Behavioral data of Nucella lamellosa in the presence of predators within laboratory mesocosms at Bodega Marine Lab in 2018

Website: https://www.bco-dmo.org/dataset/948204
Data Type: experimental
Version: 1
Version Date: 2025-01-09

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

Contributors	Affiliation	Role
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Abstract
To examine the intensity of anti-predatory behavior of both Tegula funebralis and Nucella lamellosa, we measured the proportion of time individual snails spend above the waterline in the presence and absence of their predator species, Pisaster ochraceus and Cancer productus. Data from this experiment are used to calculate estimated predation rates for snails that do not behaviorally respond to their predators, which are used to determine the impact anti-predatory responses have on the strength of trophic cascades. The experiment was conducted within laboratory mesocosms at Bodega Marine Lab in 2018 and 2019. This dataset reports results from mesocosms in this experiment with Nucella lamellosa in the presence of predator cues. See "Related Datasets" section for results from other mesocosms and experiments to be published in Ng & Gaylord (2025, in-prep).

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Coverage

Location: Collections along coastline of Sonoma County and Washington Park, CA; mesocosms at Bodega Marine Lab, CA
Spatial Extent: **N**:48.50219 **E**:-122.691865 **S**:38.309334 **W**:-123.076438
Temporal Extent: 2018-12-11 - 2018-12-25

Dataset Description

See "Related Datasets" section for other datasets to be published in Ng & Gaylord (2025, in-prep). These datasets are also listed on the "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

All datasets in this project can be viewed from the "Dataset Collections" of the project page https://www.bco-dmo.org/project/712799

Of particular note are :

Dataset: Fear behavior with predators: Tegula in the presence of Cancer crab cues
https://www.bco-dmo.org/dataset/948210

Dataset: Fear behavior with predators: Tegula in the presence of Pisaster cues
https://www.bco-dmo.org/dataset/948216

* The supplemental file "Fear_behavior_with_predators_analysis_package.zip" is attached to BCO-DMO datasets 948204 (this dataset), 948210, and 948216. The analysis package includes raw data and analysis R-scripts for all three datasets.

Methods & Sampling

To examine the intensity of anti-predatory behavior of both *Tegula funebralis* and *Nucella lamellosa*, we measured the proportion of time individual snails spend above the waterline in the presence and absence of their predator species, *Pisaster ochraceus* and *Cancer productus*. Data from this experiment are used to calculate estimated predation rates for snails that do not behaviorally respond to their predators, which are used to determine the impact anti-predatory responses have on the strength of trophic cascades. The experiment was conducted within laboratory mesocosms at Bodega Marine Lab in 2018 and 2019.

Pisaster ochraceus, *Cancer productus*, and *Tegula funebralis* were collected along the coastline of Sonoma County, California in 2018. Both *Pisaster* and *Tegula* were sampled at Carmet Beach (38.372172 N, -123.076438 W), and the *Cancer* crabs were gathered subtidally from Doran Beach (38.309334 N, -123.048703 W). *Nucella lamellosa* were collected at Washington Park in Anacortes, Washington (48.502190 N, -122.691865 W) in July 2019.

We measured the behavior of both *Nucella* and *Tegula* in the presence and absence of their respective predators. We established 20 mesocosms (33cm x 20cm x 11.5cm) each with 10 *Tegula* that were provided with *Ulva* sp. *ad libitum.* Half of the mesocosms were exposed to *Pisaster* cue and the other 10 to just seawater. Predator exposure was accomplished by placing an individual *Pisaster* in a separate container, and then allowing cue generated by it to flow into the appropriate mesocosms. *Pisaster* were fed an individual *Tegula* once a week. Over a period of 14 days, we measured the number of snails either above or below the water line. *Ulva* sp. was included in the experiment in case its presence affected the snails' decision to leave the water. We used the same procedure with *Cancer* to estimate *Tegula's* behavioral response to them. We also used an analogous procedure to estimate *Nucella's* behavioral response to *Pisaster*, with the exception that only five snails were used in each mesocosm due to the larger sizes of individuals of this snail species, and a small rock with *Balanus glandula* replaced *Ulva* as the basal resource.

Because a subset of our *Nucella* displayed morphological inducible defenses from the induction period, we also crossed the *Pisaster* cue treatment with the induced morphology treatment such that of the 10 mesocosms experiencing *Pisaster* cues, half of them contained induced *Nucella* and the other half had non-induced *Nucella*. Of the 10 mesocosms with no predator cue, half had induced *Nucella* and the other half had non-induced individuals.

To test the effect of predator cue on the snails' behavior, we conducted a logistic regression on the proportion of snails in and out of the water line with container as a random effect. For *Nucella*, we also added induced morphology as a predictor along with its interaction with *Pisaster* cue, but because both terms were non-significant, we removed them from the final model. In addition, we added the containers they were housed in during the induction period as an additional random effect.

Organism identifiers (taxonomic names used in dataset metadata):

Scientific Name, Life Science Identifier (LSID)

Tegula funebralis, urn:lsid:marinespecies.org:taxname:534190
Nucella lamellosa, urn:lsid:marinespecies.org:taxname:404218
Pisaster ochraceus,urn:lsid:marinespecies.org:taxname:240755
Cancer productus,urn:lsid:marinespecies.org:taxname:440382
Ulva sp., urn:lsid:marinespecies.org:taxname:144296
Balanus glandula, urn:lsid:marinespecies.org:taxname:394848

Data Processing Description

See "Supplemental Files" for analysis package (R-language).

BCO-DMO Curation Notes

* Raw data and analysis R-scripts for three related datasets were packaged into the supplemental file Fear_behavior_with_predators_analysis_package.zip (no modifications to files). The zip file was attached to all three datasets (BCO-DMO datasets 948204, 948210, 948216).

* Data table from submitted file "Nucella behavior data.csv" was imported into the BCO-DMO data system for this dataset (948204). Table will appear on this dataset page as Data File: 948204_v1_fear-behavior_nucella.csv (with other download format options).

* Column "Date" renamed to "Date_local", and "Time" renamed to "Time_local". [US/Pacific local time]

* New column "ISO_DateTime_UTC" added by combining "Date_local" and "Time_local" with timezone conversion to UTC in ISO 8601 format.

* Bounding box for dataset determined by sampling locations provided and location of experiment at Bodega Bay Marine Laboratory (38.3180548,-123.0743098).

* Any column names with characters other than letters, numbers and underscores were renamed to meet BCO-DMO naming conventions designed to support broad re-use by a variety of research tools and scripting languages. [Only numbers, letters, and underscores. Can not start with a number]

Missing Data Identifiers:
* In the BCO-DMO data system missing data identifiers are displayed according to the format of data you access. For example, in csv files it will be blank (null) values. In Matlab .mat files it will be NaN values. When viewing data online at BCO-DMO, the missing value will be shown as blank (null) values.

* Taxonomic identifiers added to the metadata (Life Science Identifiers (LSID)). Names matched using the World Register of Marine Species (WoRMS) on 2024-01-02.

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Data Files

File
Raw data of Nucella behavior in the presence of predator cue filename: 948204_v1_fear-behavior_nucella.csv (Comma Separated Values (.csv), 95.01 KB) MD5:cf1b6ab6baa7fa21f5ff23ece1380025 Primary data file for dataset ID 948204, version 1. These data are also included in the supplemental file "Fear_behavior_with_predators_analysis_package.zip" in a format compatible with the analysis scripts "Nucella behavior data.csv"

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Supplemental Files

File
Fear behavior with predators: Analysis package (R-language) filename: Fear_behavior_with_predators_analysis_package.zip (ZIP Archive (ZIP), 95.77 KB) MD5:b5f80498b119b1e7cd2e49497fbd6ba2 This analysis and plotting package contains scripts for analyzing the laboratory data. Note that the csv data tables included in this package are the exact format of the data required to import into the supplied R-scripts. They differ slightly form the data provided from the BCO-DMO data system due to column naming requirements and date formats (see "BCO-DMO Processing" section). Files included in analysis zip package: 'Tegula Cancer Behavior stats.csv' - File containing raw data of Tegula behavior in the presence of Cancer crab cues. This is the source file imported into the BCO-DMO data system for dataset 948210 version 1 (https://www.bco-dmo.org/dataset/948210). 'Tegula Cancer behavior stats.R' - R script containing statistical analysis on Tegula behavior in the presence of Cancer crab cues 'Tegula Pisaster behavior stats.csv' - File containing raw data of Tegula behavior in the presence of Pisaster cues. This is the source file imported into the BCO-DMO data system for dataset 948216 version 1 (https://www.bco-dmo.org/dataset/948216). 'Tegula Pisaster behavior stats.R' - R script containing statistical analysis on Tegula behavior in the presence of Pisaster cues 'Nucella behavior data.csv' - File containing raw data of Nucella behavior in the presence of predator cue. This is the source file imported into the BCO-DMO data system for dataset 948204 version 1 (https://www.bco-dmo.org/dataset/948204). 'Nucella behavior data stats_ part 1.R' - Part 1 of R script containing statistical analysis on Nucella behavior in the presence of predator cue 'Nucella behavior data stats_part 2.R' - Part 2 of R script containing statistical analysis on Nucella behavior in the presence of predator cue

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Related Publications

Ng, G., & Gaylord, B. (2025). Identifying the role of fear in trophic cascades. Ecosphere. Manuscript in preparation.
Results

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Related Datasets

IsRelatedTo

Ng, G., Gaylord, B. (2025) **Algal consumption data from Tegula in the presence of the predator Cancer productus, displaying anti-predatory responses or not within mesocosms at Bodega Marine Lab in 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-01-02 doi:10.26008/1912/bco-dmo.947753.1 [view at BCO-DMO]
Relationship Description: Data from experiments to be published in results publication Ng & Gaylord (2025, in-prep). See "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

Ng, G., Gaylord, B. (2025) **Algal consumption data from Tegula in the presence of the predator Pisaster ochraceus, displaying anti-predatory responses or not within mesocosms at Bodega Marine Lab in 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-01-02 doi:10.26008/1912/bco-dmo.947757.1 [view at BCO-DMO]
Relationship Description: Data from experiments to be published in results publication Ng & Gaylord (2025, in-prep). See "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

Ng, G., Gaylord, B. (2025) **Barnacle consumption of Nucella lamellosa that either displayed behavioral or morphological fear responses or not in the presence of predators within laboratory mesocosms at Bodega Marine Lab in 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-01-09 doi:10.26008/1912/bco-dmo.948228.1 [view at BCO-DMO]
Relationship Description: Data from experiments to be published in results publication Ng & Gaylord (2025, in-prep). See "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

Ng, G., Gaylord, B. (2025) **Behavioral data of Tegula funebralis in the presence of predator Cancer productus within laboratory mesocosms at Bodega Marine Lab in 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-01-09

doi:10.26008/1912/bco-dmo.948210.1 [view at BCO-DMO]
Relationship Description: Data from experiments to be published in results publication Ng & Gaylord (2025, in-prep). See "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

Ng, G., Gaylord, B. (2025) **Behavioral data of Tegula funebralis in the presence of predator Pisaster ochraceus within laboratory mesocosms at Bodega Marine Lab in 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-01-09 doi:10.26008/1912/bco-dmo.948216.1 [view at BCO-DMO]
Relationship Description: Data from experiments to be published in results publication Ng & Gaylord (2025, in-prep). See "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

Ng, G., Gaylord, B. (2025) **Nucella lamellosa morphometric measurements after induction in the presence of predatory Pisaster ochraceus at Bodega Marine Laboratory in 2018 and 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-04-21 doi:10.26008/1912/bco-dmo.959533.1 [view at BCO-DMO]
Relationship Description: Data from experiments to be published in results publication Ng & Gaylord (2025, in-prep). See "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

Ng, G., Gaylord, B. (2025) **Predation data of tethered Nucella lamellosa in the presence of predator Pisaster ochraceus within laboratory mesocosms at Bodega Marine Lab in 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-01-09 doi:10.26008/1912/bco-dmo.948222.1 [view at BCO-DMO]
Relationship Description: Data from experiments to be published in results publication Ng & Gaylord (2025, in-prep). See "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

Ng, G., Gaylord, B. (2025) **Predation data of tethered Tegula funebralis in the presence of predator Cancer productus within laboratory mesocosms at Bodega Marine Lab in 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-04-21 doi:10.26008/1912/bco-dmo.959435.1 [view at BCO-DMO]
Relationship Description: Data from experiments to be published in results publication Ng & Gaylord (2025, in-prep). See "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

Ng, G., Gaylord, B. (2025) **Predation data of tethered Tegula funebralis in the presence of predator Pisaster ochraceus within laboratory mesocosms at Bodega Marine Lab in 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-04-21 doi:10.26008/1912/bco-dmo.959441.1 [view at BCO-DMO]
Relationship Description: Data from experiments to be published in results publication Ng & Gaylord (2025, in-prep). See "Related-Resource" page for that results publication https://www.bco-dmo.org/related-resource/948176

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Parameters

Parameter	Description	Units
Day	the number of days since the start of the experiment.	days
Date_local	date (local, US/Pacific time zone) of data collection.	unitless
Time_local	time (local, US/Pacific time zone) of data collection.	unitless
ISO_DateTime_UTC	datetime with timezone (UTC, in ISO 8601 format) of the data collection.	unitless
Sump	Sump identifier. Which of two sump tanks were used in the experiment.	unitless
Container	mesocosm identfier. A unique identifier for individual mesocosm.	unitless
Container_past	a unique identifier for past mesocosms the snails were housed in.	unitless
Indiv	a unique identifier for each individual Nucella.	unitless
Induced	whether the snail has an induced morphology or not.	unitless
Pisaster	whether predatory Pisaster cue were used in the treatment or not	unitless
Pisaster_size	the size of the Pisaster used (length in mm from madreporite to longest arm) if applicable.	millimeters (mm)
Behavior	a binary response variable of whether the snail was below the waterline (I) or outside the water line (O) which is then coded to 1 and 0 respectively in the column Behavior_num	unitless
Behavior_num	a binary response variable of whether the snail was below the waterline (1) or outside the water line (0) which is then coded to (I) and (O) respectively in the column "Behavior"	unitless

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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.

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Funding

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

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