Surveys tracking the abundance of intermediate predator species with tidal elevation from 2014-2015 following sea star wasting disease from coastal Oregon

Website: https://www.bco-dmo.org/dataset/653793
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Project
» Testing the rocky intertidal community consequences of the decimation of purple sea star populations along the Oregon coast by sea star wasting disease (Sea star wasting)

Program
» Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)

Contributors	Affiliation	Role
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Dataset Description

Data are from surveys tracking the abundance of intermediate predator species with tidal elevation from 2014-2015 following sea star wasting disease. The surveys were in permanent transect lines that were in an inverted "T" shape with a vertical line from the low to high zones and a horizontal line at the lower edge of the mussel bed.

Related Reference:

Elizabeth B. Cerny-Chipman, Jenna M. Sullivan, and Bruce A. Menge. Whelk predators exhibit limited population responses and community effects following disease-driven declines of the keystone sea star *Pisaster ochraceus.* In Revision: MEPS.

Related Datasets:
Predator removals
Prey percent covers
Whelk size distributions: counts
Whelk size distributions: individuals

Methods & Sampling

Study system: Our study included 4 sites along the Oregon coast: Strawberry Hill (44.250°N-124.115°W) and Yachats Beach (44.319°N-124.109°W), located on Cape Perpetua, and Fogarty Creek (44.837°N-124.0587°W) and Boiler Bay (44.832°N-124.061°W) located on Cape Foulweather (Fig.1). Cape Perpetua is a rocky headland adjacent to a wide continental shelf offshore that promotes retention of propagules such as larvae and phytoplankton (Menge et al. 2015). As a result, Cape Perpetua intertidal sites are characterized by high phytoplankton productivity and high recruitment of invertebrates (Menge et al. 1997, 2004, 2015). Cape Foulweather, in contrast, is characterized by a narrower offshore continental shelf, which leads to reduced retentiveness, lower invertebrate abundance, and high macrophyte abundance. Prior to the onset of SSWD, densities of P. ochraceus could be as high as 8 individuals m-2 at Cape Perpetua and 4 individuals m-2 at Cape Foulweather sites (Menge et al. 2016).

Surveys of subordinate predator distribution
In the absence of the keystone predator, we predicted that whelk predators would shift toward foraging lower down on the shore in response to reduced consumptive pressure and increased resource density. We tested for changes in the vertical distribution of whelks from April-September of 2014 (before and after peak SSWD incidence in P. ochraceus) and in January-July of 2015 (when incidence was low and adult densities had been fully reduced) using vertical transect surveys. In our surveys, we measured the density of whelks, Leptasterias spp., and any P. ochraceus within five intertidal zones at four sites. These zones were defined by ecology rather than absolute tide height, and included (from low to high on the shore): the upper algal zone dominated by algae and barnacles, the lower edge of the mussel bed, the middle section of mussel bed, the upper edge of the mussel bed, and the high zone dominated by barnacles and fucoid algae. In some cases where M. trossulus was abundant within the upper algal zone, we conducted additional quadrats to target this zone specifically.

At each of four sites (Boiler Bay, Fogarty Creek, Strawberry Hill, and Yachats Beach, see Fig. 1), we conducted surveys using five replicate transect lines that ran vertically along the shore. These transect lines were marked at both ends with stainless steel lag screw. Within each transect, we measured density in one 0.25 m2 quadrat within each of the five ecological zones, recording the distance of each quadrat along the transect line for consistency over temporally repeated sampling. Because we expected to see the greatest changes due to SSWD in the lower ecological zones where P. ochraceus had previously been abundant, we measured predator density in additional quadrats in the upper algal zone and the lower edge of the mussel bed. This was done using a horizontal transect line that ran perpendicular from the low point of each vertical transect line described above forming an inverted "T" shape. Along each of the five replicate horizontal transect lines, we included four quadrats in the upper algal zone and four in the lower edge of the mussel bed.
We conducted these surveys to track changes in the vertical distribution of subordinate predators and changes in their overall abundance. We also took a photograph of every quadrat monitored in order to have a record of prey availability for each set of predators counted. Surveys were mostly conducted during morning low tides and, when possible, we attempted to finish all four sites within a single tide series. We recorded the tidal height of each quadrat in July 2015 relative to Mean Low Low Water (MLLW) using a laser level and stadia rod to measure the height of each plot above reference measurements at the water line in centimeters (Pincebourde et al. 2008).

Subordinate predator removal experiment
To assess the effects of subordinate predators in the absence of the keystone, we conducted a factorial removal experiment at two intertidal sites located on Cape Perpetua, Oregon (Strawberry Hill and Yachats Beach, see Fig. 1). We predicted that whelk predators would affect establishment of the dominant mussel, Mytilus californianus, by consuming the mid-successional prey species that facilitate its recruitment. As such, we chose to follow prey dynamics from a mid-successional stage by placing plots where there was abundant cover of the mussel Mytilus trossulus and several barnacle species. This mid-successional community is where we expected to see the greatest effects of subordinate predators and the largest changes in community structure following SSWD. We originally examined the effects of two groups of subordinate predators, gastropod whelks Nucella canaliculata and N. ostrina (W) and the smaller sea star Leptasterias spp. (L), in a factorial design including four treatments: +W +L, -W +L, +W -L, and -W -L. However, Leptasterias spp. were rare in our plots, and treatments were combined to include control (+W) and whelk removal (-W) treatments only (see data analysis section below). It is important to note that our experiment tested the effects of subordinate predators at reduced P. ochraceus densities, rather than comparing their effects in the presence or absence of P. ochraceus.

We followed prey community structure over time at 5 replicate plots (10 when treatments were combined) within each site at the upper edge of the low zone. The main treatment plots were 0.25 m2 in size and corners were marked with stainless steel lag screws. Each main plot was surrounded by four additional subplots

adjacent to each plot side that were meant to act as a buffer for the main plot. We monitored plots either bi-weekly or monthly as tides permitted from experimental initiation in June 2014 through May 2015. At each monitoring, we counted the total number of each subordinate predator species (N. canaliculata, N. ostrina, and Leptasterias spp.), as well as any less common predators, such as the whelk Nucella lamellosa, in all plots. When possible, we conducted a full monitoring with counts and removals of predators in the main plot, the four adjacent subplots, and in the corners between subplots. On some occasions, particularly during winter months with limited site access, we only monitored the main plots. All removal of whelks and Leptasterias spp. was conducted using forceps, and removed predators were relocated away from the plot area. In plots without removals, we mimicked the use of forceps in the plot while counting subordinate predators to limit the possibility that the physical action of predator removal would influence our results. Although SSWD caused declines in Pisaster ochraceus densities, it did not extirpate the species entirely from our sites. We recorded and relocated any P. ochraceus within each plot and any adult and juvenile P. ochraceus from a 3m radius around each plot.

Data Processing Description

Statistical Analyses
Percent-cover data were arcsine-square root transformed prior to analysis. In all tests, we examined plots of residuals for assumptions of normality, homogeneity of variance, and independence of error terms. In our experimental subordinate predator removals, Leptasterias spp. predators were very low in all treatment plots (zero in most plots). We used ANOVAs and Tukey's HSD post-hoc tests to see if a) removals of only Leptasterias spp. (-L+W) were different from the no-removal treatment (+L+W), and b) removals of only whelks (-W+L) were different from removals of both predators (-W-L). In both cases there were no differences, so we combined treatments (at the replicate level) to make a +Whelks (i.e. +W+L and +W-L) and a -Whelks (-W+L and -W-L) comparison.

To test the effects of whelks on prey species, we used linear mixed effects models to analyze percent cover of prey species separately using the 'nlme' package in R (Pinheiro et al. 2014). Models included a random effect for plot to account for repeated measurements over time. The final model for each prey species was determined by removing terms from a full model based on the Akaike Information Criterion corrected for small sample size (AICc) from in the package 'AICcmodavg' (Mazerolle 2015). We used AIC to determine if adding a weighted variance structure was necessary in cases where plots of residuals revealed heterogeneity of variance. Time was treated as a categorical variable because of non-linear relationships with percent cover. Because plots started with different prey communities, we analyzed both percent cover and change in percent cover from initial cover with qualitatively similar results. We made post-hoc comparisons using the 'phia' package in R (De Rosario-Martinez 2015) with Holm's-corrected p-values.
To determine whether population abundances of subordinate predators had changed from 2014 to 2015, we used negative binomial regression for survey count data, which were overdispersed, in the 'MASS' package (Venables & Ripley 2002) in R. In this case, a full model included a site x year interaction, which was dropped if non-significant. Because 2014 had many survey time points and 2015 had fewer surveys, we tried analyzing data from all time points and also from only the July 2014 and 2015 time points. We used all survey data as results were similar in both cases. To assess spatial changes in subordinate predator distributions, we ordered quadrats by measured tide height and analyzed differences in the cumulative distributions of whelk counts between the two years using two-sample Kolmogorov-Smirnov Tests with p-values bootstrapped using the package 'Matching' (Sekhon 2011). For these tests, we used only matched July time points in order to minimize distributional changes due to season.

BCO-DMO Processing:
- added conventional header with dataset name, PI name, version date
- renamed parameters to BCO-DMO standard
- reformatted date from m/d/yyyy to yyyymmdd
- sorted data by site, date, treatment

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Data Files

File
whelk_survey.csv (Comma Separated Values (.csv), 57.80 KB) MD5:52f9aa41af30be12f0d643e9f3c8968c Primary data file for dataset ID 653793

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Parameters

Parameter	Description	Units
date	Date of monitoring in format YYYYMMDD	year-month-day
site	One of four sites: BB=Boiler Bay; FC=Fogarty Creek; SH=Strawberry Hill; YB=Yachats Beach	unitless
transect	Within each site the number of each permanent transect line. Ranges from 1-5 at all sites except SH which ranges from 1-6.	unitless
distance	Distance from lower bolt in the low zone to bolt in the high zone that marked each permanent transect line.	meters or 0/1 flag
main_transect_flag	Binary variable: y=on the main vertical transect line; n=on the horizontal line	unitless
zone	Ecological zone: ua=upper algae; mt=bed of Mytilus trossulus in the low zone; lm=lower edge of mussel bed; mm=middle of mussel bed; um=upper edge of mussel bed; hi=high zone	unitless
N_canaliculata	Number of N. canaliculata individuals in quadrat	individuals
N_ostrina	Number of N. ostrina individuals in quadrat	individuals
L_hexactis	Number of Leptasterias spp. in quadrat	individuals
P_och_rec	Number of P. ochraceus recruits in quadrat	individuals
P_och_juv	Number of P. ochraceus juveniles (3-8 cm) in quadrat	individuals
P_och_adult	Number of adult P. ochraceus in quadrat	individuals
whelk_eggs	Presence (1) or absence (0) of whelk eggs	unitless
N_lamellosa	Number of N. lamellosa in quadrat	individuals
Henricia_spp	Number of Henricia spp. in quadrat	individuals
C_foliatum	Number of Ceratostoma foliatum in quadrat	individuals

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Deployments

Menge_2014

Website	https://www.bco-dmo.org/deployment/653801
Platform	OSU
Start Date	2014-04-16
End Date	2015-07-17
Description	Benthic ecology before and after Seastar Wasting Disease infection.

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Project Information

Testing the rocky intertidal community consequences of the decimation of purple sea star populations along the Oregon coast by sea star wasting disease (Sea star wasting)

Website: http://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/sea-star-wasting/

Coverage: Oregon coast

This study will investigate the ecological consequences of the decimation of sea star populations by wasting disease along the Oregon coast. Hallmarks of wasting disease are the formation of sores on the sea star that progress to cause loss of arms, and ultimately death of the animal. Wasting disease was reported in sea star populations including those of the purple sea star, Pisaster ochraceus, in British Columbia, Washington, and California as early as April 2013. In Oregon, wasting was first observed in April 2014, and by June 2014 rates of infection ranged up to 80%, and sea star abundance had declined. At that rate, many populations may disappear by the end of summer 2014. Prior research has shown that in the absence of the purple sea star, mid-shore mussel populations increase, and ultimately overgrow the sea weeds and invertebrates that occur low on the shore, reducing biodiversity. However, because disease events of this magnitude have never occurred along the entire coastline, it is unclear if the small-scale expansion of mussels observed previously will be a general result of this event. One possibility is that predators unaffected by wasting, such as whelks and crabs, will increase their predation effects and blunt the expected invasion of mussels to the low shore. The research in this project will evaluate this possibility by testing the role of these alternative predators. Broader Impacts include the training of undergraduate and graduate students, the involvement of coastal residents and the production of microdocumentaries and video to document the changing context of this ecosystem.

The research project is designed to test three hypotheses. First, that in the absence of Pisaster ochraceus, predation by whelks will increase in strength through increases in whelk abundance and in whelk size, and at least partially compensate for the absence of Pisaster. Second, the small sea star Leptasterias spp. will also expand its role as a predator through increased size and abundance, and expansion of its habitat beyond mussel beds. Although individuals of this sea star have been observed to suffer from wasting as well, the frequency so far appears low, and it seems likely this species may persist. Third, the crab Cancer productus, normally mostly a subtidal species, will expand its range into the intertidal and help to compensate for the loss of Pisaster. Tests of these hypotheses will include manual removal experiments (whelk removal, Leptasterias removal, removal of both and of neither), cage exclusion experiments (whelk exclusions), cage inclusion-exclusion experiments (Leptasterias inclusion, Leptasterias exclusion). Experiments will be replicated with appropriate controls, and done at multiple sites on the central Oregon coast that vary naturally in population abundances, rates of prey and predator recruitment, and oceanographic conditions. Results obtained under this unprecedented set of circumstances will deepen and expand our empirical understanding of the dynamics of an iconic ecosystem, and will help parameterize community models.

Additional Project Information: Sea Star Wasting Map

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Program Information

Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)

Website: http://www.piscoweb.org/

Coverage: West coast of North America from Mexico to Alaska

The Partnership for Interdisciplinary Studies of Coastal Oceans is a long-term ecosystem research and monitoring program established with the goals of:

- understanding dynamics of the coastal ocean ecosystem along the U.S. west coast

- sharing that knowledge so ocean managers and policy makers can make science based decisions regarding coastal and marine stewardship
- producing a new generation of scientists trained in interdisciplinary collaborative approaches

Over the last 10 years, PISCO has successfully built a unique research program that combines complementary disciplines to answer critical environmental questions and inform management and policy. Activities are conducted at the latitudinal scale of the California Current Large Marine Ecosystem along the west coast of North America, but anchored around the dynamics of coastal, hardbottom habitats and the oceanography of the nearshore ocean – among the most productive and diverse components of this ecosystem. The program integrates studies of changes in the ocean environment through ecological monitoring and experiments. Scientists examine the causes and consequences of ecosystem changes over spatial scales that are the most relevant to marine species and management, but largely unstudied elsewhere.

Findings are linked to solutions through a growing portfolio of tools for policy and management decisions. The time from scientific discovery to policy change is greatly reduced by coordinated, efficient links between scientists and key decision makers.

Core elements of PISCO are:

- Interdisciplinary ecosystem science
- Data archiving and sharing
- Outreach to public and decision-making user groups
- Interdisciplinary training
- Coordination of distributed research team

Established in 1999 with funding from The David and Lucile Packard Foundation, PISCO is led by scientists from core campuses Oregon State University (OSU); Stanford University's Hopkins Marine Station; University of California, Santa Cruz (UCSC); and University of California, Santa Barbara (UCSB). Collaborators from other institutions also contribute to leadership and development of PISCO programs. As of 2005, core PISCO activities are funded by collaborative grants from The David and Lucile Packard Foundation and the Gordon and Betty Moore Foundation. Core support, along with additional funding from diverse public and private sources, make this unique partnership possible.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1448913

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