Temperature-dependence of juvenile Black sea bass growth and lipid accumulation determined through lab experiments conducted from September 2021 to February 2022 at UConn Avery Point

Website: https://www.bco-dmo.org/dataset/898012
Data Type: experimental
Version: 1
Version Date: 2023-07-18

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
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Abstract
The northern stock of Black sea bass (BSB, Centropristis striata) has greatly expanded over the past decade, potentially due to warming Northwest Atlantic shelf waters affecting overwintering especially in juveniles. To gather better empirical data we quantified winter growth and lipid accumulation in BSB juveniles from Long Island Sound using two complementing experiments. The data from Experiment 2 are presented here. The data from Experiment 1 are presented in a related dataset (https://www.bco-dmo.org/dataset/897895). Experiment 2 measured the same traits as Experiment 1 but exposed juveniles to a simulated thermal overwinter profile (October - March) with seasonally varying food rations. Monthly individual length growth (GR) and weight-specific growth (SGR) responded in the direction of seasonal food level changes, showing reduced growth in December-February in a 'Winter dip' treatment, but compensatory growth in a 'Winter pulse' treatment. A 6-month consumption average of 1.7% feeding-1 ('Winter pulse') elicited a mean GR of 0.15 millimeters per day (mm d-1) and SGR of 0.55% d-1, whereas juveniles consuming on average 3.8% per feeding ('Winter dip') had significantly faster GR (0.20 mm d-1) and SGR (0.71% d-1). Growth efficiencies ranged between 15-30% and were inversely related to food consumption. In both experiments, juveniles disproportionally accumulated lipid over lean mass, with lipid proportions tripling in Exp2 from 4% at 65 mm to 12% at 120 mm.

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Coverage

Spatial Extent: **Lat**:41.3236 **Lon**:-72.0019
Temporal Extent: 2021-09-03 - 2022-04-01

Methods & Sampling

Juvenile Black sea bass (BSB) were caught on September 3rd (collection 1) and 21st 2021 (collection 2) via beach seine (30 × 2 meters) in Mumford Cove (41° 19' 25"N, 72° 01 '07"W), a shallow protected bay with extensive eelgrass cover in eastern Long Island Sound, USA.

Experiment 2 quantified juvenile winter growth and lipid accumulation under seasonally varying food and temperature conditions over the course of 182 days (October 1, 2021 to April 1, 2022). Initial total length (TL, mean ± SD = 70.9 ± 5.4 millimeters (mm)) and wet weight (wW, mean ± SD = 4.4 ± 0.9 grams (g)) were determined on briefly anesthetized specimens, followed by randomly distributing 48 juveniles into individual 20-liter (L) rearing containers with mesh-screened holes, an air stone, and a PVC hide. An additional baseline sample (n = 25, mean ± SD TL = 71.4 ± 9.4 mm, wW = 4.7 ± 1.8g) was euthanized and stored at -20° Celsius (C). We then used six 700 L recirculating tanks to each house eight individual BSB rearing containers (mean maximum stocking density = 0.13 kilograms per cubic meter (kg m^{-3}). Tanks (n = 2 tanks per treatment; n = 8 containers per tank) were randomly assigned to one of three seasonally varying food treatments (Otohime C1 pellets) designed to simulate three phases of contrasting overwinter food availability for BSB juveniles. The 'Winter dip' treatment was fed 5% body wW 3× weekly during Phase 1 ("Fall": October, November), 2% wW 3× weekly during Phase 2 ("Winter": December – February) and again 5% body wW 3× weekly during Phase 3 ("Spring": March). This was to simulate a scenario of good onshore feeding conditions for juveniles in fall and spring, but poorer feeding conditions at their offshore overwintering habitats. Conversely, our 'Winter pulse' treatment was to simulate poor fall and spring feeding conditions for juveniles onshore by feeding 1% wW 3× weekly during Phase 1 and 3, but 2% wW during Phase 2, thereby simulating the same offshore winter feeding conditions (Fig.2A of Zavell et al. (in review)). Last, we included a 'Constant' treatment as control, which fed 2% wW 3× weekly throughout the entire six months of rearing (Phases 1-3). Food rations were based on both Cotton (2002), who showed no difference in growth at rations of 5 - 7.5% wW, but reduced growth at 2.5% wW and Watanabe et al. (2021) who report ideal feeding rates between 3 – 5% wW. For all treatments, rations were individually recalculated after the 1^{st} of each month, based on re-measured wW and TL on briefly anesthetized fish.

Temperature conditions in Exp2 were recorded in 30 minute intervals using HOBO temperature loggers (Onset MX®).

Response traits. Initial, monthly (Exp2 only), and final measurements of individual fish (TL, wW) were used to calculate total (final – initial), cumulative (end of month – initial), and/or serial (end of month – start of month) growth (e.g., cumulative and serial DTL for month 2 = TL_{d61} – TL_{d0} and TL_{d61} – TL_{d31}), respectively) and average daily growth rates (growth/days in growth interval). Specific growth rates (SGR; % wW per day) were calculated similarly but used ln(wW) at each time period (e.g., $100*[\ln(wW_{d61})-\ln(wW_{d31})]$). Growth efficiency (GE, %) was calculated cumulatively (Exp1, Exp2) and monthly (Exp2 only) as the change in body dry weight (DdW_b, g) divided by total food consumed (DF, g) during a given time interval. (In Exp2, three GE values > 100% were excluded as outliers). Q_{10} values (Exp1) were calculated for GR, SGR, and GE between 6-12°C and 12-19°C.

For each experiment, we also determined the lipid, lean, and ash dry weights of each surviving BSB juvenile and those of the baseline samples. Whole specimens were first transferred to -80°C for one week, then freeze-dried at -50°C for one week and re-measured for whole body dry weight (dW_b, 0.001 g). Dried specimens were then loaded into pre-weighed Alundum medium-porosity extraction thimbles and transferred into a custom-designed Soxhlet apparatus, where they were bathed in petroleum ether for a total of 3.5 hours to extract all metabolically accessible lipids (15-minute cycles of bathing, flushing, and ether replacement). After extraction, thimbles were dried overnight at 60°C and re-weighed to determine DdW, which equaled the total lipid content (dW_{Lipid}, milligrams (mg)) of each specimen after accounting for any tissue loss during transfer from vial into thimble. Thimbles were then placed in a muffle furnace for 4 hours at 550°C and re-weighed, with DdW during this second step corresponding to a fish's lean mass (dW_{Lean}, mg), again after accounting for any tissue loss during transfer from vial into thimble. The difference between the final weight and the pre-weighed empty thimble equaled ash (dW_{Ash}, mg), i.e., the inorganic fraction of each individual.

Data Processing Description

BCO-DMO Processing:

- Imported original file named "BCO-DMO-Source-BSB-Juvenile-Overwintering-V2.xlsx" sheet 3 into the BCO-

DMO data system;
- renamed fields to comply with BCO-DMO naming conventions (replaced spaces with underscores);
- converted dates to YYYY-MM-DD format;
- added columns for latitude and longitude in decimal degrees;
- rounded values to 3 decimal places;
- named the final file "898012_v1_bsb_experiment2.csv".

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Data Files

File
898012_v1_bsb_experiment2.csv (Comma Separated Values (.csv), 69.14 KB) MD5:0781d9e43cf76b303609fffff7ab48e1 Primary data file for dataset ID 898012, version 1.

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Related Publications

Cotton. (2002). Optimizing growth for aquaculture of juvenile black sea bass Centropristis striata L.: effects of temperature, salinity, commercial diet and feeding ration [University of Georgia]. http://getd.libs.uga.edu/pdfs/cotton_charles_f_200208_ms.pdf
Methods

Watanabe, W. O., Carroll, P. M., Alam, M. S., Dumas, C. F., Gabel, J. E., Davis, T. M., & Bentley, C. D. (2021). The status of black sea bass, Centropristis striata, as a commercially ready species for U.S. marine aquaculture. Journal of the World Aquaculture Society, 52(3), 541–565. Portico. https://doi.org/10.1111/jwas.12803
Methods

Zavell, M.D., Mouland, M.E.P., Matassa, C.M., Schultz, E.T., and Baumann, H. (in review) Temperature- and ration-dependent winter growth in Northern stock Black Sea Bass juveniles. Transactions of the American Fisheries Society.
Results

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Related Datasets

IsRelatedTo

Zavell, M. D., Baumann, H. (2023) **Winter growth and lipid accumulation in juvenile Black sea bass exposed to varying food and temperature conditions during lab experiments conducted from September 2021 to April 2022 at UConn Avery Point.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-07-18 doi:10.26008/1912/bco-dmo.897895.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Site	Site name; Mumford Cove, CT - all fish	unitless

Longitude	Longitude of collection site in decimal degrees (negative values = West)	decimal degrees
Latitude	Latitude of collection site in decimal degrees (positive values = North)	decimal degrees
Date_col	Date of juvenile collection in the wild	unitless
Species	Name of species (Black Sea Bass - Centropristis striata)	unitless
Tank	Experiment Tank (A - F), G represents Baseline Samples	unitless
BSB_ID	ID of each BSB individual	unitless
Group	Experiment 2 OR Baseline (sacrificed at the beginning of the experiment)	unitless
Treat	Seasonally varying food treatment, either 'Winter dip', 'Winter pulse', or 'Constant' | 'Baseline' denotes fish sampled at the beginning of the experiment (10/1/21; n=25) for initial lipid analyses. They were NOT reared and therefore have EMPTY fields for experimental parameters	unitless
Food	Mean realized food ration per feeding, based on offered food, consumed food per week, averaged over whole experiment, values of 3.8% feeding-1 ('Winter dip'), 1.7% feeding-1 ('Winter pulse'), and 2.2% feeding-1 ('Constant')	percent (%) wW per feeding
Date_sam	Date of repeated length and weight measurments	unitless
Exp_Phase	Phase i - iii of the experiment. Phase i was 'Fall' (Oct,Nov), Phase 'ii' was 'Winter' (Dec,Jan,Feb), Phase 'iii' was ''Spring (Mar)	unitless
Month	Month of length and weight measurements	unitless
TP	Time Point (values of 1 - 6)	unitless
TL	Total length at the end of the month	millimeters (mm)
TL0	Total length at experiment start	millimeters (mm)
DTL	Change in TL from experiment start	millimeters (mm)
wW	Wet Weight at the end of the month	grams (g)
wW0	Wet Weight at experiment start	grams (g)

DwW	Change in wet Weight at experiment start	grams (g)
dW_est	Dry weight (estimated from post-mortem wet/dry weight relationship)	grams (g)
dW0	Dry weight at experiment start	grams (g)
DdW	Change in dry weight from experiment start	grams (g)
GR_TP	Growth in TL during month	millimeters (mm)
GR_wW	Growth wW during month	grams (g)
GR_dW	Growth in dW during month	grams (g)
Time	Days of the month	Days
GRTL	Growth in TL per day	millimeters per day (mm d-1)
SGRwW	Weight-specific growth per day	percent (%) wW per day
SGRdW	Dry weight-specific growth per day	percent (%) dW per day
Temp	Mean monthly temperature	Degrees Celsius °C
TempSD	Standard deviation of mean monthly temperature	Degrees Celsius °C
DD	Degree days this month	degree-days (°C × days)
Consum	Food consumed this month	grams (g)
GE	Gross growth efficiency (dryweight-based)	percent (%)
dW_final	Dry weight measured after freeze-drying the specimen post-experiment	milligrams (mg)
TL_final	Final total length at the end of the experiment	millimeters (mm)
Lipid	Lipid content of the specimen	milligrams (mg)

Lean	Muscle/lean = protein content of the specimen	milligrams (mg)
Ash	Inorganic = ash content of the specimen	milligrams (mg)
Prop_Lipid	Lipid / dW_final	percent (%)
Prop_Lean	Lean / dW_final	percent (%)
Prop_Ash	Ash / dW_final	percent (%)

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Instruments

Dataset-specific Instrument Name	Automated Larval Fish Rearing System (ALFiRiS)
Generic Instrument Name	Automated Larval Fish Rearing System
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	Custom-designed Soxhlet apparatus for Lipid/Lean analyses
Generic Instrument Name	Soxhlet extractor
Generic Instrument Description	A Soxhlet extractor is a piece of laboratory apparatus designed for the extraction of a lipid from a solid material. The solid is placed in a filter paper thimble which is then placed into the main chamber of the Soxhlet extractor. The solvent (heated to reflux) travels into the main chamber and the partially soluble components are slowly transferred to the solvent.

Dataset-specific Instrument Name	HOBO temperature loggers (Onset)
Generic Instrument Name	Temperature Logger
Generic Instrument Description	Records temperature data over a period of time.

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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

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1536336

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