Urchin and abalone density responses to caged Pycnopodia field experiment in Sitka Sound urchin barrens, February 2023 from from February 2023 (High latitude kelp dynamics project)

Website: https://www.bco-dmo.org/dataset/942725
Data Type: experimental
Version: 1
Version Date: 2024-11-01

Project
» CAREER: Energy fluxes and community stability in a dynamic, high-latitude kelp ecosystem (High latitude kelp dynamics)

Contributors	Affiliation	Role
Kroeker, Kristy J.	University of California-Santa Cruz (UCSC)	Principal Investigator
Galloway, Aaron W.E.	University of Oregon	Co-Principal Investigator
Gravem, Sarah	Oregon State University (OSU)	Co-Principal Investigator
Raimondi, Peter T.	University of California-Santa Cruz (UCSC)	Co-Principal Investigator
Campbell, Rose S.	University of California-Santa Cruz (UCSC)	Student, Contact
Hunter, Nathan	University of California-Santa Cruz (UCSC)	Student
Mancuso, Raphael T.	University of California-Santa Cruz (UCSC)	Student
Newman, Sawyer	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
We conducted a field experiment in three replicate sea urchin barrens in Sitka Sound, AK (57°2'1"N 135°15'51"W) in February of 2023, where we deployed kelp blades at discrete distances on four meter radial cables from caged adult P. helianthoides and control cages for 24 hours. Via SCUBA we performed quadrat density surveys of three important kelp forest grazers (Haliotis kamtschatkana, Strongylocentrotus droebachiensis, and Mesocentrotus franciscanus) at discrete distances from the cage before, 15-30 min after, and 24 hours after P. helianthoides were added to the treatment cages.

Table of Contents

Coverage

Location: Sitka Sound, Alaska, USA (57.033762 N, 135.264282 W) depth 6-9m
Spatial Extent: **N**:57.036 **E**:-135.255 **S**:57.033 **W**:-135.28
Temporal Extent: 2023-02-14 - 2023-02-23

Methods & Sampling

Experiment

To test whether and at what distance the presence of *Pycnopodia* can reduce prey density, we performed an underwater caging experiment at three urchin barren sites approximately six km east of Sitka in February

2023: Ellsworth Cut (57.036, -135.280), Harris Island (57.033, -135.277), and Whale Park (57.033, -135.255). Each experimental array consisted of a central cage with four 4 m long radial transect lines (Figure 1). We constructed cages (30 x 30 x 15 cm; l x w x h) using a PVC frame covered in ~1cm Vexar mesh fastened with zip ties that could be opened underwater to add a *Pycnopodia*. We attached a 4m long lead line to each corner of the cage, forming a plus pattern (Figure 1). We simultaneously deployed four of these arrays at each site in two blocks. In each block, one cage served as an experimental treatment (with a *Pycnopodia*) and the second cage served as a control (an empty cage). We placed all arrays in areas with high sea urchin density, hard rocky substrate, and low rugosity, and the cages within a block were ~20-30 m apart.

Once the four cages and attached lead lines were deployed, but before adding sea stars to the treatment cages, we surveyed the initial densities of pinto abalone and red and green sea urchins using 0.25m^2 quadrats at metre marks 0, 0.5, 1, 2, and 3.5 along each lead line. The experiment began when we sealed a *Pycnopodia* (9.5-19.5 cm radius, lab acclimated for >2 weeks) into the experimental treatment cage and the control cage was sealed with a dive weight. To each lead line of all cages, we attached a yellow nylon “kelp line” each with 9 blades attached at distinct meter marks. At 15-30 minutes after sea stars were deployed, we resurveyed the grazer densities in the same quadrat locations. We then left the array overnight and surveyed grazer densities again at approximately 24 hours. After the 24 hour surveys, we removed the arrays.

Analyses

First, we calculated the change in sea urchin density from the start of the experiment [as density at each time point - density before start] for each quadrat location and species (abalone, red or green urchins), so that positive and negative values represent increases and decreases in density (respectively) after 30 mins or 24 hours of deployment. We dropped pinto abalone (*H. kamtschatkana*) from analyses due to low counts in density surveys. We tested the main and interactive effects of *Pycnopodia* treatment and continuous distance from the cage on the change in density of grazers in each quadrat using four mixed effects hierarchical linear models, one for each urchin species and time point combination, fit using the lmer() function in the lme4 package in R. When possible, we included site, block (nested within site), and array (nested within site, block, and treatment) as random factors to account for the non-independence of quadrats within a given array, and arrays within a block, and blocks within a given site. Array was dropped from the red urchins at 30 minutes model and site and array were dropped from the green urchins at 30 minutes model to avoid singularity errors while keeping the maximal random effects structure justified by the design. We again included site, block (nested within site), and array (nested within site, and block, and treatment), and transect (nested within site and array) as random factors.

We then calculated the net effect of the sea star at 24 hours on sea urchin density as the difference in the average urchin density in the sea star treatment minus its paired control treatment (i.e., the differences between treatments in each block). In other words, for each block and at a given distance from the cage at 24 hours we calculated: [avg. density in sea star treatments at each distance - avg. density in paired control treatments at each distance]. We tested the main and interactive effects of continuous distance from the cage and species (red or green urchins) on the net sea star effect using a linear model (lm()) in base R. We originally performed a model that included site, block and array as random factors matching the model construction as above, but were forced to simplify the model to avoid singularity errors. We then ran follow-up, individual linear fits (lm()) for each species separately to obtain the equation for each line (i.e., net effect = intercept + (slope * distance from cage)). Finally, we calculated the radius of the ‘halo of influence’ of the sea star by setting the net effect to zero and solving for the distance to the cage (i.e., the distance at which the sea star effect was no longer detectable). We calculated the area of influence using pie*(radius2), with the radius being defined as the distance from the cage statistic solved from the previous equation. This gives us an approximate measure of how far from an inactive sea star we can expect sea urchin density to be suppressed for at least 24 hours, even when kelp is present in an urchin barren.

BCO-DMO Processing Description

- Added a field to the primary data table containing fully written scientific names of represented abalone and urchins

[table of contents | back to top]

Parameters

Parameter	Description	Units
QuadID	Placement of quad on array: Site_Treatment_Replicate_Ray_Distance from cage.	unitless
RayID	Identity of ray (transect line): Site_Treatment_Replicate_Ray.	unitless
Site	Urchin barren name (ELL=Ellsworth Cut, HAR=Harris Island, WHA=Whale Park).	unitless
Lat	Latitude in decimal degrees; a positive value indicates a Northern coordinate.	decimal degrees
Long	Longitude in decimal degrees; a positive value indicates a Western coordinate.	decimal degrees
Treatment	Treatment (Pyc=Pycnopodia in cage) or control (Con=empty cage).	unitless
Replicate	Paired spatial blocks within a site either 1 or 2.	unitless
TreatRep	Identity of entire array: Treatment (P=Pycnopodia, C=control) and RepID (block #).	unitless
Ray	Direction of 4m transect line attached to cage (1-4).	unitless
Date	YYYY-MM-DD, AKST (Alaska Standard Time), UTC -9.	unitless
Diver	Diver ID.	unitless
Survey	Type of survey (BEF1=no kelp/Pycnopodia, BEF2/BEF3=just after adding kelp+Pycnopodia, AFTER=24 hrs after BEF1).	unitless
TimePoint	description needed	units needed
HoursElapsed	Time 0.0 is when bare array (cage+rays) is laid out, HH.HH.	hours
Depth_ft	Depth at time of survey in feet.	feet (ft)
Depth_m	Depth at time of survey in meters.	meters (m)
Quad	Order of quadrat position along one ray (1-5).	unitless
Dist_m	Distance between 0.25m2 quadrate and cage.	meters (m)

Species	Grazer species (HALIKAM=Haliotis kamtschatkana, STRODRO= Strongylocentrotus droebachiensis, STROFRAN=Mesocentrotus franciscanus).	unitless
Count	Count of grazer species in 0.25m2 quadrat.	individual
Density_m2	Count*4 = density/m2.	meters squared (m2)
Notes	Rugosity and kelp consumption observations.	unitless

[table of contents | back to top]

Project Information

CAREER: Energy fluxes and community stability in a dynamic, high-latitude kelp ecosystem (High latitude kelp dynamics)

Coverage: SE Alaskan coastal waters

NSF Award Abstract:
High latitude kelp forests support a wealth of ecologically and economically important species, buffer coastlines from high-energy storms, and play a critical role in the marine carbon cycle by sequestering and storing large amounts of carbon. Understanding how energy fluxes and consumer-resource interactions vary in these kelp communities is critical for defining robust management strategies that help maintain these valuable ecosystem services. In this integrated research and education program, the project team will investigate how consumer populations respond to variability in temperature, carbonate chemistry and resource quality to influence the food webs and ecosystem stability of kelp forests. A comprehensive suite of studies conducted at the northern range limit for giant kelp (Macrocystis pyrifera) in SE Alaska will examine how kelp communities respond to variable environmental conditions arising from seasonal variability and changing ocean temperature and acidification conditions. As part of this project, undergraduate and high school students will receive comprehensive training through (1) an immersive field-based class in Sitka Sound, Alaska, (2) intensive, mentored research internships, and (3) experiential training in science communication and public outreach that will include a variety of opportunities to disseminate research findings through podcasts, public lectures and radio broadcasts.

Consumer-resource interactions structure food webs and govern ecosystem stability, yet our understanding of how these important interactions may change under future climatic conditions is hampered by the complexity of direct and indirect effects of multiple stressors within and between trophic levels. For example, environmentally mediated changes in nutritional quality and chemical deterrence of primary producers have the potential to alter herbivory rates and energy fluxes between primary producers and consumers, with implications for ecosystem stability. Moreover, the effects of global change on primary producers are likely to depend on other limiting resources, such as light and nutrients, which vary seasonally in dynamic, temperate and high latitude ecosystems. In marine ecosystems at high latitude, climate models predict that ocean acidification will be most pronounced during the winter months, when primary production is limited by light. This project is built around the hypothesis that there could be a mismatch in the energetic demands of primary consumers caused by warming and ocean acidification and resource availability and quality during winter months, with cascading effects on trophic structure and ecosystem stability in the future. Through complementary lab and field experiments, the project team will determine 1) how temperature and carbonate chemistry combine to affect primary consumer bioenergetics across a diversity of species and 2) the indirect effects of ocean acidification and warming on primary consumers via environmentally mediated changes in the availability, nutritional quality and palatability of primary producers across seasons. Using the data from the laboratory and field experiments, the project team will 3) construct a model of the emergent effects of warming and ocean acidification on trophic structure and ecosystem stability in seasonally dynamic, high latitude environments.

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-1752600

[table of contents | back to top]