Lottia gigantea growth data from field experiments of experimentally manipulated competitor densities on the Northern and Central California coast from Feb to Dec 2023

Website: https://www.bco-dmo.org/dataset/1000489
Data Type: Other Field Results, experimental
Version: 1
Version Date: 2026-06-09

Project
» Evolutionary and ecological dynamics of a contemporary climate-driven range expansion (LottiaRangeExp)

Contributors	Affiliation	Role
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Abstract
We harnessed an ongoing poleward range shift of the giant owl limpet (Lottia gigantea) in California, USA to test whether the effects of competition vary between the range core and expanding edge. To assess the strength of competition across the range, we experimentally manipulated densities of L. gigantea, and a competing grazer (L. scabra), at five rocky intertidal sites and measured limpet growth over ~10 months as a metric of performance. As predicted, field surveys confirmed that L. gigantea density was higher in the range core than the range edge. Contrary to theory, range-core limpets that evolved in these dense populations were more strongly impacted by intra- and interspecific competition than range-edge limpets when both were held under standardized experimental densities of competitors. Importantly, both forms of competition had similar effects across the range, even though interspecific competition is rarely integrated into range-expansion theory. Consistent with theory, growth rates were fastest at the expanding edge. However, growth in range-edge limpets did not decline under high intra- and interspecific densities, suggesting that rapid growth rate did not come at the cost of reduced competitive ability. Growth in the expanded range may be enhanced by greater food availability as cooler temperatures lower metabolic demand and ameliorate competition. Our findings suggest that predicting the dynamics of range expansions will require greater consideration of how diverse recipient communities and environmental heterogeneity mediate the strength of competition and performance across an expanding species' range.

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Coverage

Location: Northern and Central California coast
Spatial Extent: **N**:38.5973 **E**:-120.6144 **S**:34.5878 **W**:-123.363
Temporal Extent: 2023-02-20 - 2023-12-13

Methods & Sampling

To test the hypothesis that the effects of both intra- and interspecific competition on performance vary geographically in a range-shifting species, we experimentally manipulated the densities of *L. gigantea* and *L. scabra* at the five study sites across the range. The sites included 3 range core sites (Vandenberg, Soberanes Point, and Hopkins Marine Station) and 2 expanding edge sites (Bodega Marine Reserve and Kruse Ranch).

To manipulate densities, we used hand tools to clear ~650 cm^2 sections of rocky intertidal substrate of all invertebrates and algae. To ensure habitat suitability, we selected gently sloping areas in the mid-intertidal zone with relatively high *L. gigantea* abundance. Once cleared, we enclosed these areas with 650 cm^2 octagonal cages with walls made of stainless-steel mesh with 3 mm wide openings (McMaster Carr). Cages were covered with a plastic vexar mesh lid with 1.27 cm wide openings to prevent most small grazers from entering the cages. We bolted cages to the rock to secure them to the substratum and then sealed the edges to the rock with marine epoxy (Z-spar splash zone compound).

Cages were deployed in a complete block design, with four cages in each block randomly assigned one of four treatments in spring 2023. Each treatment included a focal *L. gigantea* collected from that site (initial shell length = 25-40 mm) used to quantify growth rate. The control treatment included only the focal owl limpet; the “intraspecific competition” treatment included the focal owl limpet along with a second, slightly larger owl limpet (initial shell length = 30-40 mm); the “interspecific competition” treatment included the focal owl limpet and nine *L. scabra* (initial shell length 18-22 mm); and the “combined” treatment included the focal owl limpet, a larger owl limpet, and nine *L. scabra*. The densities in each treatment reflected the upper end of natural abundances that occur in the range core (Walkes, *unpublished data*). Each block was replicated 8 times, for a total of 32 experimental cages at each site distributed over ~200m of shoreline. In each cage, we tagged the single focal *L. gigantea* using a small (6 mm) Floy tag attached to surface of the shell using a small dab of marine epoxy (Z-spar splash zone epoxy compound). To assess performance as a response to each treatment, we recorded absolute growth rate based on change in shell length through time for the focal *L. gigantea* in each cage. Shell length was measured using calipers along the posterior to anterior axis of the shell at the beginning and end of the experiment to calculate growth rate. Cages were checked approximately every three months at each site to remove algae and other fouling organisms, and to replace any dead focal limpets (N = 7) and competing limpets. The experiment ended after 10 months in November-December 2023.

Data Processing Description

We recorded absolute growth rate (AGR) as the change in shell length (in mm) through time.

BCO-DMO Processing Description

- Loaded lottia_exp.csv as table "lottia_exp" in CSV format, treating empty string, "nd", and "na" as missing values
- Renamed columns to BCO-DMO conventions: date_i to date_initial, Length_i to Length_initial, Length_f to Length_final, date_f to date_final
- Converted date_initial from M/D/YY format to ISO 8601 YYYY-MM-DD date type
- Converted date_final from M/D/YY format to ISO 8601 YYYY-MM-DD date type
- Output written to 1000489_v1_lottia_growth_experiment.csv

Problem Description

Several entries are missing final growth measurements due to animal loss. Missing growth measurements are indicated as empty cells.

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Related Datasets

IsRelatedTo

Walkes, S., Bay, R., Sanford, E. (2026) **TidBiT logger temperature data for intertidal ocean temperatures in Northern and Central California between Jun 2022 and Dec 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2026-06-09 http://lod.bco-dmo.org/id/dataset/1000482 [view at BCO-DMO]
Relationship Description: Data were collected in conjunction with a manipulative field experiment to assess how the strength of competition varies across the range edge and range core for Lottia gigantea.

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Parameters

Parameter	Description	Units
Block	Cages were placed in a block design, with four cages adjacent to each other at each site. Each block contained one of the four treatments: (control, intraspecific, interspecific, or combined), though several limpets (n = 7) died over the course of the experiment. Note that the identifier is not unique in the spreadsheet	unitless
Treatment	The experimental treatment the limpet received. Either control, intraspecific, interspecific, or combined	unitless
Tag	Tag number for each focal limpet. Blank values represent lost tags	unitless
Site	The site at which the growth data were recorded; Vandenberg, Soberanes, Hopkins, Bodega Marine Reserve, or Kruse Ranch	unitless
date_initial	Date of initial size measurement	unitless
Length_initial	Initial shell length measured using handheld calipers along the longest posterior to anterior axis of the shell	mm
Length_final	Final shell length measured using handheld calipers along the longest posterior to anterior axis of the shell	mm
date_final	Date of final size measurement	unitless
dt	Days between initial and final shell length measurements	Days
AGR	Absolute growth rate. Measured as the change in shell length through time ((Length_f – Length_i)/dt)	mm/day
Latitude	Latitude of study site, positive is North	Decimal degrees
Longitude	Longitude of study site, negative is West	Decimal degrees

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Instruments

Dataset-specific Instrument Name	calipers
Generic Instrument Name	calipers
Dataset-specific Description	Shell length was measured using calipers along the posterior to anterior axis of the shell at the beginning and end of the experiment to calculate growth rate.
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	Floy tag
Generic Instrument Name	labeling tag
Dataset-specific Description	In each cage, we tagged the single focal L. gigantea using a small (6 mm) Floy tag attached to surface of the shell using a small dab of marine epoxy (Z-spar splash zone epoxy compound).
Generic Instrument Description	Passive devices attached to captured organisms to specifically identify them when recaptured after release.

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Project Information

Evolutionary and ecological dynamics of a contemporary climate-driven range expansion (LottiaRangeExp)

Coverage: Coastal California intertidal

NSF abstract:
Anthropogenic climate change is shifting the distributions of species across the globe. Such contemporary shifts in species' ranges may have cascading effects on entire ecosystems. This project disentangles the mechanisms underlying climate-driven species range shifts in marine systems using the intertidal owl limpet as a case study. During the recent marine heatwaves off the Pacific coast of North America, populations at the northern range limit in northern California have expanded, with ongoing reproduction even after termination of the heatwave events. This is therefore an ideal system to explore the dynamics of natural selection that occur as species occupy new regions. Broadly, this project deepens understanding of how range shifts occur in marine systems and furthers the ability to predict future species distributions in response to climate change. The project provides research experiences for high school and undergraduate students from historically underrepresented groups by engaging with existing, demonstrably-effective programs. The investigators host leadership and skill-building workshops for senior female graduate students and engage the public in

partnership with the California Academy of Sciences, Bodega Marine Lab, and San Francisco Exploratorium. Finally, the project provides training for a postdoctoral scholar and two graduate students.

Although phenomenological studies suggest that climate-associated range shifts are common in marine systems, to date, mechanistic studies of the climate-organism interactions that alter geographic distributions have largely focused on terrestrial systems. However, dispersal dynamics greatly differ in many marine systems, as currents may frequently transport planktonic larvae into new environmental regimes. This project integrates detailed demographic observations of the recent range expansion of the intertidal owl limpet, Lottia gigantea, with ecological, phenotypic, and genomic measurements of divergence across its range. Specifically, the work 1) documents phenotypic divergence in larval and juvenile traits across the zone of range expansion, 2) uses whole genome sequencing to estimate gene flow across the entire range, 3) identifies genomic patterns of selection across the zone of range expansion and through time, and 4) identifies drivers of variation in performance over latitudinal and microgeographic scales. The ability to monitor this range shift in real time, along with the suitability of this system for tracking individuals across multiple years, allows the investigators to examine the impact of selection in novel range-edge conditions at the phenotypic and genomic levels, and scale from individuals to species-level responses to ongoing environmental change.

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-2023297

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