Effects of ocean acidification on anti-predator behavior of snails from Bodega Bay, CA.

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Data Type: experimental
Version: 1
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Project
» Trophic consequences of ocean acidification: Intertidal sea star predators and their grazer prey (BOAR Trophic)

Contributors	Affiliation	Role
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Abstract
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Table of Contents

Dataset Description

This dataset has also been contributed to Dryad, see related publications section. This dataset has been served at BCO-DMO at 2017-08-19 at BCO-DMO, but has only received a DOI on 2021-11-09. No changes were made to the dataset during that time.

Methods & Sampling

Adult marine snails (*Tegula funebralis*) and sea stars (*Pisaster ochraceus*) were collected from mid-intertidal pools on the Bodega Marine Reserve (BMR) near Bodega Bay, California, in February and April 2014. Snail and sea star size (mean ± se) were standardized as much as possible (snail height and diameter = 19.1±0.3 and 21.0±0.2 mm, respectively; sea star diameter = 143.3±9.0 mm). These sizes match those of many individuals involved in predator-prey interactions between these species in the field. Immediately following collection, snails and sea stars were placed in separate flow-through aquaria at Bodega Marine Laboratory (BML) where they were allowed to acclimate to laboratory conditions for two weeks prior to experimentation. During acclimation, snails were fed kelp (*Macrocystis pyrifera*) and sea stars were fed *T. funebralis* individuals *ad libitum*. The latter protocol facilitated ‘dietary tagging,’ in which predators feeding on a particular prey species

emit chemical compounds (likely originating from breakdown products of consumed tissue) that operate as especially strong anti-predator cues for that prey.

Once animals had been acclimated to ambient seawater conditions, anti-*Pisaster* flight responses in the snails were assessed under multiple levels of altered seawater pH, in two separate five-day experiments. Five days is typical of the duration of low tide series that induce chronic exposure of rock-pool organisms to strongly depressed pH levels. In the first experiment, *T. funebralis* individuals were exposed to waterborne cue emitted by *Pisaster* under conditions of temporally constant pH (constant-pH experiment). In the second experiment, the pH of each treatment was varied semi-diurnally (fluctuating-pH experiment) to mimic temporal changes in pH that occur naturally in intertidal rock pools during many low tide series, in particular those for which pools become isolated from the adjacent ocean only at night (i.e., ~12 low tide series per year along the northern California coast, each lasting five days or longer).

For additional details see: Jellison, B.M. et al., 2016.

Data Processing Description

pCO2 was calculated from daily alkalinity and pH using CO2SYS assuming dissociation constants from Mehrbach et al. 1973 as refit by Dickson and Millero 1987, and KSO4 from Dickson 1990.

Temperature, salinity, dissolved oxygen, and pH were measured using a YSI ProPlus Sensor.
Total pH was measured using a Sunburst SAMI spectrophotometric unit modified for benchtop use.
Total alkalinity was measured using a Metrohm 855 autotitrator.

[table of contents | back to top]

Data Files

File
anti_pred_behavior.csv (Comma Separated Values (.csv), 2.21 KB) MD5:b581c855c79218aae477ad10e2e4782d Primary data file for dataset ID 713962

[table of contents | back to top]

Related Publications

Dickson, A. G. (1990). Thermodynamics of the dissociation of boric acid in synthetic seawater from 273.15 to 318.15 K. Deep Sea Research Part A. Oceanographic Research Papers, 37(5), 755–766. doi:10.1016/0198-0149(90)90004-f https://doi.org/10.1016/0198-0149(90)90004-F
Methods

Dickson, A. G., & Millero, F. J. (1987). A comparison of the equilibrium constants for the dissociation of carbonic acid in seawater media. Deep Sea Research Part A. Oceanographic Research Papers, 34(10), 1733–1743. doi:10.1016/0198-0149(87)90021-5
Methods

Jellison, B. M., Ninokawa, A. T., Hill, T. M., Sanford, E., & Gaylord, B. (2016). Ocean acidification alters the response of intertidal snails to a key sea star predator. Proceedings of the Royal Society B: Biological Sciences, 283(1833), 20160890. doi:10.1098/rspb.2016.0890
Results

Jellison, B. M., Ninokawa, A. T., Hill, T. M., Sanford, E., & Gaylord, B. (2016). *Data from: Ocean acidification alters the response of intertidal snails to a key sea star predator* (Version 1) [Data set]. Dryad. https://doi.org/10.5061/DRYAD.38M23 https://doi.org/10.5061/dryad.38m23
Results

Mehrbach, C., Culberson, C. H., Hawley, J. E., & Pytkowicx, R. M. (1973). Measurement of the apparent dissociation constants of carbonic acid in seawater at atmospheric pressure. Limnology and Oceanography, 18(6), 897–907. doi:10.4319/lo.1973.18.6.0897
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
Experiment	Column distinguishing data from two separate experiments	Constant pH/Fluctuating pH
Snail	Unique number for each snail in each container for each of the two experiments	number
Cue	Presence or absence of predator cue	Yes/No
Low_pH	Values of total pH for each container averaged over the 5 day experiments, measured using a YSI ProPlus Sensor and calibrated to the total scale using daily samples run on a Sunburst SAMI spectrophotometric unit modified for benchtop use.	pH units on the total scale
Out_of_water	Total number of 2-minute assessment intervals each snail was above the water line	number from 0-11
In_water	Total number of 2-minute assessment intervals each snail was below the water line	number from 0-11
Proportion_of_time_out_of_water	Proportion of 2-minute assessment intervals for which each snail was above the water line, out of the total 11 assessment intervals in which snails were physically capable of leaving the water	number from 0-1
Path_Length	Sum of the net distances travelled across all 2-min assessment intervals during the 28-min recording period	cm
Path_Shape	Total path length divided by the maximum displacement (the latter calculated as the linear distance between the start location and farthest position travelled for a given snail over the 28 min), yielding a relative scale with 1.0 being closest to a straight line	number from 1-infinity

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Metrohm 855 autotitrator
Generic Instrument Name	Automatic titrator
Dataset-specific Description	Total alkalinity was measured using a Metrohm 855 autotitrator
Generic Instrument Description	Instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

Dataset-specific Instrument Name	Sunburst SAMI spectrophotometric unit
Generic Instrument Name	Submersible Autonomous Moored Instrument
Dataset-specific Description	Total pH was measured using a Sunburst SAMI spectrophotometric unit modified for benchtop use
Generic Instrument Description	The Submersible Autonomous Moored Instrument (SAMI) measures and logs levels of dissolved chemicals in sea and fresh water. It is a plastic cylinder about 6 inches wide and 2 feet long that is self-powered and capable of hourly measurements for up to one year. All data collected are logged to an internal memory chip to be downloaded later. SAMI sensors usually are placed a few feet underwater on permanent moorings, while others on floating drifters sample the water wherever the wind and currents carry them. The instruments have been used by researchers around the globe in a variety of studies since 1999. Dr. Mike DeGrandpre, University of Montana, developed the SAMI between 1990 and 1993 during his postdoctoral work at the Woods Hole Oceanographic Institution (Woods Hole, MA, USA). For additional information, see URL: http://www.sunburstsensors.com/ from the manufacturer, Sunburst Sensors, LLC, 1226 West Broadway, Missoula, MT 59802.

Dataset-specific Instrument Name	YSI ProPlus Sensor
Generic Instrument Name	YSI Professional Plus Multi-Parameter Probe
Dataset-specific Description	Temperature, salinity, dissolved oxygen, and pH were measured using a YSI ProPlus Sensor.
Generic Instrument Description	The YSI Professional Plus handheld multiparameter meter provides for the measurement of a variety of combinations for dissolved oxygen, conductivity, specific conductance, salinity, resistivity, total dissolved solids (TDS), pH, ORP, pH/ORP combination, ammonium (ammonia), nitrate, chloride and temperature. More information from the manufacturer.

[table of contents | back to top]

Project Information

Trophic consequences of ocean acidification: Intertidal sea star predators and their grazer prey (BOAR Trophic)

Coverage: Central California coast, USA

NSF Award Abstract:
The absorption of human-produced carbon dioxide into the world's oceans is altering the chemistry of seawater, including decreasing its pH. Such changes, collectively called "ocean acidification", are expected to influence numerous types of sea creatures. This project examines how shifts in ocean pH affect animal behavior and thus interactions among species. It uses a case study system that involves sea star predators, snail grazers that they eat, and seaweeds consumed by the latter. The rocky-shore habitats where these organisms live have a long history of attention, and new findings from this work will further extend an already-large body of marine ecological knowledge. The project provides support for graduate and undergraduate students, including underrepresented students from a nearby community college. The project underpins the development of a new educational module for local K-12 schools. Findings will moreover be communicated to

the public through the use of short film documentaries, as well as through established relationships with policy, management, and industry groups, and contacts with the media.

Ocean acidification is a global-scale perturbation. Most research on the topic, however, has examined effects on single species operating in isolation, leaving interactions among species underexplored. This project confronts this knowledge gap by considering how ocean acidification may shift predator-prey relationships through altered behavior. It targets as a model system sea stars, their gastropod grazer prey, and macoalgae consumed by the latter, via four lines of inquiry. 1) The project examines the functional response of the focal taxa to altered seawater chemistry, using experiments that target up to 16 discrete levels of pH. This experimental design is essential for identifying nonlinearities and tipping points. 2) The project addresses both consumptive and non-consumptive components of direct and indirect species interactions. The capacity of ocean acidification to influence such links is poorly known, and better understanding of this issue is a recognized priority. 3) The project combines controlled laboratory experiments with field trials that exploit tide pools and their unique pH signatures as natural mesocosms. Field tests of ocean acidification effects are relatively rare and are sorely needed. 4) A final research phase expands upon the above three components to address effects of ocean acidification on multiple additional taxa that interact in rocky intertidal systems, to provide a broad database that may have utility for future experiments or modeling.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1636191

[table of contents | back to top]