Counts of organisms recorded during emergent and rapid emergent surveys conducted in the subtidal zone of northern California, Sonoma and Mendocino counties, from 1999 to 2023

Website: https://www.bco-dmo.org/dataset/927682
Data Type: Other Field Results
Version: 1
Version Date: 2024-08-30

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

Contributors	Affiliation	Role
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Abstract
The Kelp Forest Monitoring data record span surveys across 24 years from 1999 through 2023 at 20 locations on the Sonoma-Mendocino Coast, Northern California. Years without data, inclusive: 2002, 2020, 2021. These surveys are ongoing and are conducted by the California Department of Fish and Wildlife dive team with participation from dive program partners at UC Davis, UC Santa Cruz, Cal Poly Humboldt, Sonoma State, and other dive programs and volunteers. Not all sites were surveyed in all years. Surveys prior to 2000 were not conducted by the same teams or with the same methods except that all surveys were done using Scuba along 30 x 2 meter (m) transects randomly placed in the subtidal zone in rocky habitats dominated by bull kelp, Nereocystis luetkeana, forests. These randomly placed band transects surveys were stratified by depth (A=0-15, B=16-30, C=31-45, D=46-60 ft) as we know sea urchin and abalone populations differ by depth. Data collected include the number of live, dying (in some years during the mass mortality events), and dead sea urchins (red-Mesocentrotus franciscanus and purple-Strongylocentrotus purpuratus), red abalone (Haliotis rufescens), pinto abalone (H. kamtschatkana), flat abalone (H. walallensis), as well as empty abalone shells (again in some years). Additional data collected (if Scuba bottom time and/or air allowed): red abalone size, numbers or presence of associated species such as sea stars and predators, algal group quantification, and presence of bull kelp, substrate type. Data on algae and associated species differed depending on the year and the focus of the studies in response to ecosystem conditions but all years quantified sea urchins and abalones. These data provide a baseline of biological conditions in the kelp forest before, during and after the major marine heatwave of 2014-2016 in northern California. These data were used to manage the recreational red abalone fishery by the California Department of Fish and Wildlife from 2002 to the closure of the fishery in 2018. These data are from the two counties Sonoma and Mendocino County that had 95% of the bull kelp forests in northern California.

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Coverage

Location: Sub-tidal zone, North Coast of California, Sonoma and Mendocino counties
Spatial Extent: **N**:39.428584 **E**:-123.071539 **S**:38.31536 **W**:-123.82905
Temporal Extent: 1999-06-23 - 2023-09-18

Methods & Sampling

Data were collected during day-trips aboard California Department of Fish and Wildlife or NOAA patrol boats, generally 2-5 days at select survey locations in 1999, 2000, 2001, 2003-2019, 2022, and 2023.

All surveys were done using SCUBA along 30x2 meter (m) transects (60 square meters total area) randomly placed in the subtidal zone in rocky habitats dominated by bull kelp (*Nereocystis luetkeana*) forests. These randomly placed band transect surveys were stratified by depth (A=0-15, B=16-30, C=31-45, D=46-60 ft) as we know sea urchin and abalone populations differ by depth. Two divers (a dive team) work together to count and measure organisms.

Divers were deployed as teams to randomly-selected GPS waypoints within designated depth strata (A, B, C, D). Divers typically complete multiple transects within each of the four depth strata ranging from 0 to 60 feet at each site. Divers swim along transect tapes measuring 30 x 2m in area across the rocky reef. All transect surveys were in habitat dominated (>70% rock) by rocky reef.

Emergent Surveys:
Emergent sampling focused on emergent, exposed, or cryptic animals in rock crevices or under rock ledges but visible without turning rocks or the use of a flashlight. Data collected on the transects include depth of transect, dive number, the number of each species of abalone and sizes of *Haliotis rufescens*, pinto abalone (*H. kamtschatkana*), flat abalone (*H. walallensis*), number of sea urchins (red, *Mesocentrotus franciscanus*, or purple, *Strongylocentrotus purpuratus*) and size as time allowed, number of associated species and predators, substrate, algal type percent cover. Where needed divers mark abalone shells with yellow forestry crayons to avoid duplicate counts and measures. Data from each dive were recorded on waterproof datasheets which the divers fill out along the transect. Upon return to the boat, data sheets were checked by the lead diver to ensure accuracy and readability for the first field site quality control check.

Rapid Emergent Surveys:
In response to the extreme purple sea urchin population increase and abalone mortality event in 2016-18, survey methodology changed somewhat with fewer transects per site (approx. 12 per site). Divers conducted a rapid assessment sampling technique: Rapid Emergent Abalone Surveys were similar to standard emergent surveys (see above) but focused on purple sea urchin and red abalone counts of live and dead abalone and sea stars. Divers conduct two to four rapid emergent transects per dive.

Primary data collected on each rapid transect are number of live, dying, and dead red sea urchins, purple sea urchins, red abalone, pinto abalone, and flat abalone, as well as empty abalone shells. Additional data collected (if bottom time and/or air allowed): red abalone size, number of associated species and predators, algal habitat coverage, substrate type, and presence of bull kelp. Abalone that were measured were marked with yellow forestry crayons to avoid duplicate counts and measures. As with the emergent surveys, the divers fill out data on waterproof datasheets along the transect. Upon return to the boat data sheets are checked by the lead diver to ensure accuracy and readability for the first field site quality control check.

The data specific to this dataset are the numbers of purple sea urchins, red sea urchins, red abalone, flat abalone, and pinto abalone, as well as associated species along each transect.

Data Processing Description

Data were entered from the field data sheets into a Microsoft Access database, where they were sorted and exported to Excel files. Once data were proofed, they were saved in a text file as comma-separated values (CSV).

BCO-DMO Processing Description

- Imported original files "NSF_OCE_2023664_KelpForestSurveys_Species_CODES_v2_20240119.csv" (species code list) and "NSF_OCE_2023664_KelpForestSurveys_LOCATIONS_v4_20240105.csv" (site code list) into the BCO-DMO system.
- Imported original file "NSF_OCE_2023664_KelpForestSurveys_Species_COUNTS_v7_20240725.csv" (species counts) into the BCO-DMO system.
- Added the following columns from the site code list to the species count data: SiteName.
- Added the following columns from the species code list to the species count data: CommonName, ScientificName.
- Removed the non-standard character in Comments column in rows 2117 to 2130.
- Converted the SurveyDate column to YYYY-MM-DD format.
- On rows 22771 and 22772 of the original Excel file, the SurveyDate column has years of 2024 and 2025. Changed these to 2023 to match the Year column.
- Saved the final file as "927682_v1_kelp_forest_surveys_invert_species_counts.csv".

Problem Description

Surveys were not conducted in 2002, 2020, 2021.
Not all locations were surveyed in every year.

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Data Files

File	
927682_v1_kelp_forest_surveys_invert_species_counts.csv	(Comma Separated Values (.csv), 5.63 MB) MD5:c7003fe5c90966b4e3f3087a6d2f42dd
Primary data file for dataset ID 927682, version 1	

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Related Publications

García-Reyes, M., Thompson, S. A., Rogers-Bennett, L., & Sydeman, W. J. (2022). Winter oceanographic conditions predict summer bull kelp canopy cover in northern California. PLOS ONE, 17(5), e0267737. https://doi.org/10.1371/journal.pone.0267737
Results

Hamilton, S. L., Saccomanno, V. R., Heady, W. N., Gehman, A. L., Lonhart, S. I., Beas-Luna, R., Francis, F. T., Lee, L., Rogers-Bennett, L., Salomon, A. K., & Gravem, S. A. (2021). Disease-driven mass mortality event leads to widespread extirpation and variable recovery potential of a marine predator across the eastern Pacific. Proceedings of the Royal Society B: Biological Sciences, 288(1957), 20211195. https://doi.org/10.1098/rspb.2021.1195
Results

McPherson, M. L., Finger, D. J. I., Houskeeper, H. F., Bell, T. W., Carr, M. H., Rogers-Bennett, L., & Kudela, R. M. (2021). Large-scale shift in the structure of a kelp forest ecosystem co-occurs with an epizootic and marine heatwave. Communications Biology, 4(1). https://doi.org/10.1038/s42003-021-01827-6
Results

Okamoto, D. K., Schroeter, S. C., & Reed, D. C. (2020). Effects of ocean climate on spatiotemporal variation in sea urchin settlement and recruitment. Limnology and Oceanography, 65(9), 2076–2091. Portico. https://doi.org/10.1002/lno.11440
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

Rogers-Bennett, L., & Catton, C. A. (2019). Marine heat wave and multiple stressors tip bull kelp forest to sea urchin barrens. Scientific Reports, 9(1). https://doi.org/10.1038/s41598-019-51114-y
Methods

Rogers-Bennett, L., & Catton, C. A. (2022). Cascading impacts of a climate-driven ecosystem transition intensifies population vulnerabilities and fishery collapse. Frontiers in Climate, 4. https://doi.org/10.3389/fclim.2022.908708
Results

Rogers-Bennett, L., & Okamoto, D. (2020). Mesocentrotus franciscanus and Strongylocentrotus purpuratus. Sea Urchins: Biology and Ecology, 593–608. https://doi.org/10.1016/b978-0-12-819570-3.00032-9 https://doi.org/10.1016/B978-0-12-819570-3.00032-9
Methods

Rogers-Bennett, L., Kawana, S.K., Catton, C.A., Klamt, R., Dondanville, R., Maguire, A., and D. Okamoto. (In revision). Abalone recruitment patterns before and after sea urchin barrens formation in northern California: Incorporating climate change. New Zealand Journal Marine and Freshwater Research.
Results

Rogers-Bennett, L., Klamt, R., & Catton, C. A. (2021). Survivors of Climate Driven Abalone Mass Mortality Exhibit Declines in Health and Reproduction Following Kelp Forest Collapse. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.725134
Results

Rogers-Bennett, L., Yang, G., & Mann, J. D. (2022). Using the Resist-Accept-Direct management framework to respond to climate-driven transformations in marine ecosystems. Fisheries Management and Ecology, 29(4), 409–422. Portico. https://doi.org/10.1111/fme.12539
Methods

Spindel, N. B., Lee, L. C., & Okamoto, D. K. (2021). Metabolic depression in sea urchin barrens associated with food deprivation. Ecology, 102(11). Portico. https://doi.org/10.1002/ecy.3463
Methods

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Parameters

Parameter	Description	Units
SurveyNum	The unique identifier used for each dive transect. For example, ALB18-A1-1 where ALB is the DFW_short_code for Albion Bay; 18 is the year (2018); A1-1 is the randomized transect. For those years with a letter preceding a number, the letter refers to a depth stratum in feet: A=0-15, B=16-30, C=31-45, D=46-60 ft.	unitless
DFW_short_code	An alphanumeric code for the location	unitless
SiteName	The name of the location, e.g., Albion Bay	unitless
Lat	The latitude of the location	decimal degrees
Lon	The longitude of the location; negative values = West	decimal degrees
SurveyType	There are two survey types: Emergent surveys do not involve rolling over boulders or picking up rocks and do involve looking in rock crevices and under rocky overhangs. Transect-30m x 2 m (Emergent) - pre-2016. Transect-30m x 2 m (Rapid Emergent) - post-2017	unitless

SurveyDate	The date of the dive survey	unitless
Year	4-digit year of the dive survey	unitless
Month	Month of the dive survey	unitless
Day	Day of month of the dive survey	unitless
Timezone	Time zone; all surveys were conducted in the Pacific Standard Time Zone	unitless
SpeciesID	The alphanumeric code for the species encountered and/or measured	unitless
ScientificName	The scientific name of the species per the World Register of Marine Species (WoRMS)	unitless
CommonName	The common name of the species used by the researchers	unitless
Count	The number of the observed species along the transect	number of indiviuals
Presence	Whether or not the species was observed. Depending on time constraints, species were listed as observed, but not counted.	unitless
Comments	The divers' comments regarding conditions and other observations that may affect the data	unitless
ProtectionStatus	The special regulations for the location of the transect, e.g., no take MPA is a no take Marine Protected Area	unitless
AverageDepth	The average depth of the transect	feet
MinimumDepth	The shallowest depth of the transect	feet
MaximumDepth	The deepest part of the transect	feet

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Instruments

Dataset-specific Instrument Name	calipers
Generic Instrument Name	calipers
Generic Instrument Description	A caliper (or "pair of calipers") is a device used to measure the distance between two opposite sides of an object. Many types of calipers permit reading out a measurement on a ruled scale, a dial, or a digital display.

Dataset-specific Instrument Name	Handheld GPS (WGS84 datum)
Generic Instrument Name	Global Positioning System Receiver
Generic Instrument Description	The Global Positioning System (GPS) is a U.S. space-based radionavigation system that provides reliable positioning, navigation, and timing services to civilian users on a continuous worldwide basis. The U.S. Air Force develops, maintains, and operates the space and control segments of the NAVSTAR GPS transmitter system. Ships use a variety of receivers (e.g. Trimble and Ashtech) to interpret the GPS signal and determine accurate latitude and longitude.

Dataset-specific Instrument Name	
Generic Instrument Name	Self-Contained Underwater Breathing Apparatus
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

Dataset-specific Instrument Name	dive slates, underwater data sheets, pencils, and erasers
Generic Instrument Name	Underwater Writing Slate
Generic Instrument Description	Underwater writing slates and pencils are used to transport pre-dive plans underwater, to record facts whilst underwater and to aid communication with other divers.

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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.

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Funding

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

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