

Respiration and protein content of brooded coral larvae at high and ambient temperature and pCO2, Taiwan, March 2011 (Cumbo et al, JEMBE, 2013) (MCR LTER & Climate Coral Larvae projects)

Website: <https://www.bco-dmo.org/dataset/535328>
Data Type: experimental
Version: 1
Version Date: 2014-10-07

Project
» [Moorea Coral Reef Long-Term Ecological Research site](#) (MCR LTER)
» [The ecophysiological basis of the response of coral larvae and early life history stages to global climate change](#) (Climate_Coral_Larvae)

Program
» [Long Term Ecological Research network](#) (LTER)

Contributors	Affiliation	Role
Edmunds, Peter J.	California State University Northridge (CSUN)	Principal Investigator
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Abstract
The physiological development of brooded larvae from the pocilloporid corals *Pocillopora damicornis* in southern Taiwan under elevated temperature and pCO2 was examined. These data include respiration rates and protein content of brooded coral larvae at high and ambient temperature and pCO2 conducted in March 2011. These data were published in Cumbo et al, JEMBE, 2013.

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Coverage

Spatial Extent: Lat:21.93817 Lon:120.74602
Temporal Extent: 2011-03-02 - 2011-03-18

Methods & Sampling

Larval respiration was measured in a confined respirometer use a Ruthenium-based optrode (FOXY-R, 1.58 diameter, Ocean Optics) connected to a spectrophotometer (USB2000, Ocean Optics) and interfaced with a computer running the manufacturers software (OOISensor, version 1.00.08). The optrode was calibrated using a zero solution (0.01 M Na2B4O7·10H2O supersaturated with Na2SO3) and 100% air saturation using water-saturated air at the treatment temperature. To measure respiration, 6 larvae were removed from the tubs in the treatment tanks and placed into 2-mL glass Wheaton vials filled with filtered seawater from the same treatment tank and sealed with Parafilm. A study conducted concurrently with the present analysis demonstrated that respiration of *P. damicornis* larvae in identical vials could be measured accurately with 5 larvae vial-1 (Edmunds et al., 2011).

Initial O2 concentration in the seawater was determined before the vials were sealed, and vials without larvae used as controls. Larvae in the sealed vials were incubated at their temperature treatments for 1.5-2 h in the dark using water baths set to the temperature of the respective treatments (±0.1 °C, Hipoint, models LC-06 and LC-10); vials were carefully moved throughout the incubations to ensure the seawater remained mixed. Incubation times were selected to ensure O2 concentrations remained >75% saturation. On completion of the incubations, vials were removed from the water baths, gently inverted to mix the seawater, and analyzed for O2 saturation. O2 saturation was converted to concentration using tabulated values of O2 solubility (N. Ramsing and J. Gundersen at <http://www.unisense.com> [based on Garcia and Gordon, 1992]) and the temperature and salinity of the seawater, and the change in O2 concentration used to calculate O2 flux after adjusting for controls. The respiration rates are expressed as nmol O2 mg protein-1 min-1.

Protein content was determined spectrophotometrically using the Bio-Rad Coomassie Blue assay in the microtiter plate protocol (BioRad Life Sciences Research, CA). At each sampling, 1 group of 8 larvae from each tub within each tank (i.e., 2 replicates tank-1) was frozen in liquid nitrogen and stored. Proteins were solubilized in 0.1 M NaOH, aided by sonication (10% amplitude for 15 s using a Branson Digital Sonifier S-250D, USA) and warming at 50 °C for 5 h. The extract was neutralized with 1 M HCl and processed in triplicate with the addition of the dye reagent. Following 30 min incubation, absorbances were measured at 595 nm using a plate reading spectrophotometer (Biotek Synergy H4 Hybrid Reader, USA), and converted to protein using a calibration prepared from bovine serum albumin. Protein content was expressed as µg larva-1.

The 'ambient' and 'high' pCO2 levels: 49.4 Pa versus 86.2 Pa
The 'ambient' and 'high' temperatures: 24.00 °C [ambient] versus 30.49 °C

Data also available from PANGAEA: [doi:10.1594/PANGAEA.823582](https://doi.org/10.1594/PANGAEA.823582)

Data Processing Description

BCO-DMO processing notes:

- added conventional header with dataset name, PI name, version date, reference information
- renamed parameters to BCO-DMO standard
- added lab, lat, lon columns
- reformatted date from d-Mon-yy to yyyy-mm-dd
- changed Ambient to ambient; High to high; P. dam to Pocillopora_damicornis

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Data Files

File
brood3_resprotein.csv (Comma Separated Values (.csv), 5.75 KB) MD5:787e3c3198db9f4c92a4813e706767df
Primary data file for dataset ID 535328

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Supplemental Files

File
Biological data for "brooded coral larvae expt. 3" datasets filename: Cumbo_eta1_2012_JEMBE_data1_BCODMO.xls (Octet Stream, 154.50 KB) MD5:e6c5e6012df9bfc581b9f769f7e52a98 Original biological data for Cumbo et al 2013 including respiration raw data, respiration by mg protein, symbiont densities, protein content, % mortality
Tank physical data filename: Cumbo_eta1_2012_JEMBE_Tank_Parameters_BCODMO.xlsx (Octet Stream, 57.05 KB) MD5:0170402805d7c1fe4784a51d2b26fb66 Tank physical data for "brooded coral larvae 3" experiment including seawater chemistry, light and temperature data.

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Related Publications

Cumbo, V. R., Fan, T. Y., & Edmunds, P. J. (2013). Effects of exposure duration on the response of Pocillopora damicornis larvae to elevated temperature and high pCO2. Journal of Experimental Marine Biology and Ecology, 439, 100–107. doi:[10.1016/j.jembe.2012.10.019](#)
Results

Edmunds, P. J., Cumbo, V., & Fan, T.-Y. (2011). Effects of temperature on the respiration of brooded larvae from tropical reef corals. Journal of Experimental Biology, 214(16), 2783–2790. doi:[10.1242/jeb.055343](#)
Results

Garcia, H. E., & Gordon, L. I. (1992). Oxygen solubility in seawater: Better fitting equations. Limnology and Oceanography, 37(6), 1307–1312. doi:[10.4319/l.1992.37.6.1307](#)
General

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Related Datasets

IsRelatedTo

Edmunds, P. J., Cumbo, V. R., Fan, T. (2014) **Light data in tanks from experiment on brooded coral larval, Taiwan, March 2011 (Cumbo et al, JEMBE, 2013) (MCR LTER & Climate Coral Larvae projects)**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2014-10-07 <http://lod.bco-dmo.org/id/dataset/535219> [[view at BCO-DMO](#)]

Edmunds, P. J., Cumbo, V. R., Fan, T. (2014) **Protein content of brooded coral larvae at high and ambient temperature and pCO2, March 2011 (Cumbo et al, JEMBE, 2013) (MCR LTER & Climate Coral Larvae projects)**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2014-10-07 <http://lod.bco-dmo.org/id/dataset/535425> [[view at BCO-DMO](#)]

Edmunds, P. J., Cumbo, V. R., Fan, T. (2014) **Respiration of brooded coral larvae at high and ambient temperature and pCO2, Taiwan, March 2011 (Cumbo et al, JEMBE, 2013) (MCR LTER & Climate Coral Larvae projects)**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2014-10-07 <http://lod.bco-dmo.org/id/dataset/535266> [[view at BCO-DMO](#)]

Edmunds, P. J., Cumbo, V. R., Fan, T. (2014) **Seawater carbonate chemistry from experiment on brooded coral larval, March 2011, Taiwan (Cumbo et al, JEMBE, 2013) (MCR LTER & Climate Coral Larvae projects)**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2014-10-07 <http://lod.bco-dmo.org/id/dataset/535163> [[view at BCO-DMO](#)]

Edmunds, P. J., Cumbo, V. R., Fan, T. (2014) **Symbiont Symbiodinium density in brooded coral larvae at high and ambient temperature and pCO2, Taiwan, March 2011 (Cumbo et al, JEMBE, 2013) (MCR LTER & Climate Coral Larvae projects)**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2014-10-07 <http://lod.bco-dmo.org/id/dataset/535358> [[view at BCO-DMO](#)]

Edmunds, P. J., Cumbo, V. R., Fan, T. (2014) **Temperature data from tanks from experiment on brooded coral larval, Taiwan, March 2011 (Cumbo et al, JEMBE, 2013) (MCR LTER & Climate Coral Larvae projects)**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2014-10-07 <http://lod.bco-dmo.org/id/dataset/535244> [[view at BCO-DMO](#)]

Edmunds, P. J., Cumbo, V. R., Fan, T. (2021) **Settling and mortality measurements of brooded coral larvae at high and ambient temperature and pCO2, Taiwan, March 2011 (MCR LTER project, Climate Coral Larvae project)**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2014-10-07 doi:10.26008/1912/bco-dmo.535462.1 [[view at BCO-DMO](#)]

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Parameters

Parameter	Description	Units
lab	laboratory	unitless
lat	latitude; north is positive	decimal degrees
lon	longitude; east is positive	decimal degrees
date	local date	yyyy-mm-dd
tank	tank id number	tank
temp	target temperature	degrees Celsius
treatment_pCO2	pCO2 treatment: ambient (47.5 - 49.3 Pa) or high (85.2 - 87.2 Pa)	unitless
days	days since start of experiment	unitless
resp_larv	respiration rate per larva	nmol O2/larva/min
mg_protein_larv	milligrams protein content per larva	mg/larva
resp_prot	respiration rate per milligram of protein	nmol O2/mg protein/min
ug_protein_larv	micrograms protein content per larva	ug/larva

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Instruments

Dataset-specific Instrument Name	Aquarium chiller
Generic Instrument Name	Aquarium chiller
Dataset-specific Description	Aquatech Ac11 or Shyeh Duwai Enterprise
Generic Instrument Description	Immersible or in-line liquid cooling device, usually with temperature control.

Dataset-specific Instrument Name	Gas Analyzer
Generic Instrument Name	Gas Analyzer
Dataset-specific Description	Infra Red gas analyzer (S151, Qubit Systems)
Generic Instrument Description	Gas Analyzers - Instruments for determining the qualitative and quantitative composition of gas mixtures.

Dataset-specific Instrument Name	Immersion heater
Generic Instrument Name	Immersion heater
Dataset-specific Description	300 Wheaters, Taikong Corporation
Generic Instrument Description	Submersible heating element for water tanks and aquaria.

Dataset-specific Instrument Name	LI-COR LI-192 light sensor
Generic Instrument Name	LI-COR LI-192 PAR Sensor
Dataset-specific Description	cosine-corrected quantum light meter (Li-Cor LI-192 attached to an LI-1400)
Generic Instrument Description	The LI-192 Underwater Quantum Sensor (UWQ) measures underwater or atmospheric Photon Flux Density (PPFD) (Photosynthetically Available Radiation from 360 degrees) using a Silicon Photodiode and glass filters encased in a waterproof housing. The LI-192 is cosine corrected and features corrosion resistant, rugged construction for use in freshwater or saltwater and pressures up to 800 psi (5500 kPa, 560 meters depth). Typical output is in um s-1 m-2. The LI-192 uses computer-tailored filter glass to achieve the desired quantum response. Calibration is traceable to NIST. The LI-192 serial numbers begin with UWQ-XXXXX. LI-COR has been producing Underwater Quantum Sensors since 1973. These LI-192 sensors are typically listed as LI-192SA to designate the 2-pin connector on the base of the housing and require an Underwater Cable (LI-COR part number 2222UWB) to connect to the pins on the Sensor and connect to a data recording device. The LI-192 differs from the LI-193 primarily in sensitivity and angular response. 193: Sensitivity: Typically 7 uA per 1000 umol s-1 m-2 in water. Azimuth: < ± 3% error over 360° at 90° from normal axis. Angular Response: < ± 4% error up to ± 90° from normal axis. 192: Sensitivity: Typically 4 uA per 1000 umol s-1 m-2 in water. Azimuth: < ± 1% error over 360° at 45° elevation. Cosine Correction: Optimized for underwater and atmospheric use. (www.licor.com)

Dataset-specific Instrument Name	optrode
Generic Instrument Name	Optode
Dataset-specific Description	A Ruthenium-based optrode (FOXY-R, 1.58 diameter, Ocean Optics) connected to a spectrophotometer (USB2000, Ocean Optics) and interfaced with a computer running the manufacturers software (OOISensor, version 1.00.08). The optrode was calibrated using a zero solution (0.01 M Na2B4O7·10H2O supersaturated with Na2SO3) and 100% air saturation using water-saturated air at the treatment temperature.
Generic Instrument Description	An optode or optrode is an optical sensor device that optically measures a specific substance usually with the aid of a chemical transducer.

Dataset-specific Instrument Name	
Generic Instrument Name	plate reader
Dataset-specific Description	BioRad Life Sciences Research, CA
Generic Instrument Description	Plate readers (also known as microplate readers) are laboratory instruments designed to detect biological, chemical or physical events of samples in microtiter plates. They are widely used in research, drug discovery, bioassay validation, quality control and manufacturing processes in the pharmaceutical and biotechnological industry and academic organizations. Sample reactions can be assayed in 6-1536 well format microtiter plates. The most common microplate format used in academic research laboratories or clinical diagnostic laboratories is 96-well (8 by 12 matrix) with a typical reaction volume between 100 and 200 μ L per well. Higher density microplates (384- or 1536-well microplates) are typically used for screening applications, when throughput (number of samples per day processed) and assay cost per sample become critical parameters, with a typical assay volume between 5 and 50 μ L per well. Common detection modes for microplate assays are absorbance, fluorescence intensity, luminescence, time-resolved fluorescence, and fluorescence polarization. From: http://en.wikipedia.org/wiki/Plate_reader , 2014-09-0-23.

Dataset-specific Instrument Name	spectrophotometer
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	- USB2000, Ocean Optics - plate reading spectrophotometer (Biotek Synergy H4 Hybrid Reader, USA)
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

Dataset-specific Instrument Name	sonicator
Generic Instrument Name	ultrasonic cell disrupter (sonicator)
Dataset-specific Description	Branson Digital Sonifier
Generic Instrument Description	Instrument that applies sound energy to agitate particles in a sample.

Dataset-specific Instrument Name	Water Temp Sensor
Generic Instrument Name	Water Temperature Sensor
Dataset-specific Description	certified digital thermometer (Model 15-077-8, Fisher Scientific, ± 0.05 $^{\circ}$ C)
Generic Instrument Description	General term for an instrument that measures the temperature of the water with which it is in contact (thermometer).

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Deployments

lab Edmunds NMMBA

Website	https://www.bco-dmo.org/deployment/58892
Platform	Natl Museum Mar. Bio. and Aquar. Taiwan
Start Date	2010-03-18
End Date	2010-03-24
Description	Experiments related to the research project: 'RUI- The ecophysiological basis of the response of coral larvae and early life history stages to global climate change' were conducted at the laboratories of the National Museum of Marine Biology and Aquarium in Southern Taiwan.

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Project Information

Moorea Coral Reef Long-Term Ecological Research site (MCR LTER)

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

Coverage: Island of Moorea, French Polynesia

From <http://www.lternet.edu/sites/mcr/> and <http://mcr.lternet.edu/>:

The Moorea Coral Reef LTER site encompasses the coral reef complex that surrounds the island of Moorea, French Polynesia (17°30'S, 149°50'W). Moorea is a small, triangular volcanic island 20 km west of Tahiti in the Society Islands of French Polynesia. An offshore barrier reef forms a system of shallow (mean depth ~ 5-7 m), narrow (~0.8-1.5 km wide) lagoons around the 60 km perimeter of Moorea. All major coral reef types (e.g., fringing reef, lagoon patch reefs, back reef, barrier reef and fore reef) are present and accessible by small boat.

The MCR LTER was established in 2004 by the US National Science Foundation (NSF) and is a partnership between the University of California Santa Barbara and California State University, Northridge. MCR researchers include marine scientists from the UC Santa Barbara, CSU Northridge, UC Davis, UC Santa Cruz, UC San Diego, CSU San Marcos, Duke University and the University of Hawaii. Field operations are conducted from the UC Berkeley Richard B. Gump South Pacific Research Station on the island of Moorea, French Polynesia.

MCR LTER Data: The Moorea Coral Reef (MCR) LTER data are managed by and available directly from the MCR project data site URL shown above. The datasets listed below were

collected at or near the MCR LTER sampling locations, and funded by NSF OCE as ancillary projects related to the MCR LTER core research themes.

This project is supported by continuing grants with slight name variations:

- LTER: Long-Term Dynamics of a Coral Reef Ecosystem
- LTER: MCR II - Long-Term Dynamics of a Coral Reef Ecosystem
- LTER: MCR IIB: Long-Term Dynamics of a Coral Reef Ecosystem
- LTER: MCR III: Long-Term Dynamics of a Coral Reef Ecosystem
- LTER: MCR IV: Long-Term Dynamics of a Coral Reef Ecosystem

The ecophysiological basis of the response of coral larvae and early life history stages to global climate change (Climate_Coral_Larvae)

Coverage: Moorea, French Polynesia; Southern Taiwan; California State University Northridge

Tropical coral reefs face a suite of environmental assaults ranging from anchor damage to the effects of global climate change (GCC). The consequences are evident throughout the tropics, where many coral reefs have lost a substantial fraction of their coral cover in a few decades. Notwithstanding the importance of reducing the impacts of environmental stresses, the only means by which these ecosystems can recover (or simply persist) is through the recruitment of scleractinians, which is a function of successful larval development, delivery, settlement, metamorphosis, and post-settlement events. Despite wide recognition of the importance of these processes, there are few pertinent empirical data, and virtually none that address the mechanisms mediating the success of early coral life stages in a physical environment varying at multiple spatio-temporal scales.

The objective of this research is to complete one of the first comprehensive ecophysiological analyses of the early life stages of corals through a description of: (1) their functionality under 'normal' conditions, and (2) their response to the main drivers of GCC. These analyses will be completed for 2 species representative of a brooding life history strategy, and the experiments will be completed in two locations, one (Taiwan) that provides unrivalled experience in coral reproductive biology, and superb microcosm facilities, and the other (Moorea), with access to a relatively pristine environment, a well described ecological and oceanographic context (through the MCR-LTER), and the capacity to bring a strong biogeographic contrast to the project. The results of the study will be integrated through modeling to explore the effects of GCC on coral community structure over the next century.

The following publications and data resulted from this project:

2013 Wall CB, Fan TY, Edmunds PJ. Ocean acidification has no effect on thermal bleaching in the coral *Seriatopora calandrum*. Coral Reefs 33: 119-130.

[Symbiodinium_Seriatopora photosynthesis](#)

[Symbiodinium_Seriatopora PI curve](#)

[Symbiodinium_Seriatopora temp-salinity-light](#)

[Symbiodinium_Seriatopora water chemistry](#)

[- Download complete data for this publication \(Excel file\)](#)

2013 Wall CB, Edmunds PJ. *In situ* effects of low pH and elevated HCO₃⁻ on juvenile *Porites* spp. in Moorea, French Polynesia. Biological Bulletin 225:92-101.

Data at MCR and PANGAEA: [doi:10.1594/PANGAEA.833913](https://doi.org/10.1594/PANGAEA.833913)

[- Download complete data for this publication \(Excel file\)](#)

2013 Vivian R Cumbo, Peter J Edmunds, Christopher B Wall, Tung-Yung Fan. Brooded coral larvae differ in their response to high temperature and elevated pCO₂ depending on the day of release. Marine Biology DOI 10.1007/s00227-013-2280-y.

Data also at PANGAEA: [doi:10.1594/PANGAEA.831612](https://doi.org/10.1594/PANGAEA.831612)

[brooded coral larvae 2 - carbonate chemistry](#)

[brooded coral larvae 2 - larval release March 2003-2008](#)

[brooded coral larvae 2 - respiration photosynth mortality](#)

[- Download complete data for this publication \(Excel file\)](#)

2013 Edmunds PJ, Cumbo VR, Fan TY. Metabolic costs of larval settlement and metamorphosis in the coral *Seriatopora calandrum* under ambient and elevated pCO₂. Journal Experimental Marine Biology and Ecology 443: 33-38 Data also at PANGAEA: [doi:10.1594/PANGAEA.821644](https://doi.org/10.1594/PANGAEA.821644)

[Coral post-settlement physiology](#)

[- Download complete data for this publication \(Excel file\)](#)

2013 Aaron M Dufault, Aaron Ninokawa, Lorenzo Bramanti, Vivian R Cumbo, Tung-Yung Fan, Peter J Edmunds. The role of light in mediating the effects of ocean acidification on coral calcification. Journal of Experimental Biology 216: 1570-1577.

[coral-light expt.- PAR](#)

[coral-light expt.- carbonate chemistry](#)

[coral-light expt.- temp_salinity](#)

[coral-light expt.- growth](#)

[coral-light expt.- protein](#)

[coral-light expt.- survival](#)

[- Download complete data for this publication \(Excel file\)](#)

2012 Cumbo, VR, Fan TY, Edmunds PJ. Effects of exposure duration on the response of *Pocillopora damicornis* larvae to elevated temperature and high pCO₂. J Exp Mar Biol Ecol 439: 100-107.

Data is also at PANGAEA: [doi:10.1594/PANGAEA.823582](https://doi.org/10.1594/PANGAEA.823582)

[brooded coral larvae 3 - carbonate chemistry](#)

[brooded coral larvae 3 - light](#)

[brooded coral larvae 3 - mortality](#)

[brooded coral larvae 3 - protein](#)

[brooded coral larvae 3 - respiration and protein](#)

[brooded coral larvae 3 - respiration raw data](#)

[brooded coral larvae 3 - symbiont density](#)

[brooded coral larvae 3 - tank temperature](#)

[- Download part 1 of data for this publication \(Excel file\)](#)

[- Download tank parameters data for this publication \(Excel file\)](#)

2012 Cumbo, VR, Fan TY, Edmunds PJ. Physiological development of brooded larvae from two pocilloporid corals in Taiwan. Marine Biology 159: 2853-2866.

[brooded coral - carbonate chemistry](#)

[brooded coral - release](#)

[brooded coral - respiration](#)

[brooded coral - settlement competency](#)

[brooded coral - size July](#)

[brooded coral - size protein symbionts photosynth](#)

[- Download complete data for this publication \(Excel file\)](#)

2012 Dufault, Aaron M; Vivian R Cumbo; Tung-Yung Fan; Peter J Edmunds. Effects of diurnally oscillating pCO₂ on the calcification and survival of coral recruits. Royal Society of London (B) 279: 2951-2958. doi:10.1098/rspb.2011.2545

Data is also at PANGAEA: [doi:10.1594/PANGAEA.830185](https://doi.org/10.1594/PANGAEA.830185)

[recruit_growth_area](#)

[recruit_growth_weight](#)

[recruit_seawater_chemistry](#)

[recruit_survival](#)

[- Download complete data for this publication \(Excel file\)](#)

2011 Edmunds PJ, Cumbo V, Fan TY. Effects of temperature on the respiration of brooded larvae from tropical reef corals. Journal of Experimental Biology 214: 2783-2790.

[Coral larvae comparison respi](#)

[Coral larvae release](#)

[Coral larvae respi](#)

Program Information

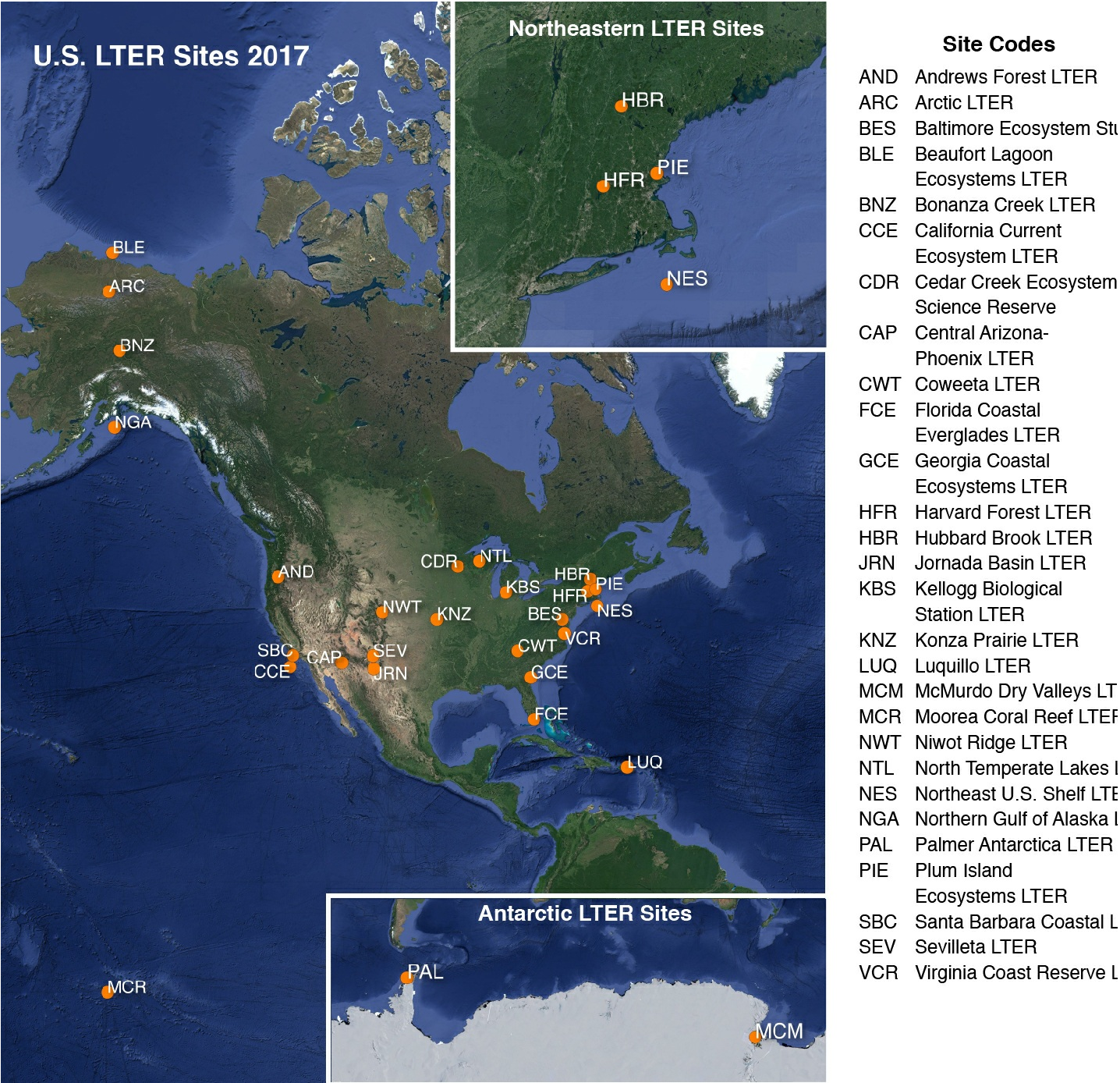
Long Term Ecological Research network (LTER)

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

Coverage: United States

adapted from <http://www.lternet.edu/>

The National Science Foundation established the LTER program in 1980 to support research on long-term ecological phenomena in the United States. The Long Term Ecological Research (LTER) Network is a collaborative effort involving more than 1800 scientists and students investigating ecological processes over long temporal and broad spatial scales. The LTER Network promotes synthesis and comparative research across sites and ecosystems and among other related national and international research programs. The LTER research sites represent diverse ecosystems with emphasis on different research themes, and cross-site communication, network publications, and research-planning activities are coordinated through the LTER Network Office.



Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0844785