Elemental ratio data from LA ICP-MS analysis of oyster larvae exposed to various temperature, salinity, and elemental concentration treatments conducted in December of 2013 (EstuarineMetaDyn project)

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Data Type: experimental
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Project
» Interacting Effects of Local Demography and Larval Connectivity on Estuarine Metapopulation Dynamics (EstuarineMetaDyn)

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Dataset Description

This dataset contains elemental ratio data from LA ICP-MS analysis of oyster larvae exposed to various temperature, salinity, and elemental concentration treatments.

Methods & Sampling

Sampling and Analytical Methodology:

To investigate environmental effects on larval (prodissoconch) shell signatures, we manipulated temperature, salinity, and elemental concentration of the water surrounding developing oyster larvae. Individual tanks were set up with the following treatments: low (21°C) or high (26.5°C) temperature; low (12.5 ppt) or high (20 ppt) salinity; and ambient (no addition), mid spike (+16 ppb Mn/0.16 ppb Pb addition), or elevated spike (+32 ppb Mn/0.32 ppb Pb) in concentrations of aqueous Mn and Pb. Temperature and salinity treatments were selected based on representative high and low observations in Pamlico Sound at the time of the experiment (mid-September). Trace metal spikes were calculated to increase the ambient levels of Mn and Pb in seawater, as measured by Becker et al. (2005), by 400% and 800% for mid and elevated spike levels, respectively.

Three-day old *C. virginica* larvae were obtained from the University of Maryland's Horn Point Laboratory in Cambridge, Maryland, USA. Upon arrival at the Institute of Marine sciences (IMS) in Morehead City, NC, larvae were divided equally into 2, 1.2 L aerated holding tanks filled with a 12.5 ppt seawater mix (ultrapure H_2O added to filtered seawater from Bogue Sound, NC). Over the next 4 days, larvae were acclimatized, with one tank receiving a salinity increase of approximately 2 ppt per day, resulting in a final salinity of 20 ppt, while the

other tank remained at 12.5 ppt.

After the acclimatization process was complete, larvae from both holding tanks, now 7 days old, were divided equally into 72 “larval homes”, with approximately 1.6 x 10^4 larvae per home (21.2 larvae cm^{-3}). Larval homes were constructed from hollow PVC tubing capped on each side with nitex cloth, with a 30 µm mesh opening, to allow for the flow of water and food into the home, but prevent larvae from escaping. Homes were then placed into 24 aerated aquarium tanks (35 L), with 3 homes per tank. All tubing, PVC, air stones, and nitex were soaked in a HNO_3 solution and then rinsed thoroughly with ultrapure H_2O prior to its use in the experiment.

Temperatures were maintained at either high or low level by 150 W Aquatop aquarium heaters and salinity levels were established by mixing filtered seawater with ultrapure H_2O until desired salinity was reached. Mn and Pb concentrations were spiked by the addition of 545 µl of Mn + 5.45 µl of Pb and 1090 µl of Mn + 10.90 µl of Pb, from1000 ppt Fisher Scientific reference standard solutions, for mid and elevated spike treatments, respectively. Water changes were conducted every other day by removing one-third (~12 L) of water from the tank and replacing it with a freshly made mix. Tanks with mid or elevated spike treatments were then re-spiked to maintain consistent trace element concentrations. Immediately following water changes, larvae were fed by depositing dilute Instant Algae Shellfish Diet 1800 (Reed Mariculture; Campbell, California, USA) into larval homes via syringe. Each treatment group was crossed, to produce a full factorial design with 12 total treatment combinations. The experiment ran for 7 days, until the larvae were 14 days old.

Dissolved oxygen, temperature and salinity were monitored daily with a HACH HQ40d dual input, multi-parameter portable water quality meter. Dissolved oxygen, pH, salinity and temperature measures remained consistent among the treatments throughout our laboratory experiments. Mean dissolved oxygen and pH were 8.68 ± 0.025 mg L^{-1} and 7.72 ± 0.032, respectively. Mean salinity for high and low salinity treatments were 20.7 ±0.091 ppt and 12.8± 0.120 ppt, respectively. Mean temperature for high temperature treatments was 25.7 ± 0.157 °C and 21.3 ±0.104 °C for low temperature treatments.

At the conclusion of these mesocosm incubations, larvae from each home were filtered using nitex cloth (30 µm) and then resuspended in 15 mL of water from their respective tank. A 0.5-1 mL subsample of each larval resuspension was removed and the number of whole larvae were counted. The remaining larval solution was then frozen at -23°C until sample preparation for geochemical analysis.

Frozen larvae were thawed and approximately 1000 larvae were obtained representing each replicate home. The larvae were then rinsed with ultrapure H_2O and mounted as a concentrated mass on a labeled glass microscope side covered in double-sided tape. This process continued until the contents of each larval home was mounted on a slide in haphazard order (total N=72). The slides were left to dry overnight in a laminar flow hood and then stored under the hood until analysis.

Samples were analyzed using a Thermo-Fisher Element2 inductively coupled plasma mass spectrometer with a Teledyne ATLex 300si-x 193nm Excimer laser ablation unit (LA ICP-MS). To correct for mass bias and instrument drift, National Institute of Technology Standards-certified standards (Reference Material 612, 614, and 616) were run at the beginning and end of every 4 slide sequence (~140 burns). Concentrations of the following elements were quantified from laboratory larval samples: ^{48}Ca, ^{55}Mn, ^{88}Sr, ^{138}Ba, and ^{208}Pb; and from field-collected spat: ^{26}Mg, ^{48}Ca, ^{55}Mn, ^{63}Cu, ^{88}Sr, ^{118}Sn, ^{138}Ba, and ^{208}Pb. These elements were all analyzed in low-resolution mode, and were chosen because of their previous use in uptake and tagging studies of fish otoliths and bivalve shells (Bath Martin & Thorrold 2005; Strasser et al. 2008a,b; Fodrie et al. 2011).

Larval slide-mounts from the laboratory experiment were ablated in bulk using a line transect of 150 µm with 40 µm spot size and 80% laser intensity. Isotope intensities were converted into elemental ratios (X:Ca) following Becker et al. (2007).

Data Processing Description

Data Processing:

A 2-way ANOVA was used to test the effects of salinity and temperature on elemental ratios for the elements that were not spiked during the laboratory experiment (Sr and Ba). Due to the large amount of zero values in certain cases (e.g., undetectable amounts of Ba), Sr ratios were transformed using a Box-Cox transformation

and Ba ratios were transformed to meet assumptions of normality and homogenous variances. After ensuring no interactive effects of Mn and Pb spikes with Sr or Ba signatures, or nesting effects for homes within individual tanks ($p>0.05$), all tanks were included in this analysis with individual larval homes treated as replicates ($N=6$) and temperature and salinity treated as fixed factors.

For spiked elements (Mn and Pb), a three-way ANOVA was used to test the effects of salinity, temperature, and spike level on elemental ratios. Mn ratios were transformed with a Box-Cox transformation, while Pb ratios were transformed logarithmically to meet assumptions of normality. After ensuring no nesting effects of individual tanks, homes were treated as replicates ($N=6$) temperature, salinity and spike level were treated as fixed factors. For all 4 elements, Tukey's HSD tests were used post-hoc to explore differences within and among treatment groups

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Data Files

File
lablarvae.csv (Comma Separated Values (.csv), 34.02 KB) MD5:9f90a307bbca0ae8458d571f2ce5d7bf Primary data file for dataset ID 719172

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Parameters

Parameter	Description	Units
Burn_Number	Number corresponding to the order in which the samples were burned (in a given sequence) during LA ICP-MS analysis	unitless
Burn_Date	Date the sample was run through the mass spectometer	unitless
Name	Sample ID: ##_X#_X. ## = box sample held in. X# = position in box. X = replicate burn	unitless
Sequence	Name of folder in which all ICPMS chromatograms are stored in on instrument.	unitless
Mg26_to_Ca48	Elemental ratio (Mg:Ca). Mg26 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Mn55_to_Ca48	Elemental ratio (Mn:Ca). Mn55 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Co59_to_Ca48	Elemental ratio (Co:Ca). Co59 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Cu63_to_Ca48	Elemental ratio (Cu:Ca). Cu63 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Sr88_to_Ca48	Elemental ratio (Sr:Ca). Sr88 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Cd112_to_Ca48	Elemental ratio (Cd:Ca). Cd112 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Ba138_to_Ca48	Elemental ratio (Ba:Ca). Ba138 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Sn118_to_Ca48	Elemental ratio (Sn:Ca). Sn118 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
La139_to_Ca48	Elemental ratio (La:Ca). La139 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Ce140_to_Ca48	Elemental ratio (Ce:Ca). Ce140 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Pb208_to_Ca48	Elemental ratio (Pb:Ca). Pb208 isotope intensity in counts per second divided by the Ca48 concentration	dimensionless
Temp_Treat	Temperature treatment (T+ = 26*C; T- = 21*C)	unitless
Sal_Treat	Salinity treatment (S+ = 20 ppt; S- = 12 ppt)	unitless
Elemental_Conc_Treat	[++] = 32 ppb Mn and 0.32 ppb Pb spikes; [+] = 16 ppb Mn and 0.16 ppb Mg spikes; [0] = ambient	unitless
Home	Replicate PVC larval "home" label within each experimental aquaria	unitless

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Instruments

Dataset-specific Instrument Name	Teledyne ATLex 300si-x 193nm Excimer laser ablation unit
Generic Instrument Name	Laser
Dataset-specific Description	http://www.cetac.com/product_dashboard/laser-ablation.htm
Generic Instrument Description	A device that generates an intense beam of coherent monochromatic light (or other electromagnetic radiation) by stimulated emission of photons from excited atoms or molecules.

Dataset-specific Instrument Name	Thermo-Fisher Element2 inductively coupled plasma mass spectrometer
Generic Instrument Name	Mass Spectrometer
Dataset-specific Description	Both larval and spat samples were analyzed using a Thermo-Fisher Element2 inductively coupled plasma mass spectrometer with a Teledyne ATLex 300si-x 193nm Excimer laser ablation unit (LA ICP-MS). To correct for mass bias and instrument drift, National Institute of Technology Standards-certified standards (Reference Material 612, 614, and 616) were run at the beginning and end of every 4 slide sequence (~140 burns).
Generic Instrument Description	General term for instruments used to measure the mass-to-charge ratio of ions; generally used to find the composition of a sample by generating a mass spectrum representing the masses of sample components.

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Deployments

Fodrie_EstuarineMetaDyn

Website	https://www.bco-dmo.org/deployment/688049
Platform	Back_Sound_NC
Description	Sampling between 2010 and 2015.

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Project Information

Interacting Effects of Local Demography and Larval Connectivity on Estuarine Metapopulation Dynamics (EstuarineMetaDyn)

Coverage: North Carolina Estuaries

Description from NSF award abstract:
The PIs will use the eastern oyster (*Crassostrea virginica*) in Pamlico Sound, North Carolina, as a model system and will attempt to optimize the design of networks of no-take reserves as a strategy for maintaining metapopulations of this commercially harvested species. The project specifically recognizes that network persistence depends on (1) the potential for growth, survival, and reproduction within reserves, and (2) the potential to distribute offspring among reserves. Thus, demographic processes within reserves and settling

areas play important roles, along with variability of physical transport. The PIs plan to:
(1) test and refine 3D bio-physical models of connectivity due to oyster larval transport in a shallow, wind-dominated system;
(2) test, refine, and apply technology to detect natal origins of larvae using geochemical tags in larval shell; and
(3) integrate regional connectivity and demographic rates to model metapopulation dynamics.

This study will produce new tools and test and refine others used for studying larval connectivity, a fundamentally important process in the maintenance of natural populations, and thus in biological conservation and resource management. The tools include a hydrodynamic modeling tool coupled with an open-source particle tracking model that will be available on-line with computer code and user guide. The project will use integrated modeling approaches to evaluate the design of reserve networks: results will be directly useful to improving oyster and ecosystem-based management in Pamlico Sound, and the methods will inform approaches to network design in other locations.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1155609

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