Otolith microstructure of young-of-year Atlantic silversides (Menidia menidia) from Mumford Cove during 2015

Website: https://www.bco-dmo.org/dataset/782247
Data Type: Other Field Results
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
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Abstract
Back-calculated age, hatch date, length-at-age, growth rate, and experienced temperature of young-of-year Atlantic silversides (Menidia menidia) collected during 3 successive collections in Mumford Cove, CT in fall 2015.

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Coverage

Spatial Extent: **Lat**:41.32 **Lon**:-72.02
Temporal Extent: 2015-05-28 - 2015-12-18

Dataset Description

Back-calculated age, hatch date, length-at-age, growth rate, and experienced temperature of young-of-year Atlantic silversides (Menidia menidia) collected during 3 successive collections in Mumford Cove, CT in fall 2015.

Methods & Sampling

Young-of-year (YoY) Atlantic silversides were collected from Mumford Cove (41.32N, 72.02W), a small, salt-marsh dominated embayment in eastern Long Island Sound (Connecticut USA, 0.5 km², 1-3 m depth). From a biweekly beach seine survey (30×2m seine with 3mm mesh), three samples on 23 October, 20 November, and 18 December 2015 were used. On each date, samples were pooled from two independent seine casts. All silversides were euthanized, enumerated, measured for total length (TL) to the lower 5 mm and preserved frozen (-20°C). From each collection, ~100 individuals were selected for otolith microstructure analysis using a TL-stratified random sampling design. For each individual, we again measured TL (nearest 0.1 mm) and determined its sex via visual inspection of gonads, before extracting both sagittal otoliths. Sagittae were mounted on microscope slides using CrystalBond 509 thermoplastic cement. If equally suitable, the left or right sagitta was randomly chosen for analysis. Otoliths were hand-polished using 9 µm then 3 µm lapping films (3M) until daily increments along the entire reading axis were clearly visible under 400x magnification (Nikon Eclipse E400 compound microscope). Otoliths were measured and read across the sagittal plane from the nucleus to the dorsal or ventral otolith edge, because the more conventional core to post-rostrum axis proved to be too curved to be reliably interpretable. Increments were enumerated and measured using Image Pro Premier (V9.1) connected to a Luminera Infinity2-2 digital camera. For each otolith section, multiple focal planes were captured and merged into multi-layer images to aid the reader interpreting the otolith microstructure. The radius of the hatch-check (µm) was measured. The last growth increment was presumed to be incomplete and thus excluded from growth analyses. Increment number was assumed to correspond to an individuals' age in days post hatch (dph). Hatch date was calculated by subtracting age from the date of collection, while the formation date of each increment was calculated by adding the increment number to the hatch date.

To estimate the thermal history of October YoY we used continuous temperature data recorded by a Manta Sub2 probe (Eureka© Water Probes) at our study site. Three small gaps in the record (<8 days) were linearly interpolated. Daily temperatures during a larger data gap (34 days, 18 June - 22 July) were estimated via linear regression between the Mumford Cove dataset and temperatures in nearby Niantic Bay (2015-2016) that were strongly correlated ($T_{Mumford} = 1.07 * T_{Niantic} – 0.54$ $r^2 = 0.92$, $F = 6024.9$, $p < 0.001$). Average daily temperatures were then linked to the corresponding day of increment formation for each individual. To quantify the thermal dependency of larval growth in October YoY, we calculated the mean experienced temperature during the first 30 dph for each individual and correlated it to its mean daily growth rate over the first 30dph (GR30) and its back-calculated TL at day 30 post hatch (TL30, a proxy for the end of the larval stage).

Data Processing Description

Data Processing:
The proportion of females (Nfem/Nfem+male) per 10 mm TL class in the otolith sample was used to derive sex-specific TL distributions of the population sample (beach seine), assuming sexes being randomly sampled within each TL class. Similarly, otolith-derived hatch distributions were scaled to population by applying a scale factor (SF) to each individual based on the relative frequencies (RF) of each 10 mm TL class in the population vs. otolith sample for each collection (SF = RFpopulation/RFotolith).

Only for YoY survivors from October, individuals were grouped into each of four bi-weekly hatch intervals that were chosen based on sample size and the known semi-lunar spawning periodicity of silversides. TL-at-age was back-calculated for each individual over the entire increment record (99-148dph) with the biological intercept method and an assumed length at hatch of 5 mm.

Problem Report:
As detailed in the corresponding publication, a central objective was to determine whether ages in older young-of-year Atlantic silversides could be reliably determined. Because this was found to be the case only for individuals sampled during October, but not during subsequent collections in November and December, back-calculated ages, hatch dates, length-at-age, or growth rates are only given for individuals collected in October.

BCO-DMO Processing:
- formatted all dates to yyyy-mm-dd;
- modified parameter names (replaced spaces w/ underscores; removed parens & units);
- filled in blanks with "nd" ("no data").

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Data Files

File
otolith_microstructure.csv (Comma Separated Values (.csv), 2.34 MB) MD5:2ed9ceffd3c8dfaba68087f9c6cd624d Primary data file for dataset ID 782247

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Related Publications

Pringle, J., & Baumann, H. (2019). Otolith-based growth reconstructions in young-of-year Atlantic silversides (Menidia menidia) and their implications for sex-selective survival. Marine Ecology Progress Series. doi:10.3354/meps13174
Results

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Parameters

Parameter	Description	Units
Species	Study species, Atlantic silverside young-of-year 2015, Menidia menidia	unitless
Collection_Date	Sampling date 2015: 23 October, 20 November, 18 December. Format: yyyy-mm-dd	unitless
Individual_number	Running number of analyzed specimens	unitless
Total_length	Total length of specimen	centimeters (cm)
Total_length_class	1 cm total length class of analyzed specimen	centimeters (cm)
Total_length_group	Separating the bimodal total length distribution in small (1) versus large (2) young-of-year silverside specimens - October/November collections 1:	unitless
Sex	Sex of analyzed specimen; 0 = female, 1 = male	unitless
Age	Age of specimen (October collection only)	days post hatch
Hatch_Date	Back-calculated date of hatch (October collection only). Format: yyyy-mm-dd	unitless
Biweekly_hatch_interval	14 day interval of back-calculated hatch day from 1 (earliest) to 4 (latest) - October collection only - see methods of corresponding publication for actual dates.	unitless
Hatch_check_radius	Distance between the otolith core and the hatch check, i.e., the beginning of daily increment formation	micrometer (um)
Otolith_size	Cumulative width of the hatch check radius and all measured increments	micrometer (um)
Hatch_check_flag	Quality flag of the clarity of the hatch check from 1 (best) to 4 (worst)	unitless
Otolith_flag	Quality flag of otolith microstructure interpretability from 1 (best) to 4 (worst)	unitless
Scaling_factor	Scaling factor representing the proportion of specimens per 1cm Total length class in the otolith sample relative to the population sample in the beach seine collection, please see methods in corresponding publication for details	unitless
Increment_formation_date	Date in 2015 when the corresponding otolith increment was formed. Format: yyyy-mm-dd	unitless
Temperature	Average water temperature in Mumford Cove on the corresponding date of increment formation, obtained from monitoring probe	degrees Celsius
Increment	Running number of increment from hatch to the edge of the otolith (October collection only) or the first 60 days post hatch (November and December collections)	Number
Increment_width	Width of increment formed at given age/date post hatch	micrometer (um)
Length_at_age	Back-calculated total length at age (days post hatch) - October collection only	millimeter (mm)
Growth_rate	Back-calculated growth rate on the day of increment formation - October collection only	millimeter per day (mm/d)

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Instruments

Dataset-specific Instrument Name	Luminera® Infinity2-2 digital camera
Generic Instrument Name	Camera
Dataset-specific Description	Luminera® Infinity2-2 digital camera, Image Pro® Premier (V9.1)
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	Nikon Eclipse E400 compound microscope
Generic Instrument Name	Microscope - Optical
Dataset-specific Description	Nikon Eclipse E400 compound microscope, 400x magnification
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".

Dataset-specific Instrument Name	Eureka Manta Sub2 monitoring probe
Generic Instrument Name	Water Quality Multiprobe
Dataset-specific Description	Eureka Manta Sub2 monitoring probe, deployed 0.5m above bottom in Mumford Cove, CT
Generic Instrument Description	An instrument which measures multiple water quality parameters based on the sensor configuration.

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Deployments

Mumford_Cove_Subsurface_Buoy

Website	https://www.bco-dmo.org/deployment/659887
Platform	Avery_Point
Start Date	2015-04-04
Description	Local subsurface buoy in Mumford Cove, CT, a shallow, coastal embayment in outer Long Island Sound, US Atlantic coast.

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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-1536165

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