Environmental data from experimental aquaria during a laboratory experiment testing the effects of pH, light availability and biotic interaction on coralline algae calcification and productivity at the Sitka Sound Science Center in 2017

Website: https://www.bco-dmo.org/dataset/856902
Data Type: experimental, Other Field Results
Version: 1
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Project
» CAREER: Energy fluxes and community stability in a dynamic, high-latitude kelp ecosystem (High latitude kelp dynamics)

Contributors	Affiliation	Role
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Abstract
Environmental data from experimental aquaria (“tanks”) during a laboratory experiment testing the effects of pH, light availability, and biotic interaction on coralline algae calcification and productivity. These tests took place at the Sitka Sound Science Center (SSSC) from August 7, 2017, to September 21, 2017, with algal collection taking place on August 5, 2017.

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Coverage

Spatial Extent: **Lat**:57.032 **Lon**:-135.277
Temporal Extent: 2017-08-18 - 2017-09-15

Dataset Description

Environmental data from experimental aquaria (“tanks”) during a laboratory experiment testing the effects of pH, light availability and biotic interaction on coralline algae calcification and productivity.

Acquisition Description

Methodology:

Sampling and analytical procedures: To test the response of the coralline algae Crusticorallina spp. and Bossiella orbigniana to future OA scenarios, we used an 18-aquaria indoor experimental system with flow-through seawater at the Sitka Sound Science Center to simulate three static pHT levels (current summer = 8.0, future summer/current winter = 7.7, future winter = 7.4) under two seasonal light regimes simulated with full-spectrum aquarium lights (AI Prime HD) (summer = PPFD 55μmol m-2 s-1, 13h d-1, winter = PPFD 40μmol m-2 s-1, 6h d-1). We had a total of 3 aquaria for each of the 6 treatment combinations. A full description of the pH control for this system can be found in Kroeker et al. 2021, but in short: pH was regulated using a relay system that controlled mixing of pre-equilibrated low-pH seawater (formed by bubbling pure CO2 gas into seawater: pH6.0) and ambient pH seawater into 9 header buckets (n=3 headers per pH treatment) that then flowed into the experimental aquaria. Each header bucket was equipped with a pH sensor (DuraFET, Honeywell) communicating with a controller (UDA 2152, Honeywell) to regulate flow of the low pH water through solenoid valves to maintain pre-programmed pH setpoints. Experimental pH levels were chosen to reflect current seasonal minimums of coastal pH measured at Harris Is. (57.032N, 135.277W) from 2016-2017, as well as end-of-century projections for Gulf of Alaska pH levels based on RCP 8.5 (-0.3 pHT from current levels). Experimental light regimes were defined using seasonal averages for day length and measured irradiance level at 10m depth at Harris Is.

Within each pH level and light treatment combination, half of the individual Crusticorallina spp. and B. orbigniana were randomly assigned to be paired in close proximity with the fleshy red alga Cryptopleura ruprechtiana (n=6 species treatment-1). All algal individuals were collected on Aug 5, 2017 at Harris Is. Total experimental duration was 45d (Aug 7-Sept 21, 2017). To monitor treatment conditions, we used a handheld meter (YSI) to take daily temperature readings in the replicate aquaria and measure salinity of incoming seawater daily just upstream of our experimental system. Additionally, discrete water samples were collected from replicate aquaria at four timepoints (Aug 18, 22, 25, and Sept 15) for determination of pH (total scale) and total alkalinity (TA). Discrete samples were collected without aeration in amber glass bottles, immediately poisoned with saturated HgCl2 (0.025% volume-1), and capped to prevent air exchange.

Discrete water samples for laboratory measurements of pH and/or TA were transported to UCSC for analysis within 8 months of collection. We measured pH spectrophotometrically (Shimadzu, UV-1800) using m-cresol purple dye following best practices (Dickson et al. 2017), with an average standard error of ± 0.0013 pH units among sample triplicates. TA measurements were performed using open cell titration (Metrohm, 905 Titrandro) and corrected against certified reference materials of CO2 in seawater (Dickson laboratory, Scripps Institution of Oceanography), with an average standard error of ±0.933μmol kg-1 SW-1 among sample triplicates. To calculate pHT in the replicate aquaria at the time of water sampling, we used our measurements of spectrophotometric pH, TA, temperature, and salinity, as well as the dissociation constants as inputs to the program CO2SYS. This dataset reflects all of the above-described data, including final carbonate chemistry calculations from CO2SYS.

Problem report:

Discrete water samples had to be stored and shipped from Southeast Alaska to Santa Cruz, CA for analysis, and some samples were broken in transit and unusable. Additionally, we recognize that the delay between collection and laboratory analysis of water sample spec pH and TA may have resulted in a measurable amount of drift in these parameters, but we were unable to quantify any drift that may have occurred and thus these values are uncorrected. Lastly, calculated parameters for certain samples did not follow expected relationships (e.g., among spec pH and pCO2) and thus were flagged for potentially poor quality, which may have been caused by biological contamination in bottle samples.

Processing Description

Data processing notes from researcher:

All columns with prefix “CO2SYS_” were calculated using the program CO2SYS using prior column data as inputs.

BCO-DMO processing notes:

Renamed field tank.rep to tank_rep in order to meet BCO-DMO field naming conventions

Converted datatime to ISO 8061 standard

Added UTC formatted datetime

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Related Publications

Kroeker, K. J., Powell, C., & Donham, E. M. (2020). Windows of vulnerability: Seasonal mismatches in exposure and resource identity determine ocean acidification's effect on a primary consumer at high latitude. Global Change Biology, 27(5), 1042–1051. doi:10.1111/gcb.15449
Methods

LE Bell, JB Gómez, E Donham, DL Steller, PW Gabrielson, KJ Kroeker (in review) High-latitude calcified coralline algae exhibit seasonal vulnerability to acidification despite physical proximity to a non-calcified alga. Manuscript submitted Jun 1, 2021.
Results

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Parameters

Parameter	Description	Units
header	ID of experimental header bucket	unitless
tank_rep	alphabetic ID of experimental tank replicate (B or C)	unitless
YSI_timestamp_AKST	datetime (AKST) of YSI and water sample collection; format: YYYY-MM-DD H:M	unitless
YSI_timestamp_UTC	datetime (AKST) of YSI and water sample collection; format: YYYY-MM-DDT%H:MZ	unitless
pH	experimental pH treatment level	unitless
light	experimental light regime treatment (winter or summer)	unitless
YSI_DO	YSI measured dissolved oxygen	mg/L
YSI_pH	YSI measured pH (calibrated to FW standards)	unitless
YSI_sal	YSI measured salinity	parts per thousand (ppt)
YSI_temp	YSI measured temperature	degrees C
titrator_TA	mean total alkalinity from triplicate sample measurement	μmol kg-1
spec_pH	mean spec pH from triplicate sample measurement	unitless
CO2SYS_pH	calculated pH	unitless
CO2SYS_fCO2	calculated fugacity of carbon dioxide	μatm
CO2SYS_pCO2	calculated partial pressure of carbon dioxide	μatm
CO2SYS_HCO3	calculated bicarbonate concentration	μmol/kgSW
CO2SYS_CO3	calculated carbonate concentration	μmol/kgSW
CO2SYS_CO2	calculated carbon diozide concentration	μmol/kgSW
CO2SYS_B	calculated boron concentration	μmol/kgSW
CO2SYS_OH	calculated hydroxide concentration	μmol/kgSW
CO2SYS_CaOMEGA	calculated calcite saturation state (Ω)	unitless
CO2SYS_ArgOMEGA	calculated aragonite saturated state (Ω)	unitless
quality_flag	indicator of data quality (n = no flag - quality good; m = potential flag; y = bad data)	unitless

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Instruments

Dataset-specific Instrument Name	Shimadzu UV-1800 spectrophotometer
Generic Instrument Name	UV Spectrophotometer-Shimadzu
Dataset-specific Description	We measured pH spectrophotometrically (Shimadzu, UV-1800) using m-cresol purple dye following best practices (Dickson et al. 2017), with an average standard error of ± 0.0013 pH units among sample triplicates.
Generic Instrument Description	The Shimadzu UV Spectrophotometer is manufactured by Shimadzu Scientific Instruments (ssi.shimadzu.com). Shimadzu manufacturers several models of spectrophotometer; refer to dataset for make/model information.

Dataset-specific Instrument Name	Honeywell DuraFET and UDA 2152
Generic Instrument Name	pH Sensor
Dataset-specific Description	Each header bucket was equipped with a pH sensor (DuraFET, Honeywell) communicating with a controller (UDA 2152, Honeywell) to regulate flow of the low pH water through solenoid valves to maintain pre-programmed pH setpoints.
Generic Instrument Description	General term for an instrument that measures the pH or how acidic or basic a solution is.

Dataset-specific Instrument Name	Metrohm 905 Titrandro Titrator
Generic Instrument Name	Automatic titrator
Dataset-specific Description	Total alkalinity (TA)measurements were performed using open cell titration and corrected against certified reference materials of CO2 in seawater (Dickson laboratory, Scripps Institution of Oceanography), with an average standard error of ±0.933µmol kg-1 SW-1 among sample triplicates.
Generic Instrument Description	Instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

Dataset-specific Instrument Name	18-aquaria indoor experimental system with flow-through seawater at the Sitka Sound Science Center
Generic Instrument Name	Aquarium
Dataset-specific Description	To test the response of the coralline algae Crusticorallina spp. and Bossiella orbigniana to future OA scenarios, we used an 18-aquaria indoor experimental system with flow-through seawater at the Sitka Sound Science Center to simulate three static pHT levels (current summer = 8.0, future summer/current winter = 7.7, future winter = 7.4) under two seasonal light regimes simulated with full-spectrum aquarium lights (AI Prime HD) (summer = PPFD 55μmol m-2 s-1, 13h d-1, winter = PPFD 40μmol m-2 s-1, 6h d-1). We had a total of 3 aquaria for each of the 6 treatment combinations.
Generic Instrument Description	Aquarium - a vivarium consisting of at least one transparent side in which water-dwelling plants or animals are kept

Dataset-specific Instrument Name	YSI handheld meter
Generic Instrument Name	Discrete water sampler
Dataset-specific Description	To monitor treatment conditions, we used a handheld meter (YSI) to take daily temperature readings in the replicate aquaria and measure salinity of incoming seawater daily just upstream of our experimental system. YSI handheld meter used to measure dissolved oxygen, pH, salinity, and temperature.
Generic Instrument Description	A device that collects an in-situ discrete water sample from any depth and returns it to the surface without contamination by the waters through which it passes, such as a water bottle.

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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.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1752600

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