Predation rates by Pisaster ochraceus on Mytilus californianus along the Oregon and Northern California rocky intertidal coastline from 1999 to 2023

Website: https://www.bco-dmo.org/dataset/990987
Data Type: Other Field Results, experimental
Version: 1
Version Date: 2026-01-30

Project
» LTREB: Testing tipping points in a model rocky intertidal meta-ecosystem – Climate-change, increasing variances, and response mechanisms (LTREB Intertidal Tipping Points)

Contributors	Affiliation	Role
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Abstract
This dataset contains time-series measurements of mussel (Mytilus californianus) survival and experimental predation rates by the sea star Pisaster ochraceus from rocky intertidal sites along the North American west coast from 1999 to 2023. Study/Experiment abstract: Mass mortality from disease epidemics can challenge the resistance and resilience of populations and communities. Assessing the impacts of such events and their consequences is crucially dependent on long-term datasets In 2013-16, sea star wasting disease (SSWD) caused population-wide crashes of the archetypal keystone species, the sea star Pisaster ochraceus, along the North American west coast. We used a long-term dataset to assess how predation rates by Pisaster on Mytilus californianus varied over a 16-year time series (2007-2023) of annual predation rate at 7 sites. As expected, SSWD drove predation rates to near-zero. This persisted for 3-8 years depending on site, and as of 2024, predation rates at two sites remain unrecovered.

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Coverage

Location: rocky intertidal along the Oregon and California Coast
Spatial Extent: **N**:44.83863831 **E**:-123.07365 **S**:38.31819916 **W**:-124.56512
Temporal Extent: 1999-06-14 - 2023-06-21

Dataset Description

This time series is part of the LTREB project listed on this page (Award DEB-2050017) and was supported by the prior awards listed in the “Awards” section on this page.

Organism identifiers (Life Science Identifiers, LSIDs):
Mytilus californianus, urn:lsid:marinespecies.org:taxname:367837
Pisaster ochraceus, urn:lsid:marinespecies.org:taxname:240755
Pisaster, urn:lsid:marinespecies.org:taxname:240754

Methods & Sampling

As detailed previously (Menge et al. 2004, 2016, 2023), we quantified field predation rates by determining loss rate of transplanted mussels exposed to sea stars compared to mussels protected from sea stars. Replicated experiments were conducted at all sites except Tokatee Klootchman, and each year 2007-2023, except for Rocky Point which began in 2016. In March-April each year, we translocated 10 clumps of 30-50 mussels ranging in shell length from 3-5 cm (easily eaten by adult *Pisaster*) to plots within the foraging range of *Pisaster* near the mid-low zone transition, just below the existing mussel beds. After 4-6 weeks of allowing them to reattach under plastic mesh, we removed the plastic mesh. We then fastened wire mesh open-topped 4-sided cages around 5 plots to prevent predation by *Pisaster* and fastened 2-sided partial cages next to 5 plots to allow predation, with spatially paired replicates of each treatment. We monitored the number of surviving mussels every 2-4 weeks from ~June-December of each year, thus encompassing the period of most active predation. To calculate predation rates, after adjusting for background mortality in exclusion cages, we regressed the number of mussels over time in each plot and used the slope as an estimate of predation rate (in +*Pisaster* treatments) or background mortality (in -*Pisaster* treatments). We excluded time points after the first zero (i.e., when all mussels had been eaten), when mussels increased by more than 3 (these are counting errors), or when the number of mussels dropped by more than 5 while the plot was either buried in sand, a cage was missing, or a sea star invaded the cage.

BCO-DMO Processing Description

* sheet 1 within the submitted file "BCODMO_PredRateMaster_1990-2023_2024-09-11_SAG.xlsx" was imported into the BCO-DMO data system for this dataset. Values "NA" imported as missing data values. Table will appear as Data File: 990987_v1_predation-rates.csv (along with other download format options).

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.

* Column names in the supplemental table were adjusted to conform to 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]

* Dates converted to ISO 8601 format

Supplemental files:

* Table within BCODMO_SiteList_STARS_2023-04-11_SAG.xlsx added as supplemental file sitelist_stars.csv

* Validation Lists extracted from sheet ValidationList in BCODMO_BTMasterAnnot_2000-2024_2025-03-06_SAG.xlsx. Reformatted to not imply this is a table but rather unique lists of controlled vocabulary elements the study used.

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Related Publications

Gravem, S. A., & Menge, B. A. (2025). Metapopulation-scale resilience to disease-induced mass mortality in a keystone predator: From stasis to instability. Ecosphere, 16(10). Portico. https://doi.org/10.1002/ecs2.70426
Results

Menge, B. A., Blanchette, C., Raimondi, P., Freidenburg, T., Gaines, S., Lubchenco, J., Lohse, D., Hudson, G., Foley, M., & Pamplin, J. (2004). SPECIES INTERACTION STRENGTH: TESTING MODEL PREDICTIONS ALONG AN UPWELLING GRADIENT. Ecological Monographs, 74(4), 663–684. Portico. https://doi.org/10.1890/03-4060
Methods

Menge, B. A., Cerny-Chipman, E. B., Johnson, A., Sullivan, J., Gravem, S., & Chan, F. (2016). Sea Star Wasting Disease in the Keystone Predator Pisaster ochraceus in Oregon: Insights into Differential Population Impacts,

Recovery, Predation Rate, and Temperature Effects from Long-Term Research. PLOS ONE, 11(5), e0153994. https://doi.org/10.1371/journal.pone.0153994
Results

Menge, B. A., Robinson, J. W., Poirson, B. N., & Gravem, S. A. (2023). Quantitative biogeography: Decreasing and more variable dynamics of critical species in an iconic meta-ecosystem. Ecological Monographs, 93(1). Portico. https://doi.org/10.1002/ecm.1556
Results

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Parameters

Parameter	Description	Units
GroupCode	Research group that collected field data. [usually OSU, other options are UCSC, UCSB, CON (Concordia), or LiMPETS]	unitless
SiteCode	Site code. See sitelist_stars.csv and ValidationList.txt. [See Site List]	unitless
Site	site name. [See Site List]	unitless
Latitude	Latitude.	decimal degrees
Longitude	Longitude.	decimal degrees
Cape	cape or headland of site.	unitless
Region	region of site.	unitless
State	state of site.	unitless
Year	Year of count. [Formula =YEAR(Date)]	unitless
Month	Month of count. [Formula =YEAR(Month)]	unitless
Day	Day of count.	unitless
Date	Date of count.	unitless
StartDate	Start Date of the plot and deployment Year. [Matches date of PredRate_Field, Activity Code Started" in Data Inventory]"	unitless
DaysSinceStart	Days elapsed since start. [Formula =Date-StartDate]	unitless

YearStart	Year started. Usually in early summer when vexar removed and cages deployed. [Formula=Year(StartDate)]	unitless
Exposure	E for this experiment. [E or P for Exposed or Protected]	unitless
Zone	L for this experiment. [H, M or L, for High Mid or Low]	unitless
Rep	Replicate. [Integer 1-5. Usually two treatment plots per rep. [ANTIQUATED: Rep eg 1b and 1c represent a plot that reached zero and was restarted in the same field season]]	unitless
Treatment	Complete cage for Pisaster exclusion (sometimes called open cage or cage) or partial cage for Pisaster access (sometimes called fence). [Complete cage or Partial cage]	unitless
PisTreatment	Pisaster excluded. Pisaster present.	unitless
PlotTimeline	FILL THIS IN AT END OF THE YEAR. Describes timeline of experiment. Start= vexar removed and first count is done. Monitoring = monthly counts of mussels. End = first observation of 0 mussels in a PlotYear. Inactive = subsequent observations of 0 mussels in a PlotYear. Special situations: If there is NA for a plot but subsequent counts for the plot it is still designated as Monitoring. If the final observation of a plot is NA, then the previous count is the End of the plot's timeline and that NA observation is Inactive. If an adult Pisaster is found in a complete cage plot and there is a drop in the live mussels count of 5 or more mussels, then plot is considered Inactive and the previous count is the End of the plot's timeline. If a complete cage is missing and was not replaced, then there are two options. If there was a drop in the live mussel count of the plot by 5 or more mussels, then the plot is considered Inactive, and the previous count is the End of the plot's timeline. If there was not a drop in the live mussel count by 5 or more mussels, then that count (where the cage was noted as missing) is the End of the plot's timeline and subsequent counts are Inactive. If a complete cage was missing but was replaced, then the plot is Active, unless there was a drop in the live mussel count by 5 or more mussels, in which case it should be Inactive. If there is sand in the plot, then the plot can either be designated as Monitoring or Inactive. If there was a drop in the live mussel count by 5 or more mussels during the sand event, then the count prior to the sand is the End of the plot's timeline, and if not, then the plot will continue to be designated as Monitoring during and after the sand event. If there is only an initial count for a plot use Start and then Inactive. . [Start, Monitoring, End, Inactive. Formatted as green, yellow, red, black]	unitless

PlotStatus	FILL THIS IN AT END OF THE YEAR. Describes whether experiment is active by individual plot and time point. From initial to final count the plot is considered active, after the final count the plot is inactive. If there is NA for a count the plot is still active, unless there are no subsequent counts. In this case, the plot would be Inactive and the previous count is the final count (plot Active). If there is an adult Pisaster in a complete cage plot and there is a drop in the plot's live mussels count by 5 or more mussels, the plot should be Inactivated and the previous count will be the final count (plot Active). If a complete cage is missing and it was not replaced then there are two options. If there was a drop in the live mussel count of the plot by 5 or more mussels, then the plot should be Inactivated and the previous count will be the final count (plot Active). If there was not a drop in the live mussel count by 5 or more mussels, then the plot is considered Active. If a complete cage is missing but it was replaced, then the plot is Active, unless there wa a drop in the live mussel count by 5 or more mussles, in which case it should be Inactive. If there is sand in the plot, then the plot can either be designated as Active or Inactive. If there was a drop in the live mussel count by 5 or more mussels during the sand event, then the count prior to the sand is the Active and then Inactive during the sand event and after. If there was not a drop in the live mussel count by at 5 or more mussels, then the plot will continue to be designated as Active during and after the sand event. If there is sand in the plot, so that no count can be done, then the plot is Inactive. If there is only an initial count for a plot use Active and then Inactive. We assume the counts are inaccurate between obervations if the mussels go up by >3, in which case the time point with the increase should be inactivated (likely due to folks counting small mussel recruits) . [Active or Inactive. Formatted as green, black]	unitless
MusselsAtStart	Mussels Present at start of experiment.	unitless
Count_LiveMussels	Count of live mussels in plot on Date. Disregard small mussel recruits. [Integer < 55]	unitless
PropMussRemaining	Proportion mussels alive compared to mussels at start. [Integer < 55]	unitless
Change_Mussels	Change in mussels since last observation. DO NOT ENTER DATA IN THIS CELL. [This is only for checking data and making descisions about plot timelines and is replaced later with more accurate calc. First sort for PlotID_Date. Formula = Count_ LiveMussels for Focal Row-Count_LiveMussels for above row. Any plots with a change of >3 mussels between time steps will turn red and should be investigated for accuracy (ignore values between plots). Any drops >10 in complete cages should also be investigated and inactivated if a pisater invaded, a cage was gone, or was buried.]	count
MusselsAtEnd	Mussels Present at end of experiment.	count
TotalMussKilled	Mussels at start vs end of experiment.	count
N_Observations	Number of times the plot was surveyed.	unitless

StarSearch_Count	Number of adult Pisaster o. found in a specified search radius around pred rate plot. Stars must be at least 10cm in diameter to be considered adult. If star search counts were not done use NA..	count
StarSearch_Area_m2	Record the search area of the star search in meters squared. OR search is a 1m radius or 3.14m2 search area. CA search is a 2m radius or 12.57m2 search area. If star search counts were not done use NA..	meters squared (m2)
LocalStarDens_m2	Density of Stars near the plot per m2.	stars per square meter squared (#/m2)
PISOCH_InCC	Enter Y for presence of adult Pisaster within complete cage plots ONLY. Used to determine Plot timeline and status. Data recorded in notes section of field datasheets. Assume no stars in complete cage unless noted. If no information OR for partial cages leave blank. [Y]	unitless
PISOCH_Count_InPlot	not described	unitless

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Project Information

LTREB: Testing tipping points in a model rocky intertidal meta-ecosystem – Climate-change, increasing variances, and response mechanisms (LTREB Intertidal Tipping Points)

Coverage: West coast of North America

NSF abstract:

In recent decades, ocean ecosystems, long thought to be immune to change, have undergone disruptions to their structure, diversity, and geographic range, yet the actual underlying reasons for such changes in oceanic biota are often unclear. Coastal intertidal zones (i.e., the shore between high and low tides) have long served as important ecological model systems because of advantages in accessibility and ease of observation, occupancy by easily studied and manipulated organisms of relatively short lifespans, and exposure to often severe environmental conditions. This research will address the stability of a well-known rocky shore system along the Oregon and California coasts. Prior long-term research indicates that, although casual observation suggests these systems are stable, in fact, they may be on the cusp of shifting into another state, losing iconic organisms like mussels and sea stars, and becoming dominated by seaweeds. These changes might be comparable to losing trees and large predators from terrestrial systems. This study would result in the training of undergraduates and graduate students, including individuals from under-represented groups. Additionally, this study would include outreach to the general public.

The researchers will focus particularly on impacts of increasing and more variable warming on community recovery. For example, climate oscillations (e.g., El Niño), coastal upwelling, and particularly temperature have all changed in recent decades in ways leading to increased stress on intertidal biota. In apparent response, coastal ecosystems evidently have become less productive, organismal performance (growth, reproduction) has declined, and key dynamical processes (species interactions) have weakened. The new research will pursue these strong hints of an impending “tipping point” by (1) continuing the projects that led to the insights of increasing instability, (2) adding new projects that will pinpoint ecological changes, and (3) expanding the region of work to include locations in California. Research will assess whether or not sea stars recover from wasting disease, experimentally test if species interactions are indeed weakening, quantify the annual inputs of new prey and changes in abundance, diversity, stability, and resilience of intertidal communities, and document changes in the physical environment. Using field observations and experiments, the research will provide insight into impacts of environmental change, particularly warming, on the future of coastal ecosystems, and more generally, into possible future states of Earth's ecosystems. Using these data, we will test the hypothesis that direct and indirect effects of climate change are driving, or may drive these systems into new, alternative states.

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-1061233
NSF Division of Ocean Sciences (NSF OCE)	OCE-0726983
NSF Division of Ocean Sciences (NSF OCE)	OCE-1448913
NSF Division of Environmental Biology (NSF DEB)	DEB-2050017
NSF Division of Environmental Biology (NSF DEB)	DEB-1554702
NSF Division of Environmental Biology (NSF DEB)	DEB-1050694

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