Macroalgal biomass data collected in the nearshore shallow subtidal during eight field experiments conducted at Cerro Mundo Bay in the Galapagos Islands between Sept 2021 and Apr 2023

Website: https://www.bco-dmo.org/dataset/894169
Data Type: experimental, Other Field Results
Version: 2
Version Date: 2025-11-14

Project
» The Role of Temperature in Regulating Herbivory and Algal Biomass in Upwelling Systems (Temperature and Herbivory)

Contributors	Affiliation	Role
Bruno, John	University of North Carolina at Chapel Hill (UNC-Chapel Hill)	Principal Investigator
Brandt, Margarita	Universidad San Francisco de Quito USFQ (USFQ)	Co-Principal Investigator
Agudo-Adriani, Esteban	University of North Carolina at Chapel Hill (UNC-Chapel Hill)	Student
Silva, Isabel	University of North Carolina at Chapel Hill (UNC-Chapel Hill)	Student
Mickle, Audrey	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Increased standing macroalgal biomass in upwelling zones is generally assumed to result from higher nutrient flux associated with upwelled waters. However, other factors can also strongly impact macroalgal communities. For example, herbivory and temperature—through their effects on primary producers and the metabolic demands of consumers—can influence macroalgal biomass and productivity, respectively. Although there are numerous studies examining the interactive effects of herbivores and nutrients in both temperate regions, few have addressed these dynamics in tropical or subtropical upwelling systems. The purpose of this study was to assess the effects of herbivores, temperature, and nutrient availability on standing macroalgal biomass and total algal cover. Total algal cover is presented in the related dataset. We manipulated nutrient availability and herbivory in eight field experiments conducted under contrasting productivity and thermal regimes (cool upwelling vs. warm, non-upwelling seasons) on a subtidal nearshore rocky reef. Here, we present the raw macroalgal biomass data (dry weight in grams) collected from the shallow subtidal zone during September 2021 to April 2023 field experiments.

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Coverage

Location: Cerro Mundo, San Cristobal Island, Galapagos, Ecuador (0.87044°S, 89.58189°W)

Spatial Extent: **Lat**:-0.87044 **Lon**:-89.58189
Temporal Extent: 2021-09 - 2023-04

Methods & Sampling

We conducted a fully factorial 4x2 caging experiment (n=8) from September 2021 to April 2023 in a nearshore rocky subtidal habitat (~9-10 meters deep) at Cerro Mundo reef (0°52’06.0” S; 89°35’04.0” W), San Cristóbal Island, Galápagos. Sixty-four experimental cages were deployed at a depth of nine meters to simultaneously manipulate *in situ* grazer presence and nutrient availability across a natural temperature gradient. Cages were based on designs from Witman et al. (2017) and consisted of circular concrete platforms (diameter = 0.43 m, height = 0.06 m) with Aquamesh (plastic-coated, galvanized mesh, 0.05 m mesh size) incorporated as needed per cage design. Treatments provided varying degrees of herbivore exclusion: open plots with unrestricted grazer access; full exclusion cages preventing access by large herbivores (i.e., fish, urchins, turtles, and marine iguanas) but not mesograzers (e.g., amphipods, small gastropods); and grazer inclusion cages maintaining a constant density of a single urchin species.

Cage type was crossed with two nutrient levels: ambient and enriched. Nutrient enrichment was achieved by attaching two nutrient pillows (drawstring pouches, 0.001 m mesh size, 0.1 × 0.1 m) containing 50 g total of slow-release fertilizer (Osmocote, NPK 19-6-12, without micronutrients) to half of the cages.

Eight independent four-week trials were conducted during peak periods of the warm and cold seasons. To discern the effects of the treatments (cage type × nutrient level) on the productivity and dynamics of benthic macroalgae, biomass data was collected at the end of each trial.

To obtain biomass data, macroalgae accumulated on each experimental unit were scraped and vacuumed into independent mesh bags (0.12 m × 0.18 m, 400 µm mesh size). Samples were transported to the Marine Ecology laboratory at the Galapagos Science Center, where they were dried at 60 °C for 24 hours and subsequently weighed to obtain dry weight as a proxy for biomass.

For trials between September 2021 and May 2022, ash-free dry weight (AFDW) was also determined. This was calculated as the difference between preburn dry weight and postburn weight, the latter obtained by combusting samples in a muffle furnace for 4 hours at 500 °C after the initial 24-hour drying step at 60 °C.

Data Processing Description

Note:
In the data file, 0 indicates there was no growth of macroalgae for that specific replicate. NA indicates that the macroalgae sample was not recovered at the end of the trial (e.g. collection mesh bag got lost).

BCO-DMO processing replaces NA with blank values.

BCO-DMO Processing Description

Version 1
- Imported original file "AFDW.xlsx" into the BCO-DMO system.
- Concatenated the data from separate Excel sheets (one per trial) into one data file.
- Renamed fields to comply with BCO-DMO naming conventions.
- Saved the final file as "algal_ash-free_dry_weight_cerro_mundo.csv".

Version 2
- Imported "Biomass data Sept-22.xlsx" into BCO-DMO system
- Imported original published dataset file "algal_ash-free_dry_weight_cerro_mundo.csv" into BCO-DMO system
- Concatenated the files, mapping "Dry_Preburn_weight" to "Preburn_weight"
- Renamed "Preburn_weight" to "Dry_weight"
- Exported file as 894169_v2_algal_ash-free_dry_weight.csv

**Added dry weight, or preburn weight, as biomass data for 2023 trials. Adjusted extents. Adjusted the language of the dataset to focus on biomass, rather than AFDW, which was not measured in the later trials.

Adjusted abstract, methods, and parameter language as submitted. Added scale to list of instruments. Changed title to include Apr 2023.

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Data Files

File
894169_v2_algal_ash-free_dry_weights.csv (Comma Separated Values (.csv), 30.29 KB) MD5:fb6266c8d93f371f48f97ba4adff7768 Primary data file for dataset ID 894169, version 2

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Related Publications

Witman, J. D., Smith, F., & Novak, M. (2017). Experimental demonstration of a trophic cascade in the Galápagos rocky subtidal: Effects of consumer identity and behavior. PLOS ONE, 12(4), e0175705. https://doi.org/10.1371/journal.pone.0175705
Methods

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Related Datasets

IsRelatedTo

Bruno, J., Brandt, M., Silva, I., Agudo-Adriani, E. (2025) **Algal Percent Cover Data collected in the nearshore shallow subtidal during eight field experiments conducted at Cerro Mundo Bay in the Galapagos Islands between Sep 2021 and Apr 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-10-03 doi:10.26008/1912/bco-dmo.985410.1 [view at BCO-DMO]
Relationship Description: Data were collected from the same experiment (experimental cages).

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Parameters

Parameter	Description	Units
Trial	Month and year of the experiment	unitless
Cage	Replicate number	unitless

Treatment	Four types of experimental treatments were used: (All Present) Open pizzas with full access to all grazers. (Urchins Only) Urchin inclusions, where two pencil urchins remained caged throughout the duration of each trial to maintain the identity and density of our herbivore of interest constant. (None Present) Full exclusions, preventing access to all macro-herbivores such as sea urchins, fishes, iguanas, and turtles, but not to meso-herbivores such as amphipods. These cages are covered with a top. (Procedural) Procedural control that included partial sides, designed to affect flow and light to a similar degree as other cages to test for experimental artifacts of the herbivore manipulation.	unitless
N	Nutrient category: N+= elevated nutrients, fertilizer pillows were attached to the cage's side; No N= ambient nutrients.	unitless
Algae_Type	Algae type: RF = Red filamentous; cca = Crustose Coralline algae; D = Dictyota; P = Padina; Ulva = Ulva; RA = Red algae.	unitless
Foil_cup_weight	Weight (in grams) of only the aluminum foil cup before placing the wet algae sample	grams (g)
Sample_and_foil_cup_weight	Weight (in grams) of algae sample and aluminum foil after the sample was dried in the drying oven	grams (g)
Dry_weight	Dry weight - weight in grams of sample after drying process; Subtraction of "Foil_cup_weight" from "Sample_and_foil_cup_weight"	grams (g)
Ceramic_cup_weight	Weight (in grams) of only the ceramic melting pot before placing the dried algae sample	grams (g)
Sample_and_ceramic_cup_weight	Weight of algae sample and ceramic melting pot after the sample was burned in the muffle furnace	grams (g)
Postburn_weight	Subtraction of "Ceramic_cup_weight" from "Sample_and_ceramic_cup_weight"	grams (g)
AFDW	Ash-free dry weight; subtraction of "Postburn_weight" from "Preburn_weight" or "Dry_weight"	grams (g)

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Instruments

Dataset-specific Instrument Name	Memmert UFE 400 Sterilizer Laboratory Oven
Generic Instrument Name	Drying Oven
Generic Instrument Description	a heated chamber for drying

Dataset-specific Instrument Name	Optic Ivymen System Laboratory Furnace 8.2/1100
Generic Instrument Name	muffle furnace
Generic Instrument Description	A muffle furnace or muffle oven (sometimes retort furnace in historical usage) is a furnace in which the subject material is isolated from the fuel and all of the products of combustion, including gases and flying ash. A type of jacketed enclosure that is used to heat a material to significantly high temperatures while keeping it contained and fully isolated from external contaminants, chemicals or substances. Muffle furnaces are usually lined with stainless steel, making them largely corrosion-resistant.

Dataset-specific Instrument Name	OHAUS PX224 Pioneer Analytical Balance, NJ, USA
Generic Instrument Name	scale or balance
Dataset-specific Description	Samples were transported to the Marine Ecology laboratory at the Galapagos Science Center, where they were dried at 60 °C for 24 hours and subsequently weighed to obtain dry weight as a proxy for biomass.
Generic Instrument Description	Devices that determine the mass or weight of a sample.

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Project Information

The Role of Temperature in Regulating Herbivory and Algal Biomass in Upwelling Systems (Temperature and Herbivory)

Website: http://github.com/johnfbruno/Galapagos_NSF.git

NSF Award Abstract:
A well-known pattern in coastal marine systems is a positive association between the biomass of primary producers and the occurrence or intensity of upwelling. This is assumed to be caused by the increase in nutrient concentration associated with upwelling, enabling higher primary production and thus greater standing algal biomass. However, upwelling also causes large, rapid declines in water temperature. Because the metabolism of fish and invertebrate herbivores is temperature-dependent, cooler upwelled water could reduce consumer metabolism and grazing intensity. This could in turn lead to increased standing algal biomass. Thus upwelling could influence both bottom-up and top-down control of populations and communities of primary producers. The purpose of this study is to test the hypothesis that grazing intensity and algal biomass are, in part, regulated by temperature via the temperature-dependence of metabolic rates. Broader impacts include the training and retention of minority students through UNC's Course Based Undergraduate Research program, support of undergraduate research, teacher training, and various outreach activities.

The investigators will take advantage of the uniquely strong spatiotemporal variance in water temperature in the Galápagos Islands to compare grazing intensity and primary production across a natural temperature gradient. They will combine field monitoring, statistical modeling, grazing assays, populations-specific metabolic measurements, and in situ herbivore exclusion and nutrient addition to measure the effects of temperature on pattern and process in shallow subtidal communities. The researchers will also test the hypothesis that grazer populations at warmer sites and/or during warmer seasons are less thermally sensitive, potentially due to acclimatization or adaptation. Finally, the investigators will perform a series of mesocosm experiments to measure the effect of near-future temperatures on herbivores, algae, and herbivory. This work could change the way we view upwelling systems, particularly how primary production is regulated and the temperature-dependence of energy transfer across trophic levels.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1737071

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