
Baumann, Hannes	University of Connecticut (UConn)	Principal Investigator
Zavell, Max D.	University of Connecticut (UConn)	Student
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
We experimentally examined early life CO2-sensitivities of northern stock black sea bass (Centropristis striata), an ecologically and economically important fish that seasonally migrates from offshore overwintering grounds to coastal feeding and nursery areas. We produced embryos from wild spawners and reared them until 10 days post hatch (dph) at three contrasting pCO2 levels (~400, ~2200, ~3000 µatm), finding no statistical effects of pCO2 on hatching success (~25%) or survival to 10 dph (~11%). At the extreme pCO2 level, surviving larvae were 1.2× larger and grew 55% faster compared to control pCO2 conditions. This dataset contains black sea bass morphometrics from these experiments.

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Coverage

Location: Laboratory study with embryos from adults collected in Long Island Sound; Northwest Atlantic shelf
Spatial Extent: **N**:41.3359 **E**:-71.9059 **S**:41.32361 **W**:-72.01861
Temporal Extent: 2022-05-20 - 2022-06-04

Dataset Description

See "Related Datasets" section for other data from these same laboratory experiments published in results paper Zavell et al. (2024).

Methods & Sampling

Spawning ripe black sea bass (BSB) were collected on May 20th, 2022 via hook and line angling in Long Island Sound off Stonington Borough, CT (41.3359°N, 71.9059°W) and brought to the University of Connecticut seawater laboratory on the Avery Point campus (Groton, CT) for future strip-spawning.

Experimental Design:

Our experiment assessed the CO_2 sensitivity of embryos and early life stages of BSB at a single static temperature (22°C) and three pCO_2 conditions (~400, ~2200, ~4200 µatm). On May 23rd, 2022, we strip-spawned wild, running-ripe BSB (($N_{female/male}$ = 4/3) to produce viable embryos. Upon water-hardening a 5 ml sample of eggs was randomly allocated to a replicate 19-l rearing container held within one of nine recirculating systems within the Baumann labs automated larval rearing system (ALFiRiS).

For this experiment, three ALFiRiS systems were assigned each pCO_2 treatment and received eight individual replicates. Replicate containers consisted of 750 ml plastic cups with 100 µm mesh bottoms, which were floated in larger 19-l containers. 19-l containers were fitted with four 150 µm mesh screens to allow for water transfer and each 750 ml rearing container received a gravity-fed flow of treatment water to maintain embryos in the water column (4-l $hour^{-1}$). For the ambient and elevated treatments each replicate ALFiRiS tank received eight 750 ml rearing containers, while two of the extreme treatments received eight rearing containers the other received 16. Actual pCO_2 values were measured by taking 300 ml filtered water samples from each tank every nine days for endpoint titrations. Tank temperature, pH, and total alkalinity values were used to calculate pCO_2 using CO2SYS (V2.3, Lewis and Wallace 2021; available at https://www.ncei.noaa.gov/access/ocean-carbon-acidification-data-system/oceans/CO2SYS/co2rprt.html). Throughout the experiment pH was recorded once an hour and temperature were recorded every five minutes. Additionally, ammonia (ppm) was measured once a week while salinity was measured every nine days (psu).

At 22°C hatching occurred approximately 48 hours post fertilization (hpf). Immediately, following hatch four of the eight (or eight of sixteen for one tank) replicates were euthanized with an overdose of MS-222 and immediately fixed in cold (2-4°C) paraformaldehyde (PFA) in phosphate buffered saline (PBS). The remaining replicates were reared until 10 dph, upon which they were euthanized and fixed as previously described. For the first two dph larvae were fed greenwater (RGComplete, Reed Mariculture, Campbell CA, USA) *ad libitum* 3× a day. Starting on 1 dph larvae were fed live L-type rotifers (Reed Mariculture, Campbell CA, USA) *ad libitum* 3× a day.

Response Traits
* See "Related Datasets" section for access to hatching, survival and growth data.

We estimated percent hatch at the number of hatched larvae at 0 days post hatch (dph) divided by the sum of hatched larvae and unhatched embryos × 100. Since replicate containers which were reared to 10 dph were not sampled at 0 dph to determine percent hatch, the number of embryos was estimated as the average number of embryos from the nine extra sample allocations which was then multiplied by the ALFiRiS system average hatching success to estimate total larvae at 0 dph. Subsequently, percent survival was the number of surviving larvae at 10 dph divided by the estimated number of larvae at 0 dph × 100.

At both 0 and 10 dph we individually photographed each larvae using calibrated images (Nikon SMZ1000, Image-Pro-Premier V.9.3.3) to measure individual for total length (TL; mm) and body depth (BD; mm). 10 dph larvae were also measured for notochord length (NL; mm), eye diameter (ED; mm), and mandible length (ML; mm).

Length growth rates (GR, mm d^{-1}) were calculated by dividing the difference between replicate TL means at 0 and 10 dph by 10.

Organism Identifier (LSID, Life Sciences Identifier)
Centropristis striata, urn:lsid:marinespecies.org:taxname:159348

BCO-DMO Processing Description

* Sheet "Dataset2 - morphometrics" of submitted file "BCO-DMO-Source-BSB-ELS-OA-V4-5-17-24.xlsx" was imported into the BCO-DMO data system for this dataset.

* dates that included year as 20222 corrected to be year 2022 (change confirmed to be correct by data submitter). Format changed to ISO 8601 date.
* CI rounded to three decimal places.
* Column names adjusted to conform to BCO-DMO naming conventions designed to support broad re-use by a variety of research tools and scripting languages. [Only numbers, letters, and underscores. Can not start with a number]

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Data Files

File
927800_v1_bsb_morphometrics.csv (Comma Separated Values (.csv), 111.18 KB) MD5:98b477a192474c47a2e5b64349e9eae6 Primary data file for dataset ID 927800, version 1

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Related Publications

Lewis, E., and Wallace, D. (2021) Program Developed for CO2 System Calculations. CO2SYS V2.3. Available from https://www.ncei.noaa.gov/access/ocean-carbon-acidification-data-system/oceans/CO2SYS/co2rprt.html
Software

Media Cybernetics (n.d.) Image-Pro Premier V.9.3.3 (Media Cybernetics, Rockville MD). Available from https://mediacy.com/image-pro/
Software

Zavell, M. D., & Baumann, H. (2024). Resiliency of black sea bass, Centropristis striata, early life stages to future high CO2 conditions. Environmental Biology of Fishes, 107(6), 677–691. https://doi.org/10.1007/s10641-024-01561-y
Results

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Related Datasets

IsRelatedTo

Baumann, H., Zavell, M. D. (2024) **Hatching success, survival and growth in northern stock black sea bass reared at contrasting pCO2 conditions in laboratory experiments conduced with embryos from adults collected in Long Island Sound in 2022.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-09-16 doi:10.26008/1912/bco-dmo.927786.1 [view at BCO-DMO]
Relationship Description: Data from the same experiments.

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Parameters

Parameter	Description	Units
Species	Centropristis striata (Black Sea Bass). LSID: urn:lsid:marinespecies.org:taxname:159348	unitless

Date_of_fertilization	Date of fertilization	unitless
Date	Sampling date	unitless
DPH	Day post hatch (0 or 10)	days
Tank	Tank identifying number (1 - 9)	unitless
Target_pCO2	Targeted pCO2 condition	microatmospheres (uatm)
pCO2	Mean measured pCO2 level throughout the experiment	microatmospheres (uatm)
pCO2_SD	Standard deviation from the mean pCO2 level	microatmospheres (uatm)
Actual_pH	Mean measured pH throughout the experiment	pH units
pH_SD	Standard deviation from the mean pH	pH units
Target_Temperature	Targeted temperature	degrees Celsius (degC)
Actual_Temperature	Mean measured temperature	degrees Celsius (degC)
Temperature_SD	Standard deviation from the mean temperature	degrees Celsius (degC)
Salinity	Measured mean salinity	Practical Salinity Units (PSU)
Salinity_SD	Standard deviation from the mean salinity	Practical Salinity Units (PSU)
Replicate_ID	Replicate identification for each tank. A represents the paired replicate at 0 dph and B at 10 dph. Note that tank 5 had 8 replicates, while the remaining tanks had 4 replicates	unitless
Fish_ID	A number identification for each individual within each replicate. Numbers reset for each replicate	unitless
TL	Larval total length (TL)	millimeters (mm)
BD	Larval body depth (BD)	millimeters (mm)

SL	10 dph larval standard length (SL)- note 10 dph measurements start on row 883	millimeters (mm)
ED	10 dph larval eye diameter (ED)- note 10 dph measurements start on row 883	millimeters (mm)
ML	10 dph larval mandible length (ML)- note 10 dph measurements start on row 883	millimeters (mm)
CI	Condition Index proxy which was calculated as (Body depth) / (Total length)	unitless

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Automated Larval Fish Rearing System
Dataset-specific Description	Automated Larval Fish Rearing System (ALFiRiS) – UConn Avery Point Rankin Lab – self-designed and assembled
Generic Instrument Description	The Automated Larval Fish Rearing System (ALFiRiS) was self-designed and assembled in the Rankin Lab at the University of Connecticut Avery Point. It consists of a 3 x 3 array of recirculating units (600 liters/150 gallons) that have independent computer-control over their temperature, oxygen, and pH conditions. The system was designed to sequentially monitor tank conditions via industrial-grade oxygen and pH sensors (Hach) and then control gas solenoids (air, N2, CO2) to maintain and modulate environmental conditions. The system can apply static as well as fluctuating conditions on diel and tidal scales. Computerized temperature control allows simulating heatwaves and other non-static thermal regimes. More information can be found at https://befel.marinesciences.uconn.edu/alfiris/

Dataset-specific Instrument Name	Infinity2-1R, 1.4 Megapixel USB 2.0 Microscopy Camera CCD (Teledyne Lumenera, Ottawa, Canada)
Generic Instrument Name	Camera
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	Nikon SMZ1000 Zoom Stereo Microscope (Nikon Instruments Inc., Melville, New York)
Generic Instrument Name	Microscope - Optical
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

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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

Collaborative research: The genomic underpinnings of local adaptation despite gene flow along a coastal environmental cline (GenomAdapt)

Website: https://befel.marinesciences.uconn.edu/2018/03/07/research-news-new-nsf-grant-to-study-silverside-genes/

Coverage: Eastern coastline of North America

NSF Abstract:

Oceans are large, open habitats, and it was previously believed that their lack of obvious barriers to dispersal would result in extensive mixing, preventing organisms from adapting genetically to particular habitats. It has recently become clear, however, that many marine species are subdivided into multiple populations that have evolved to thrive best under contrasting local environmental conditions. Nevertheless, we still know very little about the genomic mechanisms that enable divergent adaptations in the face of ongoing intermixing. This project focuses on the Atlantic silverside (Menidia menidia), a small estuarine fish that exhibits a remarkable degree of local adaptation in growth rates and a suite of other traits tightly associated with a climatic gradient across latitudes. Decades of prior lab and field studies have made Atlantic silverside one of the marine species for which we have the best understanding of evolutionary tradeoffs among traits and drivers of selection causing adaptive divergence. Yet, the underlying genomic basis is so far completely unknown. The investigators will integrate whole genome sequencing data from wild fish sampled across the distribution range with breeding experiments in the laboratory to decipher these genomic underpinnings. This will provide one of the most comprehensive assessments of the genomic basis for local adaptation in the oceans to date, thereby generating insights that are urgently needed for better predictions about how species can respond to rapid environmental change. The project will provide interdisciplinary training for a postdoc as well as two graduate and several undergraduate students from underrepresented minorities. The findings will also be leveraged to develop engaging teaching and outreach materials (e.g. a video documentary and popular science articles) to promote a better understanding of ecology, evolution, and local adaptation among science students and the general public.

The goal of the project is to characterize the genomic basis and architecture underlying local adaptation in M. menidia and examine how the adaptive divergence is shaped by varying levels of gene flow and maintained over ecological time scales. The project is organized into four interconnected components. Part 1 examines fine-scale spatial patterns of genomic differentiation along the adaptive cline to a) characterize the connectivity landscape, b) identify genomic regions under divergent selection, and c) deduce potential drivers and targets of selection by examining how allele frequencies vary in relation to environmental factors and biogeographic features. Part 2 maps key locally adapted traits to the genome to dissect their underlying genomic basis. Part 3 integrates patterns of variation in the wild (part 1) and the mapping of traits under controlled conditions (part 2) to a) examine how genomic architectures underlying local adaptation vary across gene flow regimes and b) elucidating the potential role of chromosomal rearrangements and other tight linkage among adaptive alleles in facilitating adaptation. Finally, part 4 examines dispersal - selection dynamics over seasonal time scales to a) infer how selection against migrants and their offspring maintains local adaptation despite homogenizing connectivity and b) validate candidate loci for local adaptation. Varying levels of gene flow across the species range create a natural experiment for testing general predictions about the genomic mechanisms that enable adaptive divergence in the face of gene flow. The findings will therefore have broad implications and will significantly advance our understanding of the role genomic architecture plays in modifying the gene flow - selection balance within coastal environments.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using

the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1536336
NSF Division of Ocean Sciences (NSF OCE)	OCE-1756751
Connecticut Sea Grant (CTSG)	R/LR-30

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