Allometric scaling of calcification data for Mytilus californianus from 2021-2022 (OA decoupling project)

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Data Type: Other Field Results, experimental
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Project
» Invertebrate calcification and behavior in seawater of decoupled carbonate chemistry (OA decoupling)

Contributors	Affiliation	Role
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Abstract
Calcification rates of mussels spanning a range of sizes. These data were used to determine a biomass scaling function for the main incubation dataset (Incubation data for Mytilus californianus calcification).

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Coverage

Location: Laboratory experiments were conducted at the Bodega Marine Laboratory in Bodega Bay, CA, USA and specimens were collected from Carmet Beach
Spatial Extent: **Lat**:38.371361 **Lon**:-123.076306
Temporal Extent: 2021-08-10 - 2022-01-03

Methods & Sampling

Sampling collection details

We gathered naturally settled, adult California mussels (*M. californianus* between 30 and 80 mm in maximum shell length) by hand from the mid-intertidal zone of Carmet Beach, along the northern California coast. We cleaned mussels of all epibionts and external byssal threads, then transported them in buckets (< 0.5 hr transit time) to Bodega Marine Laboratory, where we acclimated individuals for seven days in flow-through

seawater tables prior to subsequent experiments.

Experiment details

To account for calcification scaling allometrically with animal size, we determined the relationship between mussel tissue mass and calcification rate by incubating 26 different mussels spanning 24 mm to 67 mm in shell length and 0.07 g to 2.55 g of dry tissue in ambient, unmanipulated seawater (Supplementary Figure S3 in Romano de Orte et al. (2021), $F_{1,24} = 61.76$, $R2 = 0.71$, $p < 0.001$). This procedure yielded a scaling exponent of 0.72 and we therefore divided calcification rates of the experimental mussels by g0.72.

We calculated net calcification rates with the ammonia-corrected alkalinity anomaly technique (Gazeau et al 2015), divided by incubation duration and mussel dry tissue mass raised by a factor of 0.72 (see the Related Datasets section of this metadata page for this incubation data). The alkalinity anomaly technique builds on the observation that precipitation of CaCO3 results in an equivalent reduction in seawater [CO32-] (or reduction of [HCO3-] followed by an increase in [H+]) which contributes two equivalents of total alkalinity—simultaneous production of ammonia is the major metabolic process in mussels that can obscure this and its signal must be removed (Gazeau et al 2015). Following the incubation, we dissected each mussel and dried it at 60 °C for at least 24 hours to obtain the dry tissue mass (excluding byssal threads) and dry shell mass of each individual mussel.

We conducted additional incubations (n=87, between 3 and 9 per experiment day) without mussels throughout the trials as experimental blanks to determine background changes in alkalinity. We excluded from our analysis any experimental days where background alkalinity changes exceeded 5 µmol kg-1.

The mean of the absolute values of alkalinity change during the incubations of these experimental blanks was 1.3 ± 1.2 µmol kg-1 (n = 72).

Data Processing Description

All computations were performed with R statistical software, version 4.1.0. We performed carbonate system calculations using the package *seacarb*, using equilibrium constants from Lueker *et al*. We computed linear mixed models using the *lmer* function in in the *lmertest* package in R and focused on assessing likely candidate parameters as fixed factors, and mussel collection date as a random intercept to account for natural seasonal differences between cohorts. Conditional R2 was calculated with the package *MuMIn*. We determined parameters for non-linear fits employed to model dissolution rates by minimizing the sum of squares of model residuals using the *optim* function.

Colors for plots were chosen from color palettes in the *cmocean* package in *R*.

BCO-DMO Processing Description

- Removed special characters (e.g., periods) from column names and replaced with underscores
- Added a datetime field ("start_datetime)from the date and start time fields
- Changed the presentation of species values from "mytilus_californianus" to "Mytilus californianus" and added AphiaID and LSID to the data file
- All numeric float fields rounded to 2 degrees of precision

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Data Files

File	
925689_v1_allometric_scaling_of_calcification_for_mytilus_californianus.csv	(Comma Separated Values (.csv), 5.12 KB) MD5:b6e9eb2b112016c2dcff912dc1b0636a
Primary data file for dataset ID 925689, version 1	

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Related Publications

Gazeau, F., Urbini, L., Cox, T., Alliouane, S., & Gattuso, J. (2015). Comparison of the alkalinity and calcium anomaly techniques to estimate rates of net calcification. Marine Ecology Progress Series, 527, 1–12. https://doi.org/10.3354/meps11287
Methods

Romanó de Orte, M., Koweek, D. A., Cyronak, T., Takeshita, Y., Griffin, A., Wolfe, K., Szmant, A., Whitehead, R., Albright, R., & Caldeira, K. (2021). Unexpected role of communities colonizing dead coral substrate in the calcification of coral reefs. Limnology and Oceanography, 66(5), 1793–1803. Portico. https://doi.org/10.1002/lno.11722
Results

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Related Datasets

IsRelatedTo

Gaylord, B. (2024) **Control incubation data during Mytilus californianus calcification experiments from 2020 to 2022 (OA decoupling project).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-05-06 doi:10.26008/1912/bco-dmo.925714.1 [view at BCO-DMO]
Relationship Description: Net calcification rates are calculated using the ammonia-corrected alkalinity anomaly technique, divided by incubation duration and mussel dry tissue mass raised by a factor of 0.72. Related incubation data is included in this linked dataset.

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Parameters

Parameter	Description	Units
species	Mussel species used in incubation.	unitless
AphiaID	Unique identifier for the listed taxon in the Aphia database.	unitless
LSID	Life Science Identifier (LSID) for the listed taxon.	unitless
date_local	Incubation date in Pacific Standard Time.	unitless
start_time_local	Start time of the incubation in Pacific Standard Time.	unitless
ISO_Start_DateTime_UTC	Start datetime of the incubation in UTC.	unitless
duration	Duration of incubation in hours.	hours (h)

salinity	Incubation salinity.	PSU
temperature	Incubation Temperature.	degrees Celcius (c)
calcification	Calcification rate of mussel, can be calculated within this dataset as ((-0.5 * (delta.ta - delta.nh3) * incubation.water.mass) - calc.diss) /duration/ tissue.mass^0.71592.	umol hr^-1 g^-0.71592
tissue_mass	Dried mussel tissue mass.	grams (g)
shell_mass	Dried mussel shell mass.	grams (g)
wet_mass	Wet mass of mussel prior to incubation.	grams (g)
TA	Mean alkalinity during incubation.	umol kg-1
ph	Mean pH during incubation, total scale.	unitless
do	Mean dissolved oxygen concentration during the incubation.	umol kg-1
ci	Mussel condition index, dry tissue mass divided by total dry mass.	umol kg-1
incubation_water_mass	Mass of seawater in incubation vessel.	kilograms (kg)
byssal_threads	Byssal thread production rate during incubation.	threads hr-1
delta_ta	Measured change in alkalinity during incubation.	umol kg-1
delta_nh3	Measured change in ammonia concentration during incubation.	umol kg-1

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Project Information

Invertebrate calcification and behavior in seawater of decoupled carbonate chemistry (OA decoupling)

Coverage: California coast, USA

NSF Award Abstract:
This research is exploring the capacity of coastal organisms to cope with alterations in seawater chemistry driven by both freshwater inputs and absorption of carbon dioxide into the world's oceans (ocean

acidification). The project focuses on calcification responses and behavioral impairments of shoreline animals under altered seawater chemistry, and forefronts a common mussel species (the California mussel), and a common snail (the black turban snail), each abundant on rocky shores along the west coast of North America. The target species operate as exemplar organisms for characterizing the responses of marine invertebrates more generally. Methods involve experimental decoupling of multiple components of the carbonate system of seawater to isolate drivers that are difficult to separate otherwise. Broader impacts include transfer of scientific information to policy-makers, including legislators, as well as training and skill-set development of future generations of scientists and citizens. One Ph.D. student is supported, as are UC Davis undergraduates conducting mentored research. The project also provides research internships for undergraduates from a local community college (Santa Rosa Junior College), many of whom are from underrepresented groups. The latter project component substantially bolsters an ongoing program at Bodega Marine Laboratory that includes efforts in diversity, equity, and inclusion. Data and interpretations from the project are feeding into an existing educational program that links to local K-12 schools and reaches ~10,000 members of the public each year.

Overall, the research of the project is dissecting drivers of calcification and behavioral disruption in key shoreline invertebrates, across present-day and future carbonate system conditions appropriate to coastal marine environments. Efforts are exploring the extent to which calcification depends on one versus multiple parameters of the seawater carbonate system. In particular, existing conceptual models emphasize the importance of calcium carbonate saturation state (Ω) and/or the ratio of bicarbonate to hydrogen ion concentrations ([HCO3-]/[H+]), and the project is examining these mechanisms as well as the possibility that more than one driver acts simultaneously. It is doing so both in bivalves and in gastropods to test for generality across mollusks. The project is additionally examining whether pH is the only carbonate system factor contributing to known patterns of behavioral impairment in marine invertebrates. Leading explanations for debilitating behaviors induced by ocean acidification involve altered ion channel function, but discussion in the literature continues, and studies that explicitly decouple the carbonate system are necessary.

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-2129942

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