Historical reconstruction of sea urchin grazing events in Aleutian Island ecosystem from grazing scars, 1965-2004

Website: https://www.bco-dmo.org/dataset/755687
Data Type: Cruise Results
Version: 1
Version Date: 2019-02-13

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
Historical reconstruction of sea urchin grazing events in the ecosystem, achieved via enumerating the annual frequency of grazing scars that are archived in the calcified matrix of Clathromorphum nereostratum. Intact colonies of C. nereostratum were collected via SCUBA. Reconstructions were performed on polished and imaged sample cross-sections.

Table of Contents

Coverage

Spatial Extent: **N**:52.9336 **E**:-178.66258 **S**:51.40901 **W**:173.266
Temporal Extent: 2004-08-14 - 2014-07-16

Dataset Description

Historical reconstruction of sea urchin grazing events in the ecosystem, achieved via enumerating the annual frequency of grazing scars that are archived in the calcified matrix of *Clathromorphum nereostratum*. Intact colonies of *C. nereostratum* were collected via SCUBA. Reconstructions were performed on polished and imaged sample cross-sections.

Methods & Sampling

Clathromorphum species produce annual growth increments (hereafter "year bands") in their skeleton (Adey et al. 2013), which contain elemental and isotopic signatures that can be used to reconstruct past oceanographic conditions (e.g., Fietzke et al. 2015). We discovered that such year bands also archive urchin grazing scars, allowing us to measure the timing and frequency of past urchin grazing events on *C. nereostratum*. Wild specimens of *C. nereostratum* were thus collected and analyzed in order to reconstruct grazing events in the ecosystem.

At each site studied with respect to bioerosion, we collected *C. nereostratum* specimens (n = 10/site) with hammer and chisel, focusing on individuals without visible signs of grazing on the epithallus. Ship-side, samples were sectioned with a diamond lapidary saw and examined for quality; high quality samples were placed in an oven (50°C) until dry, then archived for subsequent analysis. Samples collected from Amchitka were of poor quality. Hence for Amchitka, we used specimens collected previously (2004) for this exercise. We also augmented our 2014 collections from Attu with samples previously collected (2008) from the same locale, because many of the 2014 samples did not meet our criteria for reconstruction (see below).

Each *C. nereostratum* specimen (n = 5/island) was mounted to a glass slide, sectioned parallel to the growth axis with a diamond lapidary saw, and polished to 3 microns resolution following established methods (Hetzinger et al. 2009). Each section was then imaged with a camera coupled to a reflected light microscope (GeoTS, Olympus Inc.), which obtains a mosaic of overlapping images and stitches them together to produce a single high-resolution image of the cross-section. This photomosaic was used to carefully identify, age, and count grazing scars that occurred along a transect oriented parallel to the alga's growth axis in the plane of the section. We scored multiple (n = 2-3) transects per sample, given that grazing events do not span the entirety of a year band. The origin of each transect was randomly plotted, then moved to the nearest location on the epithallus that was living and that displayed a flat or convex shape. The transect was then plotted through sequentially older year bands, so long as it: (i) did not cross a fusion between two individual algae; (ii) spanned at least 30 years of growth; and (iii) intercepted year bands that were clearly visible. If any of these criteria were violated, the transect was relocated.

Along each transect, we aged and measured the growth (vertical extension) of year bands in 5-year intervals, repeating this process so long as dating could be rigorously performed and end-dates aligned for all transects within a sample. Within each 5-year interval, we assessed the annual frequency of grazing scars - which manifest as a jagged interruption of the growth margin coupled with serial pitting of the reproductive conceptacles - found 5 mm to either side of the transect. Straight growth lines that lacked conceptacles or the occasional empty conceptacle within an otherwise clean growth band was not considered evidence of grazing. In instances where one side of the transect entered an area that violated the above criteria (e.g., passed under an area that had a concave epithallial surface), we analyzed only one side of the transect (10 mm). With this methodology remains the possibility that urchin grazing may have removed entire years of growth, thus obscuring our estimates of grazing frequency and the timing of each grazing event. To address this issue, we compared (double blind) our age models for a subset of samples from Alaid and Ogliuga to ages produced using Uranium series dating (Fietzke et al. 2005). Our age estimates were very similar to those produced by Uranium series dating, indicating we did not lose entire years to grazing.

We selected the year 1965 as the cutoff for our reconstruction because ecological records are scant prior to this period (Estes et al. 2010). For *C. nereostratum* samples collected in 2014, we excluded the 10 most recent years of growth (2014-2005) from our analyses due to a known bias in our collection method; since we collected non-grazed specimens from the wild and retained only the highest quality samples, we biased ourselves against finding evidence of grazing in recent years. For samples collected in 2004 and 2008, such a bias was not evident, at least for those records that met our criteria and were used in the study. For the three 2008 samples used, we excluded the first four years to align chronologies with all other specimens.

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
- removed direction (N,W,E) from latitude and longitude values

[table of contents | back to top]

Data Files

File
island_grazing_history.csv (Comma Separated Values (.csv), 38.82 KB) MD5:3d373fef1acd5bae77a73ca5f0702530 Primary data file for dataset ID 755687

[table of contents | back to top]

Related Publications

Adey, W. H., Halfar, J., & Williams, B. (2013). The coralline genus Clathromorphum Foslie emend. Adey: biological, physiological, and ecological factors controlling carbonate production in an arctic-subarctic climate archive. Smithsonian Contributions to Marine Science 40, 1-41 https://hdl.handle.net/10088/21560
Methods

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

Fietzke, J., Liebetrau, V., Eisenhauer, A., & Dullo, C. (2005). Determination of uranium isotope ratios by multi-static MIC-ICP-MS: method and implementation for precise U- and Th-series isotope measurements. Journal of Analytical Atomic Spectrometry, 20(5), 395. doi:10.1039/b415958f https://doi.org/10.1039/B415958F
Methods

Fietzke, J., Ragazzola, F., Halfar, J., Dietze, H., Foster, L. C., Hansteen, T. H., … Steneck, R. S. (2015). Century-scale trends and seasonality in pH and temperature for shallow zones of the Bering Sea. Proceedings of the National Academy of Sciences, 112(10), 2960-2965. doi:10.1073/pnas.1419216112
Methods

Hetzinger, S., Halfar, J., Kronz, A., Steneck, R. S., Aday, W., Lebenick, P. A., & Schone, B. R. (2009). High-Resolution Mg/Ca Ratios in a Coralline Red Alga as a Proxy For Bering Sea Temperature Variations from 1902 to 1967. Palaios, 24(6), 406-412. doi:10.2110/palo.2008.p08-116r
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
collection_date	date of collection; formatted as yyyy-mm-dd	unitless
island	name of island	unitless
site_name	name of collection site	unitless
latitude	latitude of collection site	decimal degrees
longitude	longitude of collection site	decimal degrees
depth_feet	depth of sample collection	feet
replicate	replicate individual alga studied	unitless
sample_ID	unique sample identifier	unitless
transect	replicate transect within individual	unitless
end_period	upper bound of 5-year period scored	year
start_period	lower bound of 5-year period scored	year
time_period	discrete 5-year time interval scored	years
growth_increment_um	net algal growth incurred over 5-year period	micrometers
grazing_events	number of grazing events observed within 5-year period	unitless

[table of contents | back to top]

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.

[table of contents | back to top]

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)

[table of contents | back to top]

Funding

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

[table of contents | back to top]