Histological gonad reproductive scores for purple sea urchins from experiments at the Bodega Marine Laboratory from Sep to Dec 2023

Website: https://www.bco-dmo.org/dataset/968787
Data Type: experimental
Version: 1
Version Date: 2025-07-16

Project
» Collaborative Research: The effects of marine heatwaves on reproduction, larval transport and recruitment in sea urchin metapopulations (Urchin metapopulations)

Contributors	Affiliation	Role
Okamoto, Daniel K.	University of California-Berkeley (UC Berkeley)	Principal Investigator
Karelitz, Sam E.	University of California-Berkeley (UC Berkeley)	Scientist
Swezey, Daniel	Kashia Band of Pomo Indians	Scientist
Munstermann, Maya J.	University of California-Berkeley (UC Berkeley)	Student
Ward-Diorio, Rebecca	University of California-Berkeley (UC Berkeley)	Technician
Mickle, Audrey	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
These data include histological scores of individual purple sea urchins, Strongylocentrotus purpuratus (urn:lsid:marinespecies.org:taxname:240747), involved in a multifactorial laboratory experiment at the Bodega Marine Laboratory between 2023-09 and 2023-12. The experiment investigated how population source (Sonoma, Santa Barbara, San Diego Counties) and temperature (10 degrees, 20 degrees, and dynamic historical temperature trends (21-18 °C mimicking a historical El Nino) affected reproductive stage of the organisms.

Table of Contents

Coverage

Location: Bodega Marine Laboratory with wild animals collected from Stillwater Cove (38.546455, -123.298284), Mowhawk Reef (34.394139, -119.729361) and Point Loma (32.711484, -117.272601)
Spatial Extent: **N**:38.546455 **E**:-117.272601 **S**:32.711484 **W**:-123.298284
Temporal Extent: 2021-09-20 - 2021-12-06

Methods & Sampling

These data include histological scores of individual purple sea urchins, *Strongylocentrotus purpuratus*, involved in a multifactorial laboratory experiment at the Bodega Marine Laboratory between 2023-09 and 2023-12. The experiment investigated how populaton source (Sonoma, Santa Barbara, San Diego Counties) and temperature

(10 degrees, 20 degrees, and dynamic historical temperature trends (21-18 °C mimicking a historical El Nino) affected reproductive stage of the organisms.

Field Collections and Acclimation

We collected animals from three locations in California including Stillwater Cove in Sonoma County, Mohawk Reef in Santa Barbara, and Point Loma in San Diego using SCUBA from 3-5 meters mean low water. Urchins were dry transported layered between kelp and transferred via ground transportation and into the ambient flow through sea water tanks at Bodega Marine Lab within 24 hours of collection. Temperature ramps and acclimation periods were manually adjusted in 1ºC increments.

Mesocosm System

Animals were housed in a temperature controlled seawater system at the Bodega Marine Laboratory. We placed individuals in a custom-built experimental array at the Bodega Marine Laboratory in which individuals from each population were placed in a split plot design in replicated (N = 4 each 140L - 73 (W) x 66 (H) x 32 (D) cm) acrylic tanks per treatment (Oceans Design Inc). Tanks were fed by sumps fixed with both 0.25hp chillers (Aqualogic Delta Star®) and 1000W heat sticks (TSHTCE-1000S) and temperature controllers to regulate temperature in a partially recirculating flow through system with fresh seawater allocated to each system at a rate of 0.5L/min (approx. 5x turnover per day). Each sump was affixed with protein skimmers, UV filter, and bio-ball filters such that water was first filtered and then UV sterilized upon recirculation. Temperatures were set by hand each day for the heatwave treatments and checked with temperature probes for all treatments. We ran experiments from September 15, 2023, to December 19, 2023.

Animal husbandry

We fed individuals uniform dry pellets combining several macroalgal species formulated for the aquaculture of *S. purpuratus* (Urchinomics Canada Inc., Halifax, NS, Canada). Animals in mesocosms were fed twice per week and we removed uneaten food and refuse every 72 h. To optimize access for all mesocosm inhabitants to abundant food, we enclosed subjects and food in aquaculture baskets (two baskets per mesocosm, 7 or 8 animals per basket, Thunderbird Plastics 48 x 33.5 x 10 cm Fish Farm Tray) such that food was always readily accessible, and movement was not impeded. Each animal was supplied approximately 2.7 grams of pelleted food twice per week for the duration of the experiment.

Histological and gonad assays

Animals were measured and sacrificed and gonads were carefully excised from the opened test. Using a clean, sterile scalpel we excised an approximately 2 mm cross section from the first gonad which we immediately placed in a histological cassette, preserved in Hartmann’s fixative for 24 hours, and transferred to 70% EtOH. Preserved gonads were embedded in paraffin, sliced, stained using eosin and hematoxylin, and mounted. We assessed gonad samples for sex and developmental stage using four visual subsections and the entire sample collectively to ensure agreement among subsamples. Histological slides were scored on a scale of I to IV (Byrne 1990).

BCO-DMO Processing Description

- Imported "pop_comparison_histology.csv" into the BCO-DMO system
- Replaced periods with underscores to comply with BCO-DMO guidelines
- Exported file as "968787_v1_pop_comparison_histology_bml.csv"
- Species name Strongylocentrotus purpuratus (urn:lsid:marinespecies.org:taxname:240747) verified as current accepted form on 2025-07-08, using the WoRMs World Registery of Marine Species database.

[table of contents | back to top]

Related Publications

Byrne, M. (1990). Annual reproductive cycles of the commercial sea urchinParacentrotus lividus from an exposed intertidal and a sheltered subtidal habitat on the west coast of Ireland. Marine Biology, 104(2), 275–289. https://doi.org/10.1007/bf01313269 https://doi.org/10.1007/BF01313269

Methods

Okamoto, D. K., Spindel, N. B., Collicutt, B., Mustermann, M. J., Karelitz, S., Gimenez, I., Rolheiser, K., Cronmiller, E., Foss, M., Mahara, N., Swezey, D., Ferraro, R., Rogers-Bennett, L., & Schroeter, S. (2023). Thermal suppression of gametogenesis explains historical collapses in larval recruitment. https://doi.org/10.1101/2023.09.28.559919
Results

[table of contents | back to top]

Related Datasets

IsRelatedTo

Okamoto, D. K., Munstermann, M. J., Karelitz, S. E., Spindel, N., Swezey, D., Collicutt, B., Mahara, N., Cronmiller, E., Rolheiser, K., Foss, M., Gimenez, I., Ward-Diorio, R. (2025) **Histological gonad reproductive scores for purple sea urchins from experiments at the Quadra Island Ecological Observatory from Sep to Dec 2021.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-07-16 http://lod.bco-dmo.org/id/dataset/968848 [view at BCO-DMO]
Relationship Description: Histological gonad reproductive scores for population collected in Ucluelet, British Columbia, Canada

[table of contents | back to top]

Parameters

Parameter	Description	Units
row_num	Row number	unitless
treatment	Temperature treatment consisting of constant temperatures at 10, 13, 16, 17, 18, or 20 degrees, an El Ni–o treatment dropping from 21 to 18 degrees or a La Ni–a treatment dropping from 18 to 16 degrees	unitless
location	Source location of the animal; Sonoma County (SON), Santa Barbara County (SB), or San Diego County (SD)	unitless
sex	Sex of the organism	unitless
HISTO_CASETTE_NO	Unique identifier for the histological sample that relates to the organismal data file	unitless
cat	Histological stage category; standard staging scale of 1 to 4 where 4 is fully mature and 1 is immature	unitless
latitude	Latitude animal was collected	decimal degrees
longitude	Longitude animal was collected	decimal degrees

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Microscope - Optical
Dataset-specific Description	We assessed gonad samples for sex and developmental stage using four visual subsections and the entire sample collectively to ensure agreement among subsamples.
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

Dataset-specific Instrument Name	Measure
Generic Instrument Name	ruler
Dataset-specific Description	Animals were measured and sacrificed and gonads were carefully excised from the opened test.
Generic Instrument Description	A device used for measuring or for drawing straight lines, consisting of an elongated piece of rigid or semi-rigid material marked with units for measurement. Device that allows one or more physical dimensions of a sample or specimen to be determined by visible comparison against marked graduations in units of measurement of dimension length.

Dataset-specific Instrument Name	Scalpel
Generic Instrument Name	scalpel
Dataset-specific Description	Using a clean, sterile scalpel we excised an approximately 2 mm cross section from the first gonad which we immediately placed in a histological cassette, preserved in Hartmann’s fixative for 24 hours, and transferred to 70% EtOH.
Generic Instrument Description	A scalpel, or lancet, or bistoury, is a small and extremely sharp bladed instrument used for dissection and surgery.

Dataset-specific Instrument Name	SCUBA
Generic Instrument Name	Self-Contained Underwater Breathing Apparatus
Dataset-specific Description	For the second experiment, we collected animals from three locations in California including Stillwater Cove in Sonoma County, Mohawk Reef in Santa Barbara, and Point Loma in San Diego using SCUBA from 3-5 meters mean low water.
Generic Instrument Description	The self-contained underwater breathing apparatus or scuba diving system is the result of technological developments and innovations that began almost 300 years ago. Scuba diving is the most extensively used system for breathing underwater by recreational divers throughout the world and in various forms is also widely used to perform underwater work for military, scientific, and commercial purposes. Reference: https://oceanexplorer.noaa.gov/technology/technical/technical.html

[table of contents | back to top]

Project Information

Collaborative Research: The effects of marine heatwaves on reproduction, larval transport and recruitment in sea urchin metapopulations (Urchin metapopulations)

Coverage: Coastal California Waters from San Diego through Mendocino Counties

NSF Award Abstract:
Rapid and extreme warming events such as El Niño and marine heatwaves have had ecological and economic impacts on nearshore marine ecosystems. These impacts include reductions in biomass and collapses in commercial fisheries. For many species, population booms and busts are controlled by shifts in reproduction and juvenile dispersal related to warmer temperatures and ocean circulation. However, how population fluctuations are shaped by interacting processes that control adult reproduction and larval survival remains unclear. Marine heatwaves often accompany major disruptions in ocean circulation, which can affect survival and the distribution of species that produce free-floating, planktonic larvae. As a result, species can be impacted directly by temperature effects on organismal reproduction and survival, and indirectly by shifts in ocean circulation that affect larval success. This project is examining how the joint effects of temperature and ocean circulation are controlling populations of purple sea urchins (Strongylocentrotus purpuratus). To address project objectives, the team is developing oceanographic models to predict dispersal of planktonic larvae in combination with controlled experiments on adult reproductive success. This project is advancing the understanding of how ecologically important species respond to ocean temperature and circulation, which are forecast to shift under future climate change scenarios. Broader impacts of the project include training of students and post-docs in STEM and educational outreach. Curriculum development and implementation is occurring in collaboration with existing K-12 outreach programs that focus on underserved communities and under-represented groups. The goal is to empower the next generation of scientists to use integrative approaches to predict ecological consequences of climate change.

Purple sea urchins are an ideal species for studying the coupled impacts of warming and ocean circulation on recruitment and survival given a wealth of ecological and organismal data. The species has a mapped genome, can be transported large distances as larvae by ocean currents, and larval abundances in California exhibit orders of magnitude variation with heatwaves and El Niño fluctuations. To quantify the processes that shape spatial and temporal variability in larval supply, researchers are applying a novel combination of biophysical modeling, experiments and statistical modeling of long-term, high-resolution data on larval settlement across the Southern California Bight (SCB). Research module 1 is quantifying spatial and temporal patterns of larval transport using a 3D-biophysical model of the SCB. The model is testing how interactions among historical changes in ocean circulation and temperature, larval life history, and larval behavioral traits affect variation in larval supply in space and time. Research module 2 is focused on how temperature could affect spatial and temporal variation in egg production. Experiments are characterizing reproductive thermal performance

curves and quantifying how these vary among populations and organismal history. A novel assay is assessing epigenetic regulation of gene expression associated with performance curves. Finally, Module 3 will integrate mechanistic models from Modules 1 and 2 to statistically assess their ability to explain spatial and temporal trends in a nearly three-decade dataset of larval settlement from six sites in the SCB. This is one of the first studies that integrates models of larval transport, reproductive performance and settlement data to empirically test how physical and biological processes affect local recruitment patterns in complex marine meta-populations.

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023693
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023664
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023649

[table of contents | back to top]