

Lottia gigantea body temperatures from biomimetic loggers collected from the eight California intertidal sites from Jul 2023 to May 2024

Website: <https://www.bco-dmo.org/dataset/1000461>

Data Type: Other Field Results

Version: 1

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Project

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

Contributors	Affiliation	Role
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Abstract

As the climate warms, species distributions are shifting poleward, but we have a limited understanding of how organisms perform in their expanded range and the environmental drivers that modulate performance across latitude during range expansions. The abundant center hypothesis (ACH) predicts that abundance and performance decline towards the edge of a species' range and is the foundation for most predictive theory extended to the eco-evolutionary dynamics of range shifts. However, it is unclear how often these predictions are met during actual range shifts and under what contexts deviations are expected. Here, we use a poleward range expansion of an intertidal limpet (*Lottia gigantea*) to test predictions regarding patterns of performance and environmental drivers across the geographic range. We recorded body temperature using biomimetic loggers at eight intertidal sites along the California coast. This dataset includes the recorded temperature estimates made every 30 mins for the six loggers at each of the eight sites. Temperature estimates are separated into two parameters by tidal state (air_temp and water_temp): aerial body temperatures, comprising readings recorded within 90 minutes of the largest daily low tide, and immersion body temperatures, comprising readings recorded within 90 minutes of daily high tides. Mean body temperature and lower 5th percentile body temperature declined towards higher latitude sites, however, upper 95th percentile body temperatures varied as a mosaic across latitude.

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Coverage

Location: California rocky intertidal zone

Spatial Extent: N:38.6042 E:-117.2532 S:32.8719 W:-123.3696

Temporal Extent: 2023-07-04 - 2024-05-04

Methods & Sampling

We recorded body temperature at 8 sites across the geographic range: Bodega Marine Reserve, Dillon Beach,

Fort Ross, Hopkins Marine Station, Kruse Ranch, Soberanes Point, Scripps Coastal Reserve, and Vandenberg. These sites included all sites from which we collected community data (except Seal Beach), plus Scripps Coastal Reserve. Note, we were unable to collect growth data from Scripps Coastal Reserve, because heavy barnacle recruitment obscured limpet tags and we did not deploy loggers at Seal Beach since friable rocky substrate made it difficult to secure loggers.

We estimated body temperature by deploying 6 biomimetic loggers at each site (ElectricBlue Robo Limpet). Loggers were set to record temperature every 30 minutes and were deployed in summer 2023 for 10-12 months. We attached the loggers to the substrate by filling a shallow depression in the rock with marine epoxy (Zspar Splash zone compound) and pressing the logger slightly into the epoxy. Loggers were deployed in gently sloping rocky shore habitats in the mid-intertidal zone, surrounded on 1-2 sides by mussel beds. Within 20-30 cm of each logger, we tagged 2-4 owl limpets (Shell length 30-45 mm) and recorded their growth rates to relate habitat temperature variation with performance.

From each logger, we calculated the upper 95th percentile temperature in air, lower 5th percentile temperature in air, mean immersion temperature, and the coefficient of variation for all recorded body temperature estimates. To determine aerial temperatures, we filtered logger readings for those recorded within 90 minutes of the largest daily low tide to ensure aerial exposure. To determine immersion temperatures, we filtered logger readings to include only those recorded within 90 mins of both daily high tides.

BCO-DMO Processing Description

- Loaded two CSV files (air.temps.latitude.csv and water.temp.latitude.csv) as tables res1-1 and res1-2, with missing values defined as "", "nd", and "NA"
- Converted time.pdt in res1-1 from format "%m/%d/%y %l:%M %p" (e.g., "8/3/23 1:12 PM") to ISO 8601 format "%Y-%m-%dT%H:%M:%S"
- Converted time.PDT in res1-2 from format "%m/%d/%y %H:%M" (e.g., "8/5/23 0:25") to ISO 8601 format "%Y-%m-%dT%H:%M:%S"
- Converted Date column in both res1-1 and res1-2 from M/D/YY format to ISO 8601 date format "%Y-%m-%d"
- Renamed temp column to air_temp in res1-1 and to water_temp in res1-2
- Concatenated res1-1 and res1-2 into a single table named air_water, mapping time.PDT to time.pdt and Day to new_field; added a file_name column derived from the source filename
- Renamed columns: time.pdt to time_local_pdt, new_field to day_of_week, file_name to logger_file
- Converted time_local_pdt from America/Los_Angeles (PDT) to UTC, outputting a new ISO_DateTime_UTC column in "%Y-%m-%dT%H:%M:%SZ" format
- Reordered columns to: air_temp, water_temp, logger, Site, Date, time_local_pdt, ISO_DateTime_UTC, Latitude, Longitude, day_of_week, logger_file
- Output as 1000461_v1_air_water_temps.csv

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Parameters

Parameter	Description	Units
air_temp	Biomimetic body temperature estimates recorded from the data logger when loggers were exposed to air during low tide	degrees Celsius
water_temp	Biomimetic body temperature estimates recorded by the data logger when loggers were submerged during high tide	degrees Celsius
logger	logger identifier	unitless
Site	Site identifier; BMR = Bodega Marine Reserve, DB = Dillon Beach, FR = Fort Ross, HMS = Hopkins Marine Station, KR = Kruse Ranch, SBR = Soberanes Point, Scripps = Scripps Coastal Reserve, VBS = Vandenberg Santa Barbara	unitless
Date	Date of recording, in Pacific Time (PT)	unitless
time_local_pt	Date and time of recording, in Pacific Time (PT)	unitless
ISO_DateTime_UTC	Date and time of recording (UTC)	unitless
Latitude	Latitude of study site, positive is North	decimal degrees
Longitude	Longitude of study site, negative is West	decimal degrees
day_of_week	Day of the week, abbreviated; only provided for water_temp values	unitless
logger_file	Source file for logging data	unitless

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Instruments

Dataset-specific Instrument Name	ElectricBlue Robo Limpet
Generic Instrument Name	Temperature Logger
Dataset-specific Description	We estimated body temperature by deploying 6 biomimetic loggers at each site (ElectricBlue Robo Limpet). Logger: ElectricBlue Robolimpet (T2.4)
Generic Instrument Description	Records temperature data over a period of time.

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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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