Results from experiment examining the effects of low pH and low oxygen on life-history traits of three estuarine fish species: Temporal CO2-sensitivity; conducted at Southampton Marine Station from 2011-2015

Website: https://www.bco-dmo.org/dataset/551151
Version: 18 Feb 2015
Version Date: 2015-02-08

Project
» Will rising pCO2 levels in the ocean affect growth and survival of marine fish early life stages? (OA Fish)

Contributors	Affiliation	Role
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Gobler, Christopher	Stony Brook University - SoMAS (SUNY-SB SoMAS)	Co-Principal Investigator
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Dataset Description

This study quantified the separate and combined effects of low pH and low oxygen on 4 vital early life-history traits (time- to-hatch, hatching success, post-hatch survival, and growth) of 3 ecologically important estuarine fish species (*Menidia beryllina, Menidia menidia*, and *Cyprinodon variegatus*).

Offspring were exposed from the egg through the early larval stages to ideal (pHT [pH total scale] = 7.9, DO [dissolved oxygen] = 9.0 mg per L), hypoxic (DO = 1.6−2.5 mg per L), acidified (pHT = 7.4), and hypoxic + acidified (pHT = 7.4, DO = 1.6−2.5 mg per L) conditions. Hypoxia alone significantly delayed hatching of embryos by 1 to 3 days and reduced hatching success of all 3 species by 24 to 80%. Acidification alone significantly depressed the survival of *M. beryllina*. Acidification and hypoxia had an additive negative effect on survival of *M. beryllina*, a seasonal, synergistic negative effect on survival of *M. menidia*, and no effect on survival of *C. variegatus*. Acidification and hypoxia had an additive negative effect on length of larval *M. beryllina*, while hypoxia alone significantly reduced length of *M. menidia* and *C. variegatus* from 15 to 45%. The study's findings suggest a greater sensitivity of early life estuarine fish to low oxygen compared to low pH conditions, while also demonstrating that the co-occurrence of both stressors can yield both additive and synergistic negative effects on survival and other fitness-related traits.

This dataset provides the source data to:
Depasquale, Elizabeth; Baumann, Hannes, and Gobler, Christopher. 2015. Vulnerability of early life stage Northwest Atlantic forage fish to ocean acidification and low oxygen. Marine Ecology Progress Series in press, doi: 10.3354/meps11142

Methods & Sampling

Refer to the Methods section of:
Depasquale, Elizabeth; Baumann, Hannes, and Gobler, Christopher. 2015. Vulnerability of early life stage Northwest Atlantic forage fish to ocean acidification and low oxygen. Marine Ecology Progress Series in press, doi: 10.3354/meps11142

Data Processing Description

BCO-DMO Processing:
- Replaced spaces with underscores in species column.
- Replaced blanks with 'nd' to indicate 'no data'.
- Modified parameter names to conform with BCO-DMO naming conventions.

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Data Files

File
temporal_CO2_sens.csv (Comma Separated Values (.csv), 6.33 KB) MD5:c29511be499a6e4a8c2ec611a8ad8c8d Primary data file for dataset ID 551151

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Parameters

Parameter	Description	Units
species	Name of the fish species; 3 species were tested.	unitless
exp	Experiment number (1 or 2). There were two experiments per species (except *C. variegatus* which had only 1).	unitless
date_start	Denotes when the experiment was started; in mm/dd/yyyy format	unitless
treatment_ID	Numerical treatment ID. Numbers 1 through 5.	unitless
treatment	Treatement type (control, acidified, hypoxic, hypoxic2, hypoxic-acidified, hypoxic-acidified2). All combinations of control, acidified, and hypoxic. The 2nd *M. beryllina* experiment used different (higher) oxygen levels for the hypoxic treatement, hence 'hypoxic2'.	unitless
replicate	Replicate number. There were generally 4 replicates per treatment.	unitless
DO_avg	Average dissolved oxygen levels within each treatment throughout the experiment.	milligrams per Liter (mg/L)
pH_avg	Average pH (NIST) levels within each treatment throughout the experiment.	pH (NIST) units
survivors	Total number of survivors at the end of the experiment.	number (n)
survival_tot	Total survival (multiply by 100 to obtain % survival).	fraction of 1
survival_post_hatch	Post-hatch survival (multiply by 100 to obtain % survival).	fraction of 1
hatching_success	Pre-hatch survival (multiply by 100 to obtain % survival).	fraction of 1
time_to_first_hatch	Days until the first larva hatched.	days
SL_avg	Average standard length of all larvae at the end of the experiment.	millimeters (mm)

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Deployments

lab_Baumann_Gobler_SMS

Website	https://www.bco-dmo.org/deployment/551848
Platform	Southampton Marine Station
Start Date	2011-09-01
End Date	2015-02-01

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Project Information

Will rising pCO2 levels in the ocean affect growth and survival of marine fish early life stages? (OA Fish)

Coverage: Long Island Sound, Shinnecock Bay, Long Island, NY

Description from NSF award abstract:
Ocean acidification has the potential to affect a broad spectrum of marine organisms and thereby transform the composition and function of our oceans. In contrast to calcifying marine invertebrates, marine fish are widely believed to be unaffected by the CO2 concentrations projected for the future. While this may be so for juvenile and adult fish stages, the fate of fish embryos and larvae in high CO2 oceans is less certain as CO2-sensitivity data for these stages are largely unavailable. Recognizing this knowledge gap and inspired by the findings of two recent studies on clownfish and sea bass larvae (Munday et al. PNAS 107 (2010); Checkley et al. Science 324 (2009)), the investigators performed a series of experiments exposing eggs and early larvae of inland silversides (*Menidia beryllina*) to elevated CO2 levels while strictly adhering to current "best practice" guidelines for ocean acidification research. At 1,000 ppm CO2, average *M. beryllina* survival ~1wk post-hatch significantly and consistently (five experiments) declined by ~75% compared to current day CO2 levels (390 ppm), while average length of newly hatched larvae decreased by 22%. Together with prior studies, these results suggest a surprisingly high susceptibility of fish early life stages to the CO2 increases that are projected to occur this century. Given that the abundance of many fish stocks, including most commercial species, is often regulated by processes affecting early life history growth and survival, ocean acidification may impact the dynamics of future fish populations and become yet another challenge to sustainable fisheries.

The investigators believe that there is now a pressing need to better understand how CO2 affects the viability of fish embryos and larvae in the ocean. This requires novel approaches involving longer-term, larger-scale experiments across multiple species. The investigators will comprehensively examine the impacts of current and future CO2 levels (400 - 1,000 ppm) during the egg and larval stages of three model fish species: Atlantic silversides (*M. menidia*), inland silversides (*M. beryllina*) and sheepshead minnows (*Cyprinodon variegatus*). They will also investigate populations of the same species (*M. menidia*) from differing latitudes. These species/populations are ecologically important due to their intermediate trophic position, have comparable life histories to commercial marine fish, offer differences in genetic growth capacity and presumed sensitivity, and are highly amenable to laboratory experimentation. Survival and growth (weight- and length-based) will be measured in experiments performed at different CO2, temperature (21, 27°C) and feeding conditions (low, ad libitum), thus permitting the affects of CO2 to be considered in parallel with thermal stress and food limitation. Quantification of feeding rates, gross growth efficiency, and oxygen consumption will characterize the physiological costs of high CO2 environments. Changes in calcification of larval fish otoliths and skeletal elements will be determined from weights and a Ca45 radiotracer approach. Finally, surviving *M. menidia* (or *M. beryllina*) will be reared to maturity and their offspring will be challenged with differing levels of CO2. Repeating this approach over several generations will demonstrate the extent to which CO2 resistance may evolve through natural selection. Collectively, this study will make significant advances toward understanding how ocean acidification may challenge the world's most valuable marine resource, fish.

Note that PI Hannes Baumann has since moved to the University of Connecticut. See his current contact information.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1129622

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