Latitudinal variation in the shell thickness and tissue mass of Littorina obtusata snails in 1995-1997 and 2017-2018

Website: https://www.bco-dmo.org/dataset/990839
Version: 1
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Project
» Local adaptation and the evolution of plasticity under predator invasion and warming seas: consequences for individuals, populations and communities (evolution of plasticity)

Contributors	Affiliation	Role
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Abstract
The impact of invasive predators during the early stages of invasion is often variable in space and time. Such variation is expected to initially favor plasticity in prey defenses but fixed defenses as invaders become established. Coincident with the range expansion of an invasive predatory crab in the Gulf of Maine we document rapid changes in shell thickness – a key defense against shell crushing predators – of an intertidal snail. Field experiments, conducted 20 years apart, revealed that temporal shifts in shell thickness were driven by the evolution of increased trait means and erosion of thickness plasticity. The virtual elimination of the trade-off in tissue mass that often accompanies thicker shells is consistent with the evolution of fixed defenses under increasingly certain predation risk. These data describe latitudinal variation in the shell thickness and tissue mass of snail (Littorina obtusata) populations throughout the Gulf of Maine in 1995-1997 and 2017-2018. These data allowed us to evaluate the relationship between spatiotemporal changes in green crab density and spatiotemporal variation in snail shell thickness and tissue mass.

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Coverage

Location: Rocky intertidal shores throughout the Gulf of Maine
Spatial Extent: **N**:44.85 **E**:-66.95 **S**:42.56 **W**:-70.7694
Temporal Extent: 1995 - 2018

Dataset Description

This dataset is part of a broader study conducted in the Gulf of Maine to investigate phenotypic plasticity of prey species in response to predator invasion and warming oceans:

1. Green crab surveys plus historical crab density data (dataset 990378)
2. Green crab density from field studies at rocky intertidal sites from April 2019 to December 2021 (dataset 911365)

3. Latitudinal (clinal) variation in *Littorina obtusata* shell thickness and tissue mass measured 20 years apart **(this dataset)**
4. Field experiment outplanting *Littorina obtusata* with predators (green crabs) to examine local and regional geographic variation in inducible defenses conducted from April to August 2021 (dataset 911221)
5. Morphological data from reciprocal transplant experiment in the field (dataset 990830)

Methods & Sampling

Between 1995 and 1997, our previous work (Trussell 2000) collected samples of snails (*Littorina obtusata)* from 25 populations spanning Gulf of Maine rocky intertidal habitats. Between 2017 and 2018, we collected samples from 22 of the same populations (snails were not present at 3 of the sites sampled in 1995-1997) to examine how phenotypic clines may have changed following increased ocean temperatures and increased green crab density in the northern Gulf of Maine. For each population, snails (n = 50 per population) were haphazardly collected while attempting to maximize size range and returned to the laboratory for measurement of shell length and shell thickness with digital calipers. Mean shell thickness (hereafter, shell thickness) was calculated by taking the mean of whorl thickness and opposite whorl thickness. We then used a C-clamp to crack the shell of each snail and shell fragments were separated from soft tissue. Shell fragments and soft tissue were placed in separate aluminum trays and dried at 60°C for 48 hours before weighing on an analytical balance. In the laboratory shell length and shell thickness were measured with digital calipers and shell and tissue mass were measured with a digital balance.

BCO-DMO Processing Description

- Imported original file named "3.Trussell.Corbett.Updated.ShellThickness.TissueMass.Cline.csv" into the BCO-DMO system.
- Renamed fields/columns to comply with BCO-DMO naming conventions.
- Replaced site name of 'Rogue Bluffs' to 'Roque Bluffs'
- Added column for sample identification
- Added column for longitude
- Saved the final file as "990839_v1_shell_thickness_tissue_mass_cline.csv"

Problem Description

*One of the samples from Newcastle, NH was lost prior to determining tissue mass, so that value is missing.

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Related Publications

Trussell, G. C. (2000). Phenotypic clines, plasticity, and morphological trade-offs in an intertidal snail. Evolution, 54(1), 151–166. https://doi.org/10.1111/j.0014-3820.2000.tb00016.x
Methods

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Related Datasets

IsRelatedTo

Trussell, G. C., Corbett, J. J. (2023) **Littorina obtusata shell length, shell thickness, and tissue mass measured during a field experiment conducted at 12 sites in the Gulf of Maine from April to August 2021.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-10-11 doi:10.26008/1912/bco-dmo.911221.1 [view at BCO-DMO]

Trussell, G. C., Corbett, J. J. (2026) **Morphological data of Littorina obtusata populations from**

reciprocal transplant experiments in the Gulf of Maine conducted 20 years apart. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-12-29 doi:10.26008/1912/bco-dmo.990830.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Sample_ID	Sample identification	unitless
Year	Denotes the years in which the snail populations were sampled	unitless
Site_Name	Name of the sampling site along the Gulf of Maine	unitless
Latitude	Latitude of the sampling site	decimal degrees
Longitude	Longitude of the sampling site	decimal degrees
Shell_Length	Shell length of each snail	millimeters (mm)
Shell_Thickness	Shell thickness of each snail	millimeters (mm)
Tissue_Mass	Tissue mass of each snail	milligrams (mg)
Shell_Mass	Shell mass of each snail	milligrams (mg)

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Instruments

Dataset-specific Instrument Name	digital calipers
Generic Instrument Name	calipers
Dataset-specific Description	In the laboratory shell length and shell thickness were measured with digital calipers.
Generic Instrument Description	A caliper (or "pair of calipers") is a device used to measure the distance between two opposite sides of an object. Many types of calipers permit reading out a measurement on a ruled scale, a dial, or a digital display.

Dataset-specific Instrument Name	analytical balance
Generic Instrument Name	scale or balance
Dataset-specific Description	Shell fragments and soft tissue were dried before weighing on an analytical balance.
Generic Instrument Description	Devices that determine the mass or weight of a sample.

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Project Information

Local adaptation and the evolution of plasticity under predator invasion and warming seas: consequences for individuals, populations and communities (evolution of plasticity)

NSF Award Abstract:
Over the past two decades, the Gulf of Maine has experienced unprecedented warming that, among other things, has further enabled the invasive green crab to expand its range in rocky shore habitats. The adverse ecological impacts of this invasive predator have been documented worldwide. This study examines how geographic variation in the capacity of two common prey species to respond to the combination of this predator and warming ocean temperatures can shape prey feeding and performance and impact community structure and dynamics. Hence, this research enhances understanding of the evolution of phenotypes, their plasticity, and the nature of adaptation and its role in eco-evolutionary dynamics. More broadly, it informs understanding of how organisms and marine communities may respond to future environmental change. In addition, this project makes contributions to the STEM pipeline by providing middle and high school, undergraduate, and graduate students with cross-disciplinary training in evolutionary and community ecology. In collaboration with an institutional outreach program, the investigator is also developing web-based multimedia projects and teacher resource materials based on this research.

A central principle in ecology is that species residing in the middle of food chains must balance the benefits of eating with the risk of being eaten by their predators. Solving this foraging-predation risk trade-off often involves plasticity in prey traits with consequences for the evolution of adaptation and species interactions that drive community-level processes. Hence, the foraging-predation risk trade-off provides a powerful conceptual framework that links evolutionary and community ecology. Yet at the same time, other environmental stressors like temperature can shape this trade-off, adding complexity that makes it difficult to predict the capacity of organisms to adapt to environmental change and the consequences for communities. The investigator is conducting this study in rocky shore habitats of the Gulf of Maine (GOM) which have long been influenced by strong latitudinal temperature gradients and non-native species invasions. The overarching hypothesis is that predation risk and temperature are factors shaping geographic variation in plasticity and adaptation, with consequences for individuals, populations, and communities. First, the investigator is conducting field experiments to document geographic variation in the trait plasticity of two common prey species in the green crab's diet. Second, he is using reciprocal transplant experiments to examine trait plasticity in response to risk and water temperature, generating data to compare with similar experiments conducted in the late 90s prior to recent ocean warming and expansion in range of green crabs. Third, he is conducting a laboratory common garden experiment to evaluate the effects of risk and water temperature on trait plasticity. Finally, he is using reciprocal transplant experiments in the field to understand the interactive effects of risk and water temperature on prey foraging rates and the abundance of a species that plays an important role in intertidal community structure and dynamics.

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-2017626

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