Sea urchin bio-erosion of Clathromorphum nereostratum skeleton at central and western Aleutian Islands, Alaska from visual surveys, July 2014

Website: https://www.bco-dmo.org/dataset/755299
Data Type: Cruise Results
Version: 1
Version Date: 2019-01-30

Project
» Ocean Acidification: Century Scale Impacts to Ecosystem Structure and Function of Aleutian Kelp Forests (OA Kelp Forest Function)

Program
» Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)

Contributors	Affiliation	Role
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Abstract
Characterization of the degree to which sea urchins have excavated (bio-eroded) the calcium carbonate skeleton of Clathromorphum nereostratum, a long-lived reef-building coralline alga that forms the structural base of the kelp forest. Estimates were derived from field measurements, photoquadrat surveys, and collections, all performed via SCUBA.

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Coverage

Spatial Extent: **N**:52.91344 **E**:-176.61505 **S**:51.88707 **W**:173.30659
Temporal Extent: 2014-07-08 - 2014-07-16

Methods & Sampling

We quantified the degree to which urchins have overgrazed Clathromorphum nereostratum across our 700-km study area. To do so, we haphazardly selected a single site at each island for high-resolution study ("habitat.type" = "Barren"), which were of comparable depth (30-40 feet), harbored an abundance of C. nereostratum, and have a known ecological history. We also studied new sites at Ogliuga, Amchitka, Kiska (Rat Islands), Nizki (Semichi Islands), and Attu that met the same depth and benthic composition criteria but were

situated adjacent to shallow (15-24 feet depth) remnant kelp stands; detailed study of these barren sites ("habitat.type" = "Barren + kelp subsidy") allowed us to document patterns of bioerosion in the presence of kelp-derived urchin food subsidies. We also visited similar sites at Adak and Tanaga to survey bioerosion, but these survey data were omitted due to sampling error and/or violation of site criteria.

To assess the proportion of C. nereostratum that was overgrazed at each study site, we visually estimated bioerosion using photo quadrat surveys. At each site, a diver descended to the reef and set a random compass bearing, swam in the direction of that bearing for a predetermined number of kicks, and placed a 25 x 25 cm quadrat on the nearest C. nereostratum colony. The diver then took a full frame, high-resolution photo of the quadrat (camera: Canon 5D Mark II DSLR camera with Ikelite DS-150 strobes; lens: Canon 15mm fisheye, mounted on a Kenko 1.4x teleconverter to narrow the field of view and reduce distortion). This process was repeated, photographing C. nereostratum individuals every two body lengths (~4 m distance; n = 10/site). In the lab, photos were corrected for lens barrel distortion, cropped, and edited for brightness, saturation, and contrast in Adobe Photoshop Elements. Using a grid (1 x 1 cm) overlay, we visually estimated C. nereostratum abundance within each quadrat ("Clathromorphum.cover"). We then estimated the proportion of the alga grazed by urchins ("grazed.score"), using a scale of 1-6 (where 1 = 0-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, and 6 = 96-100 % cover grazed), as the presence of white perithallus indicates overgrazing to a depth > 250 micrometers, below the meristem layer that is responsible for growth and reproduction. Overgrazing scores were ranked (1-3) because photo quality varied depending on field conditions ("quality.rank"). Low confidence estimates (rank 3 of 3) were removed from the analysis, as were measurements made in excess of n = 10 per site. We assumed all grazing was due to urchins, as they are the only large herbivore in the ecosystem and their bite scars are easy to identify.

To measure the depth (in millimeters) to which urchins grazed C nereostratum ("max.depth.grazed.mm"), a second diver haphazardly removed a small sample of the alga from each photoquadrat (after the photo was taken) with hammer and chisel. In the laboratory, the depth of the most pronounced pentaradial urchin grazing scar on each sample was measured using a microscope with ocular micrometer.

Finally, to estimate the prevalence of larger grazed features (excavation pits) in the field, which represent the cumulative impacts of grazing over decades to centuries, at each interval where photoquadrats were deployed the second diver also measured the dimensions of the nearest excavation pit ("pit.volume.cm^3") generated by grazing (n = 10/site). Each pit was measured with respect to its length, width, and depth (cm). We then approximated the volume of each pit as a half cylinder using the equation V = 1/2[PI]r2h, where r was the depth and h the length of the pit.

Data Processing Description

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- re-formatted date from m/d/yyyy to yyyy-mm-dd
- converted west longitudes to negative values and removed E/W designations
- changed latitude for Kirilof Point from 51.14198 to 51.41198 as req'd by PI

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Data Files

File	
target_bioerosion.csv	(Comma Separated Values (.csv), 9.17 KB) MD5:e4f45b25f0a995634ce75ebb96002043
Primary data file for dataset ID 755299	

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Related Publications

Estes, J. A., Tinker, M. T., & Bodkin, J. L. (2010). Using Ecological Function to Develop Recovery Criteria for Depleted Species: Sea Otters and Kelp Forests in the Aleutian Archipelago. Conservation Biology, 24(3), 852–860. doi:10.1111/j.1523-1739.2009.01428.x
Methods

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Parameters

Parameter	Description	Units
island	name of island	unitless
site_name	identity of site	unitless
latitude	latitude of study site	decimal degrees
longitude	longitude of study site	decimal degrees
depth_feet	depth of benthic survey	feet
habitat_type	phase state of habitat: see Description	unitless
date	calendar date of survey formatted as yyyy-mm-dd	unitless
replicate	replicate 0.25-m^2 quadrat identifier	unitless
Clathromorphum_cover	abundance of alga in photo	percent
grazed_score	proportion of colony grazed: percent cover per colony estimated using a score of 1-6 where 1 = 0-5%; 2 = 6-25%; 3 = 26-50%; 4 = 51-75%; 5 = 76-95%; and 6 = 96-100 % cover grazed.	unitless
quality_rank	quality of (confidence in) "grazed.score" measurement: 1 (excellent); 2 (good); or 3 (poor)	unitless
grazed_cover_median	conversion of "grazed.score" units to % cover (median of range)	percent
max_depth_grazed_mm	maximum depth of sea urchin grazing scar on collected sample	millimeters
pit_volume_cm3	volume of large pit excavated by sea urchins; approximated as the volume of a half cylinder	centimeters^3

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Deployments

PS1409

Website	https://www.bco-dmo.org/deployment/755184
Platform	R/V Point Sur
Start Date	2014-07-05
End Date	2014-07-22
Description	Benthic community studies associated with project "Project: Ocean Acidification: Century Scale Impacts to Ecosystem Structure and Function of Aleutian Kelp Forests".

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Project Information

Ocean Acidification: Century Scale Impacts to Ecosystem Structure and Function of Aleutian Kelp Forests (OA Kelp Forest Function)

Extracted from the NSF award abstract:

Marine calcifying organisms are most at risk to rapid ocean acidification (OA) in cold-water ecosystems. The investigators propose to determine if a globally unique and widespread calcareous alga in Alaska's Aleutian archipelago, *Clathromorphum nereostratum*, is threatened with extinction due to the combined effects of OA and food web alterations. *C. nereostratum* is a slow growing coralline alga that can live to at least 2000 years. It accretes massive 'bioherms' that dominate the regions' rocky substrate both under kelp forests and deforested sea urchin barrens. It develops growth bands (similar to tree rings) in its calcareous skeleton, which effectively record its annual calcification rate over centuries. Pilot data suggest the skeletal density of *C. nereostratum* began to decline precipitously in the 1990's in some parts of the Aleutian archipelago. The investigators now propose to use high-resolution microscopy and microCT imaging to examine how the growth and skeletal density of *C. nereostratum* has changed in the past 300 years (i.e., since the industrial revolution) across the western Aleutians. They will compare their records of algal skeletal densities and their variation through time with reconstructions of past climate to infer causes of change. In addition, the investigators will examine whether the alga's defense against grazing by sea urchins is compromised by ongoing ocean acidification. The investigators will survey the extent of *C. nereostratum* bioerosion occurring at 10 sites spanning the western Aleutians, both inside and outside of kelp forests. At each site they will compare these patterns to observed and monitored ecosystem trophic structure and recent *C. nereostratum* calcification rates. Field observations will be combined with laboratory experiments to determine if it is a decline in the alga's skeletal density (due to recent OA and warming), an increase in grazing intensity (due to recent trophic-level dysfunction), or their interactive effects that are likely responsible for bioerosion patterns inside vs. outside of forests. By sampling *C. nereostratum* inside and outside of forests, they will determine if kelp forests locally increase pH via photosynthesis, and thus buffer the effects of OA on coralline calcification. The combination of field observations with laboratory controlled experiments, manipulating CO2 and temperature, will help elucidate drivers of calcification and project how these species interactions will likely change in the near future. The project will provide the first in situ example of how ongoing ocean acidification is affecting the physiology of long-lived, carbonate producing organisms in the subarctic North Pacific. It will also be one of the first studies to document whether OA, ocean warming, and food web changes to ecological processes are interacting in complex ways to reshape the outcome of species interactions in nature.

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Program Information

Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean

Acidification (formerly CRI-OA) (SEES-OA)

Website: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503477

Coverage: global

NSF Climate Research Investment (CRI) activities that were initiated in 2010 are now included under Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES). SEES is a portfolio of activities that highlights NSF's unique role in helping society address the challenge(s) of achieving sustainability. Detailed information about the SEES program is available from NSF (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504707).

In recognition of the need for basic research concerning the nature, extent and impact of ocean acidification on oceanic environments in the past, present and future, the goal of the SEES: OA program is to understand (a) the chemistry and physical chemistry of ocean acidification; (b) how ocean acidification interacts with processes at the organismal level; and (c) how the earth system history informs our understanding of the effects of ocean acidification on the present day and future ocean.

Solicitations issued under this program:
NSF 10-530, FY 2010-FY2011
NSF 12-500, FY 2012
NSF 12-600, FY 2013
NSF 13-586, FY 2014
NSF 13-586 was the final solicitation that will be released for this program.

PI Meetings:
1st U.S. Ocean Acidification PI Meeting(March 22-24, 2011, Woods Hole, MA)
2nd U.S. Ocean Acidification PI Meeting(Sept. 18-20, 2013, Washington, DC)
3rd U.S. Ocean Acidification PI Meeting (June 9-11, 2015, Woods Hole, MA – Tentative)

NSF media releases for the Ocean Acidification Program:

Press Release 10-186 NSF Awards Grants to Study Effects of Ocean Acidification

Discovery Blue Mussels "Hang On" Along Rocky Shores: For How Long?

Discovery nsf.gov - National Science Foundation (NSF) Discoveries - Trouble in Paradise: Ocean Acidification This Way Comes - US National Science Foundation (NSF)

Press Release 12-179 nsf.gov - National Science Foundation (NSF) News - Ocean Acidification: Finding New Answers Through National Science Foundation Research Grants - US National Science Foundation (NSF)

Press Release 13-102 World Oceans Month Brings Mixed News for Oysters

Press Release 13-108 nsf.gov - National Science Foundation (NSF) News - Natural Underwater Springs Show How Coral Reefs Respond to Ocean Acidification - US National Science Foundation (NSF)

Press Release 13-148 Ocean acidification: Making new discoveries through National Science Foundation research grants

Press Release 13-148 - Video nsf.gov - News - Video - NSF Ocean Sciences Division Director David Conover answers questions about ocean acidification. - US National Science Foundation (NSF)

Press Release 14-010 nsf.gov - National Science Foundation (NSF) News - Palau's coral reefs surprisingly resistant to ocean acidification - US National Science Foundation (NSF)

Press Release 14-116 nsf.gov - National Science Foundation (NSF) News - Ocean Acidification: NSF awards $11.4 million in new grants to study effects on marine ecosystems - US National Science Foundation (NSF)

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Funding

Funding Source	Award
NSF Arctic Sciences (NSF ARC)	PLR-1316141

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