Oxygen evolution data for macroalgae during photo physiology incubations for photosynthesis-irradiance curves from August to September 2017 (High latitude kelp dynamics)

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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
Kroeker, Kristy J.	University of California-Santa Cruz (UC Santa Cruz)	Principal Investigator
Bell, Lauren E.	University of California-Santa Cruz (UC Santa Cruz)	Contact
Newman, Sawyer	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Oxygen evolution data for macroalgae during photo physiology incubations, for generation of photosynthesis-irradiance curves. Run in the last week of a laboratory experiment testing the effects of pH, light availability and biotic interaction on coralline algae calcification and productivity. All algal individuals were collected on Aug 5, 2017 at Harris Island. Total experimental duration was 45d (Aug 7-Sept 21, 2017).

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Coverage

Spatial Extent: **Lat**:57.0498 **Lon**:-135.3235
Temporal Extent: 2017-08-05 - 2017-09-21

Dataset Description

Oxygen evolution data for macroalgae during photo physiology incubations, for generation of photosynthesis-irradiance curves. Run in the last week of 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).

In vivo photophysiology was characterized for all red algal species at the end of the experiment by measuring the rate of oxygen evolution produced by algal thalli at seven irradiance levels. Following the final buoyant mass measurement, a small piece of thallus (mean ± SE: B. orbigniana: 0.17 ±0.02g; Crusticorallina spp.: 0.53 ± 0.03g; C. ruprechtiana: 0.07 ± 0.003g) was taken from haphazardly selected individuals (n=3 treatment-1 species-1) and placed in a 69mL incubation chamber filled with seawater from the associated aquaria and equipped with a stir bar and an oxygen sensor spot (PreSens SP-PSt4-SA). Sensor spots were calibrated daily using a two-point correction of 100% (air-saturated water) and 0% (1% Na2SO3 and 0.05% Co(NO3)2 standard solution) saturation. Incubation chambers were sealed airtight using clear plexiglass lids affixed with vacuum grease and submerged onto a magnetic stir plate in a temperature-controlled water bath. Full-spectrum aquarium lights (AI Hydra HD) were used to expose thalli in chambers to seven consecutively increasing irradiance levels (~PPFD 0, 20, 70, 140, 320, 425, 720µmol m-2 s-1). A fiber optic O2 sensor (Fibox IV, Presens) was used to record the dissolved oxygen concentration in each chamber at 30, 45 and 60min after each irradiance level was reached. Dissolved oxygen evolution rate (mg O2 min-1) at each irradiance level was calculated using linear regression, corrected against paired chamber controls (no algae), and normalized to chamber volume and thalli wet mass (mg O2 g-1 min-1 L-1).

Processing Description

Data processing notes from researchers:

Dissolved oxygen evolution rate (mg O2 min-1) at each irradiance level was calculated using linear regression, corrected against paired chamber controls (no algae), and normalized to chamber volume and thalli wet mass (mg O2 g-1 min-1 L-1).

BCO-DMO processing notes:

Renamed fields to meet BCO-DMO naming conventions; tank.rep, alg.ID, and assoc. are now tank_rep, alg_ID, and assoc, respectively

Fields rounded consistently to maximum precision.

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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
species	taxonomic identifier of individual considered	unitless
header	numerical ID of experimental header bucket	unitless
tank_rep	alphabetic ID of experimental tank replicate	unitless
alg_ID	alphabetic ID of indiv., unique to header/tank replicate	unitless
pH	experimental pH treatment level	unitless
light	experimental light regime treatment (winter or summer)	unitless
assoc	experimental algal association treatment (w = paired w/ C. ruprechtiana; wo = no pairing)	unitless
I	irradiance (PPFD) level at which oxygen evolution rate calculated	μmol m-2 s-1 n/a
o2	oxygen evolution rate at given PPFD, normalized to thalli mass & chamber volume	mg g-1 min-1 L-1

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Instruments

Dataset-specific Instrument Name	Honeywell 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. 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).
Generic Instrument Description	General term for an instrument that measures the pH or how acidic or basic a solution is.

Dataset-specific Instrument Name	PreSens SP-PSt4-SA oxygen sensor spots
Generic Instrument Name	Dissolved Oxygen Sensor
Dataset-specific Description	In vivo photophysiology was characterized for all red algal species at the end of the experiment by measuring the rate of oxygen evolution produced by algal thalli at seven irradiance levels. Following the final buoyant mass measurement, a small piece of thallus (mean ± SE: B. orbigniana: 0.17 ±0.02g; Crusticorallina spp.: 0.53 ± 0.03g; C. ruprechtiana: 0.07 ± 0.003g) was taken from haphazardly selected individuals (n=3 treatment-1 species-1) and placed in a 69mL incubation chamber filled with seawater from the associated aquaria and equipped with a stir bar and an oxygen sensor spot (PreSens SP-PSt4-SA). Sensor spots were calibrated daily using a two-point correction of 100% (air-saturated water) and 0% (1% Na_2SO_3 and 0.05% $Co(NO_3)_2$ standard solution) saturation.
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O_2) in the gas or liquid being analyzed

Dataset-specific Instrument Name	Presens Fibox IV fiber optic O_2 sensor
Generic Instrument Name	Dissolved Oxygen Sensor
Dataset-specific Description	A fiber optic O_2 sensor (Fibox IV, Presens) was used to record the dissolved oxygen concentration in each chamber at 30, 45 and 60min after each irradiance level was reached.
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O_2) in the gas or liquid being analyzed

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. 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.
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	AI Hydra HD Full-spectrum aquarium lights
Generic Instrument Name	LED light
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).
Generic Instrument Description	A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons.

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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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