

Sizes of organisms fixed to flume floor from back reef community flume experiments conducted in Moorea, French Polynesia, from Nov 2015 to Nov 2016

Website: <https://www.bco-dmo.org/dataset/793674>

Data Type: experimental

Version: 1

Version Date: 2020-02-18

Project

» [Collaborative Research: Ocean Acidification and Coral Reefs: Scale Dependence and Adaptive Capacity](#) (OA coral adaptation)

Program

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

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Abstract

These data describe the fauna that was secured to a metal grid in the bottom of the flume. These data are results of an experiment incubating a back reef community from Moorea, French Polynesia, for one year at high pCO₂ (published in Edmunds et al. 2019) from Nov of 2015 to Nov of 2016.

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Coverage

Spatial Extent: N:-17.476 E:-149.752 S:-17.605 W:-149.921

Temporal Extent: 2015-11 - 2016-11

Dataset Description

These data describe the fauna that was secured to a metal grid in the bottom of the flume. These data are results of an experiment incubating a back reef community from Moorea, French Polynesia, for one year at high pCO₂ (published in Edmunds et al. 2019) from Nov of 2015 to Nov of 2016. Related Datasets: all were used in Edmunds et al. (2019): Edmunds et al. 2019b: Sizes of organisms fixed to flume floor <https://www.bco-dmo.org/dataset/793674> Edmunds et al. 2019b: Sizes of organisms used to calculate growth and for community analysis <https://www.bco-dmo.org/dataset/793682>

Methods & Sampling

The following methodology applies to this dataset in addition to other datasets published in Edmunds et al. (2019).

Methodology:

Overview

Back reef communities were assembled in four flumes, with each randomly assigned to pCO₂ treatments targeting ambient (400 μatm), 700 μatm, 1000 μatm, and 1300 μatm pCO₂ to approximate atmospheric pCO₂ projected for ~ 2140 under representative concentration pathways (RCP) 2.6, 4.5, 6.0 and 8.5, respectively. Treatments were maintained for one year from November 2015, and actual pCO₂ treatments differed from target values. Each flume consisted of a working section that was 5.0 m long, 30 cm wide and filled to ~ 30-cm depth with ~ 500 L of seawater that was circulated and refreshed with sand-filtered (pore size ~ 450-550 μm) seawater from Cook's Bay (-17.491, -149.826, 14-m depth) at ~ 5 L min⁻¹.

Planar growth and community structure were measured because they are used in ecological analyses of coral reefs, and we reasoned they would sharpen the ability to interpret the ecological implications of the physiological impacts of OA on calcification. We anticipated that the community response to OA would include reduced linear extension, impaired planar growth of tissue and skeleton, and increase partial mortality (as in Dove et al. 2013). The mean linear extension expected for the corals in the present study (Porites rus = 15.2 ± 5.7 mm y⁻¹, massive Porites = 10.0 ± 0.6 mm y⁻¹, Montipora = 27.7 + 3.0 mm y⁻¹, and Pocillopora verrucosa = 24.7 ± 2.4 mm y⁻¹ [<https://coraltraits.org/>, accessed 8 October 2018]) were expected to create annual changes in planar area of 52 cm² (with mean initial size of 69 cm²), 32 cm² (with mean initial size of 68 cm²), 106 cm² (with mean initial size of 70 cm²), and 150 cm² (with mean initial size of 218 cm²), respectively, in the ambient flume. To evaluate the precision of the photographic method, 10 independent images of mounding and branching corals in the flumes were recorded, and were processed to provide replicate determinations of organism size (i.e., planar area). These images showed that the standard deviations of mean area determinations were 2.3% for massive Porites, and 3.8% for Pocillopora verrucosa). Based on these measures of precision, there would be a 75% chance of detecting annual growth of 0.6 cm² for massive Porites and 4.8 cm² for Pocillopora verrucosa, which represent reasonable estimates for the growth of these corals in our flumes. Given effect sizes ranging from 21.1% for Lithophyllum to 10.2% for massive Porites upon exposure to 1067 μatm pCO₂ (Comeau et al. 2014), an effect of pCO₂ on growth in the present study would be detectable for Montipora, while smaller effects of pCO₂ for other taxa might be prone to Type II errors in detection (i.e., they might not be detected when present).

Back reef communities were assembled to correspond to the mean percent cover of the major space holders in this habitat in 2013 (data archived in Edmunds 2015). The Back reef community source was latitude: -17.481, and longitude: -149.836 ± 4 km from this point along the north shore. The communities began with ~ 25% coral cover, with 11% massive Porites spp., 7% Porites rus, 4% Montipora spp., 3% Pocillopora spp., and ~ 7% crustose coralline algae (CCA), consisting of 4% Porolithon onkodes and 3% Lithophyllum kotschyannum. Coral rubble (~ 1-cm diameter) was added to ~ 5% cover, and the remainder of the benthic surface was sand. Analyses of community structure focused on the central, 2.4-m long portion of this community where corals and CCA were secured to a plastic-coated, metal grid (5 × 5 cm mesh) and represented the "fixed" community. Securing organisms to the grid was critical to reduce parallax errors in photography, to allow the organisms to grow and interact as they extended over the year experiment, and to allow ecologically meaningful analysis of community structure using photographs.

The central section of each flume included a 2.4-m long sediment box that extended the width of the flume, and contained 30-cm depth of sediment. The sediment box was flanked by ~ 2.6 m of the fiberglass floor of the flume, along which 0.8 m was occupied by the same benthic community, but with corals and CCA resting on the bottom (i.e., "unfixed"). Members of the fixed community were buoyant weighed at the start and end of the year to measure Net changes in mass (Gnet), but otherwise were left in place. Members of the unfixed community were removed monthly to measure buoyant weight to calculate Gnet (described below). The unfixed portion of the community allowed monthly resolution of Gnet, but the necessity for removal from (and return to) the flume to measure Gnet resulted in relocation error that negated their use in photographic measurement of community structure. In addition to the coral, sand, CCA, and rubble, the flumes were augmented with holothurians (~ 8-cm long, Holothuria spp.), and macroalgae (Turbinaria ornata and Halimeda minima) to approximate the cover of these algae in the back reef in 2013 (~ 4-5%).

Corals, CCA, and rubble were collected from ~ 2-m depth in the back reef, and were attached with epoxy (Z-Spar A788) to plastic bases. Sediments were collected in the same location, and were placed into boxes that were buried in situ, flush with the sediment for 3 d to promote stratification, and then installed in each flume.

Back reef communities were constructed in the flumes on 12 November 2015, and were maintained under ambient conditions until 17 November 2015, when pCO₂ treatments began in three flumes, with levels increased to target values over 24 h. Throughout the experiment, the flumes were cleaned of algal turf that grew on the walls of the flumes as well as exposed plastic and the metal grid on the floor of the flume. Turfs were not removed from natural surfaces (i.e., coral bases and rubble) with the rationale that they are a normal component of back reef communities.

Physical and chemical parameters:

Seawater was circulated at ~ 0.1 m s⁻¹ using a pump (W. Lim Wave II 373 J s⁻¹), and flow speeds were measured across the working sections using a Nortek Vectrino Acoustic Doppler Velocimeter. This flow speed was relevant for the back reef of Mo'orea. The flumes were exposed to sunlight that was shaded to a photon flux density (PFD) of photosynthetically active radiation (PAR) approximating 2-m depth in the back reef. Light was measured using cosine-corrected sensors (Odyssey, Dataflow Systems Ltd, New Zealand) that were calibrated with a LI-COR meter (LI-1400, Li-COR Biosciences, Lincoln, NE) attached to a 2π sensor (LI 192A). Maximum daily PFD varied by day and season from 364–1,831 μmol quanta m⁻² s⁻¹. Temperatures were regulated close to the mean monthly temperature in the back reef that increased from ~ 27.8°C in December 2015, to ~29.3°C in April 2016, and back to ~ 27.4 °C in November 2016.

Seawater carbonate chemistry was uncontrolled in one flume (ambient), and in the three others, seawater pH was controlled through the addition of CO₂ gas (using solenoids controlled with an Aquacontroller, Neptune Systems, USA) to approximate pCO₂ targets. A diurnal upward adjustment of ~ 0.1 pH was applied to the treatments to simulate natural variation in seawater pCO₂ in the back reef. The ambient flume also maintained a diurnal variation in pCO₂ with a nighttime pH ~ 0.1 lower than daytime. Ambient air was bubbled into all flumes.

PAR and temperature (Hobo Pro v2 [± 0.2°C], Onset Computer Corp., MA, USA) were recorded, and pH was measured daily (at various times of day) on the total hydrogen ion scale (pHT). Temperature and pH were used to adjust the thermostat and pH-set points close to values that were calculated (using seacarb) to correspond to target treatments of 400 μatm, 700 μatm, 1000 μatm, and 1300 μatm (~ 8.04, ~7.81, ~7.70 and ~7.65, respectively). Seawater carbonate chemistry (pH and AT) and salinity were measured at 14:00 hrs and 20:00 hrs weekly. A conductivity meter (Thermo Scientific, Orionstar A212, Waltham, MA, USA) was used to measure salinity. The remaining parameters of the seawater carbonate system were calculated from temperature, salinity, pHT, and AT, using the R package seacarb. Calculations were made using the carbonic acid dissociation constants, the KSO₄ concentration for the bisulfate ion, and the K_f constant.

pHT was measured using a DG 115-SC electrode (Mettler Toledo, Columbus, OH, USA) that was calibrated with a TRIS buffers. AT was measured using open-cell, acidimetric titration (SOP 3b [Dickson et al. 2007]) using certified titrant with a titrator (T50 with a DG 115-SC electrode, Mettler Toledo). The accuracy and precision of measurements were determined using reference materials (from A. Dickson, Scripps Institution of Oceanography, CA, USA), against which measured values of AT maintained an accuracy of 1.7 ± 0.3 μmol kg⁻¹ (n = 15) and precision of 1.8 ± 0.1 μmol kg⁻¹ (n = 475).

Response variables:

Net changes in mass (Gnet) of corals and CCA was measured using buoyant weight (± 1 mg) by month (unfixed) or year (fixed community). Buoyant weight was converted to dry weight of CaCO₃ using empirical seawater density (~1.02278 g cm⁻³) and the density of pure aragonite (2.93 g cm⁻³, corals) and pure calcite (2.71 g cm⁻³, CCA). Gnet in each month was expressed as the percentage change in mass relative to the initial mass in November 2015. As the area of tissue changed throughout the experiment through growth and partial mortality, "growth" could not be expressed on an area-normalized scale.

Community structure was quantified using planar photographs recorded in ambient light using a GoPro Hero 4 camera (12 MP, 3-mm focal length). The camera was moved along the flume to record the community in the working section using ~ 16 frames sampling⁻¹.

Photographs were analyzed using ImageJ software, in which the planar area of living tissue on corals and CCA was quantified by outlining organisms and scaling the image using the metal grid as a reference. Size (cm²) was expressed as a percentage of the area (240 × 30 = 7200 cm²) occupied by the fixed members of the community. The summed area of community members was used to determine overall cover of the benthic community, and changes in area were used to quantify growth. Where organisms died, their area was set to zero.

See Edmunds et al. (2019) for analyses that used these data.

Data Processing Description

BCO-DMO Data Manager Processing Notes:

- * Original data submitted as in Excel sheet "Fig. 1Permanent" extracted to csv. See Data Files for the originally submitted Excel file.
- * added a conventional header with dataset name, PI name, version date
- * modified parameter names to conform with BCO-DMO naming conventions (spaces, +, and - changed to underscores). Units in parentheses removed and added to Parameter Description metadata section.

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Data Files

File

Data published in Edmunds et al. (2019) Excel File

filename: Edmunds_MarBio_2019b_Data.xlsx

(Microsoft Excel, 211.81 KB)
MD5:1cda751d9bb6a672487ff82e3833055d

Excel file containing data published as figures in Edmunds et al. 2019 (doi: 10.1007/s00227-019-3540-2).

FIG. 1 MOBILE

These data describe the mobile fauna in the flumes that were not fixed to the bottom of the flume

A = Flume number (1 = 1400 μ atm, 2 = 700 μ atm, 3 = 400 μ atm, 4 = 1000 μ atm)

B = unique organism ID number

C = species name

D = month of incubation 0 = November 2015 (start)

E = Mass of corals and algal as dry weight calculated from bouyant weight

FIG. 1 PERMANENT

The data describe the fauna that was secured to a metal grid in the bottom of the flume

A = Flume number (1 = 1400 μ atm, 2 = 700 μ atm, 3 = 400 μ atm, 4 = 1000 μ atm)

B = unique organism ID number

C = species name

D = initial mass of corals as dry weight calculated from buoyant weight in month 0

E = Final mass of corals and algae as dry weight calculated from buoyant weight in month 12

FIGS 2 AND 3

These data support Figs 2 and 3 in the paper and describe the % cover of each organism described from planar photographs

A = Flume number (1 = 1400 μ atm, 2 = 700 μ atm, 3 = 400 μ atm, 4 = 1000 μ atm)

B = Analysis type. Actual = data as obtained with missing values (=ND). NMDS = data processed for NMDS analyses with missing values replaced as described in the methodology.

C = month of incubation 0 = November 2015 (start)

D = Year of analysis (2015 or 2016)

E = Month of analysis

F = Unique ID number for each organism

G = taxon

H = % area of flume floor represented by each organism

marbio-fig1-permanent.csv

(Comma Separated Values (.csv), 2.66 KB)
MD5:9f0c3e05c772fa67f391d2b42c2f85b9

Primary data file for dataset ID 793674

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Related Publications

Comeau, S., Edmunds, P. J., Spindel, N. B., & Carpenter, R. C. (2014). Fast coral reef calcifiers are more sensitive to ocean acidification in short-term laboratory incubations. *Limnology and Oceanography*, 59(3), 1081–1091. doi:[10.4319/lo.2014.59.3.1081](https://doi.org/10.4319/lo.2014.59.3.1081)

Methods

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. Guide to best practices for ocean CO2 measurements. PICES Special Publication 3, 191 pp. ISBN: 1-897176-07-4. URL: https://www.nodc.noaa.gov/ocads/oceans/Handbook_2007.html <https://hdl.handle.net/11329/249>

Methods

Dove, S. G., Kline, D. I., Pantos, O., Angly, F. E., Tyson, G. W., & Hoegh-Guldberg, O. (2013). Future reef decalcification under a business-as-usual CO2 emission scenario. *Proceedings of the National Academy of Sciences*, 110(38), 15342–15347. doi:[10.1073/pnas.1302701110](https://doi.org/10.1073/pnas.1302701110)

Methods

Edmunds, P. J. (2015). A quarter-century demographic analysis of the Caribbean coral, *Orbicella annularis*, and projections of population size over the next century. *Limnology and Oceanography*, 60(3), 840–855.

doi:[10.1002/lno.10075](https://doi.org/10.1002/lno.10075)

Methods

Edmunds, P. J., Doo, S. S., & Carpenter, R. C. (2019). Changes in coral reef community structure in response to year-long incubations under contrasting pCO2 regimes. *Marine Biology*, 166(7). doi:[10.1007/s00227-019-3540-2](https://doi.org/10.1007/s00227-019-3540-2)

Results

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Parameters

Parameter	Description	Units
Flume	Flume number (1 = 1400 μ atm. 2 = 700 μ atm, 3 = 400 μ atm, 4 = 1000 μ atm)	unitless
ID_number	Unique organism ID number	unitless
Species	Organism identification (Scientific name or Genus)	unitless
Initial	Initial mass of corals as dry weight calculated from bouyant weight in month 0 (Nov 2015)	grams (g)
Final	Final mass of corals and algae as dry weight calculated from bouyant weight in month 12 (Nov 2016)	grams (g)

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Camera
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Project Information

Collaborative Research: Ocean Acidification and Coral Reefs: Scale Dependence and Adaptive Capacity (OA coral adaptation)

Website: <http://mcr.lternet.edu>

Coverage: Moorea, French Polynesia

Extracted from the NSF award abstract:

This project focuses on the most serious threat to marine ecosystems, Ocean Acidification (OA), and addresses the problem in the most diverse and beautiful ecosystem on the planet, coral reefs. The research utilizes Moorea, French Polynesia as a model system, and builds from the NSF investment in the Moorea Coral Reef Long Term Ecological Research Site (LTER) to exploit physical and biological monitoring of coral reefs as a context for a program of studies focused on the ways in which OA will affect corals, calcified algae, and coral reef ecosystems. The project builds on a four-year NSF award with research in five new directions: (1) experiments of year-long duration, (2) studies of coral reefs to 20-m depth, (3) experiments in which carbon dioxide will be administered to plots of coral reef underwater, (4) measurements of the capacity of coral reef organisms to change through evolutionary and induced responses to improve their resistance to OA, and (5) application of emerging theories to couple studies of individual organisms to studies of whole coral reefs. Broader impacts will accrue through a better understanding of the ways in which OA will affect coral reefs that are the poster child for demonstrating climate change effects in the marine environment, and which provide income, food, and coastal protection to millions of people living in coastal areas, including in the United States.

This project focuses on the effects of Ocean Acidification on tropical coral reefs and builds on a program of research results from an existing 4-year award, and closely interfaces with the technical, hardware, and information infrastructure provided through the Moorea Coral Reef (MCR) LTER. The MCR-LTER, provides an unparalleled opportunity to partner with a study of OA effects on a coral reef with a location that arguably is better instrumented and studied in more ecological detail than any other coral reef in the world. Therefore, the results can be both contextualized by a high degree of ecological and physical relevance, and readily integrated into emerging theory seeking to predict the structure and function of coral reefs in warmer and more acidic future oceans. The existing award has involved a program of study in Moorea that has focused mostly on short-term organismic and ecological responses of corals and calcified algae, experiments conducted in mesocosms and flumes, and measurements of reef-scale calcification. This new award involves three new technical advances: for the first time, experiments will be conducted of year-long duration in replicate outdoor flumes; CO₂ treatments will be administered to fully intact reef ecosystems in situ using replicated underwater flumes; and replicated common garden cultivation techniques will be used to explore within-species genetic variation in the response to OA conditions. Together, these tools will be used to support research on corals and calcified algae in three thematic areas: (1) tests for long-term (1 year) effects of OA on growth, performance, and fitness, (2) tests for depth-dependent effects of OA on reef communities at 20-m depth where light regimes are attenuated compared to shallow water, and (3) tests for beneficial responses to OA through intrinsic, within-species genetic variability and phenotypic plasticity. Some of the key experiments in these thematic areas will be designed to exploit integral projection models (IPMs) to couple organism with community responses, and to support the use of the metabolic theory of ecology (MTE) to address scale-dependence of OA effects on coral reef organisms and the function of the communities they build.

The following publications and data resulted from this project:

Comeau S, Carpenter RC, Lantz CA, Edmunds PJ. (2016) Parameterization of the response of calcification to temperature and pCO₂ in the coral *Acropora pulchra* and the alga *Lithophyllum kotschyannum*. *Coral Reefs* 2016. DOI [10.1007/s00338-016-1425-0](https://doi.org/10.1007/s00338-016-1425-0).

[calcification rates](#) (2014)

[calcification rates](#) (2010)

Comeau, S., Carpenter, R.C., Edmunds, P.J. (2016) Effects of pCO₂ on photosynthesis and respiration of tropical scleractinian corals and calcified algae. *ICES Journal of Marine Science* doi:[10.1093/icesjms/fsv267](https://doi.org/10.1093/icesjms/fsv267).

[respiration and photosynthesis I](#)

[respiration and photosynthesis II](#)

Evensen, N.R. & Edmunds P. J. (2016) Interactive effects of ocean acidification and neighboring corals on the growth of *Pocillopora verrucosa*. *Marine Biology*, 163:148. doi: [10.1007/s00227-016-2921-z](https://doi.org/10.1007/s00227-016-2921-z)
[coral growth](#)
[seawater chemistry](#)
[coral colony interactions](#)

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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 Division of Ocean Sciences (NSF OCE)	OCE-1415268

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