Respiration rates, photosynthetic efficiency, and mortality of brooded coral larval experiments, March 2011 and 2012, Taiwan (Cumbo, 2013) (MCR LTER project, Climate_Coral_Larvae project)

Website: https://www.bco-dmo.org/dataset/528834
Version: 2014-08-30

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
Cumbo, Vivian R	California State University Northridge (CSUN)	Scientist
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

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Dataset Description

To evaluate the effects of temperature and pCO2 on coral larvae, brooded larvae of Pocillopora damicornis from Nanwan Bay, Taiwan (21°56.179' N, 120°44.85' E), were exposed to ambient (419-470 µatm) and high (604-742 µatm) pCO2 at ~25 and ~29 °C in two experiments conducted in March 2010 and March 2012. Larvae were sampled from four consecutive lunar days (LD) synchronized with spawning following the new moon, incubated in treatments for 24 h, and measured for respiration, maximum photochemical efficiency of PSII (F v/F m), and mortality.

The most striking outcome was a strong effect of time (i.e., LD) on larvae performance: respiration was affected by an LD × temperature interaction in 2010 and 2012, as well as an LD × pCO2 × temperature interaction in 2012; F v/F m was affected by LD in 2010 (but not 2012); and mortality was affected by an LD × pCO2 interaction in 2010, and an LD × temperature interaction in 2012. There were no main effects of pCO2 in 2010, but in 2012, high pCO2 depressed metabolic rate and reduced mortality. Therefore, differences in larval performance depended on day of release and resulted in varying susceptibility to future predicted environmental conditions. These results underscore the importance of considering larval brood variation across days when designing experiments. Subtle differences in experimental outcomes between years suggest that transgenerational plasticity in combination with unique histories of exposure to physical conditions can modulate the response of brooded coral larvae to climate change and ocean acidification.

These data include dark respiration rates, maximum photochemical efficiency of PSII (F v/F m), and mortality from the experimental tanks, March 2011 and 2012.

Related datasets:

brooded coral larvae 2 - carbonate chemistry
brooded coral larvae 2 - larval release March 2003-2008

These data are published in Vivian R Cumbo, Peter J Edmunds, Christopher B Wall, Tung-Yung Fan. (2013) Brooded coral larvae differ in their response to high temperature and elevated pCO2 depending on the day of release. Marine Biology. See Figures 1 and 2.

Download complete data for this publication (Excel file)
Data also available from PANGAEA: DOI 10.1007/s00227-013-2280-y

Methods & Sampling

March 2010:
A Ruthenium-based optode (FOXY-R, 1.58 diameter, Ocean Optics) connected to a spectrophotometer (USB2000, Ocean Optics) and interfaced with a computer running Ocean Optics software (OOISensor, version 1.00.08) was used to measure the respiration of the larvae. The optode was 2-point calibrated using a zero solution (0.01 M Na2B4O7*10H2O saturated with Na2SO3) and 100% air saturation using water-saturated air at the treatment temperature. To measure respiration, 6 larvae were removed from the treatment containers 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 in each vial (Edmunds et al. 2011). Respiration measurements were completed after the 24-h incubation period. Larvae were dark-adapted prior to measurements so that respiration would not be stimulated by light (Edmunds and Davies 1988). Initial O2 concentration in the seawater filling the vials was determined before the vials were sealed, and vials without larvae were 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 (±0.1C, Hipoint, models LC-06 and LC-10). Incubation times were selected to ensure that O2 concentrations remained[75%. On completion of the incubations, vials were removed from the chillers, gently inverted to mix the seawater, and analyzed for O2 saturation. O2 saturation was converted to concentration using gas tables [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 converted to nmol O2 min-1 larvae-1, after adjusting for control O2 fluxes.

Larval photophysiology was assessed using pulse amplitude modulated (PAM) fluorometry to measure the maximum photochemical efficiency of open reaction centers of photosystem II (RCIIs) following a period of dark adaptation (i.e., Fv/Fm) of their Symbiodinium. Changes in Fv/Fm can detect damage to the photosynthetic apparatus, with declines under elevated temperature indicating damage to PSII (Jones et al. 1998; Bhagooli and Hidaka 2003). These measurements were conducted after the 24-h incubation period, with larvae being dark-adapted during the final 2 h of the incubation. After this period of darkness, Fv/Fm was measured using a diving PAM (Walz, GmbH) fitted with an 8-mm diameter probe and standardized for measuring intensity (setting: 10) and gain (setting: 10). Fluorescence was measured by loading 8 larvae into a drop of seawater on the tip of the probe, with these manipulations completed under weak red illumination. Two groups of 8 larvae were measured for Fv/Fm from each tank, and the average value in each tank was used for statistical analysis.

To assess the number of larvae dying in the treatments, at the conclusion of the incubations, tubs were removed from the treatments and the number of swimming larvae and settled recruits (with tissue) recorded. Due to the rapid breakdown of dead larvae (Yakovleva et al. 2009), larvae that could not be accounted for were assumed dead. Mortality was expressed as a percentage of the number of larvae added at the start of the experiment.

March 2012:
The second experiment was designed to be virtually identical to the first (n = 8 tanks, 2 tanks treatment-1), although the volume of the incubation tanks was increased to 120 L, and the sample size (number of replicate tubs containing larvae in each tank) was doubled with the objective of increasing statistical power and testing for tank effects for the dependent biological variables. Experimental difficulties affecting a single tank made it problematic to include the tank in the statistical analyses, and therefore, replicates were pooled between tanks in each treatment combination. Larvae were sampled from each replicate tub, and their response to the treatment conditions was assessed using dark respiration, photophysiology (Fv/Fm), and mortality, and each dependent variable was measured as described above.

Data Processing Description

BCO-DMO processing notes:

- added conventional header with dataset name, PI name, version date, reference information
- added lab, lat, lon columns
- renamed parameters to BCO-DMO standard
- combined data from Figures 1 and 2 (respiration Fv/Fm, and mortality)
- reformated dates from m/d/yyyy to yyyy-mm-dd
- replaced 'A'with 'ambient', 'H' with 'high'
- converted mortality to percent

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Data Files

File
brood2_respir_photosyn_mort.csv (Comma Separated Values (.csv), 11.70 KB) MD5:46001a25ea973ea13feaee136784aba6
Primary data file for dataset ID 528834

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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
date_new_moon	date of the new moon	yyyy-mm-dd
days	days since start of experiment	unitless
days_after_NM	days since the new moon	unitless
temp	target temperature	degrees Celsius
tank	tank id number	tank
replicate	replicate number	unitless
respiration	respiration rate	nmol/Larvae/min
Fv_Fm	maximum photochemical quantum yield of photosystem II	unitless
mortality	percent of presumed dead larvae	percent
treatment_pCO2	relative pCO2: ambient=419-470 uatm; high=604-742 uatm	unitless

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Instruments

Dataset-specific Instrument Name	in-situ incubator
Generic Instrument Name	In-situ incubator
Dataset-specific Description	A temperature-regulated bath (±0.1C, Hipoint, models LC-06)
Generic Instrument Description	A device on a ship or in the laboratory that holds water samples under controlled conditions of temperature and possibly illumination.

Dataset-specific Instrument Name	optode
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 Ocean Optics software (OOISensor, version 1.00.08).
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	spectrophotometer
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	USB2000, Ocean Optics
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.

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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

NSF Award Abstract:

Coral reefs provide important benefits to society, from food to exceptional biodiversity to shoreline protection and recreation, but they are threatened by natural perturbations and human activities, including those causing global-scale changes. These pressures increasingly are causing coral reefs to undergo large, often abrupt, ecological changes where corals are being replaced by seaweeds or other undesirable organisms. Historically, the major agent of disturbance to coral reefs has been powerful storms, but in recent decades, episodes of mass coral bleaching from marine heat waves have become more frequent and severe as the temperature of ocean surface waters continues to rise. Coral reefs are further stressed by local human activities that cause nutrient pollution and deplete herbivorous fishes that control growth of seaweeds. Studying how coral reefs respond to these two types of disturbance under different levels of nutrient pollution and fishing provides essential information on what affects the ability of coral reefs to buffer environmental change and disturbances without collapsing to a persistent, degraded condition. The fundamental goals of the Moorea Coral Reef Long Term Ecological Research program (MCR LTER) are to understand how and why coral reefs change over time, to assess the consequences of these changes, and to contribute scientific knowledge needed to sustain coral reef ecosystems and the important societal services they provide. This research improves understanding and management of coral reefs, which benefits all groups concerned with the welfare of this ecologically, economically and culturally important ecosystem. In addition to academic communities, scientific findings are communicated to interested individuals, non-governmental organizations, island communities and governmental entities. These findings also are integrated into K-12, undergraduate, graduate and public education activities through a multi-pronged program that includes inquiry-based curricula, interactive and media-based public education programs, and internet-based resources. MCR?s research, training, education and outreach efforts all emphasize broadening participation in STEM fields and strengthening STEM literacy.

New research activities build on MCR LTER?s powerful foundation of long-term observations and broad ecological understanding of oceanic coral reefs to address the following core issues: How is the changing disturbance regime (recurrent heat waves in addition to cyclonic storms) altering the resilience of coral reefs, and what are the ecological consequences of altered resilience? Research activities are organized around a unifying framework that explicitly addresses how reef communities are affected by the nature and history of coral-killing disturbances, and how those responses to disturbance are influenced by the pattern of local human stressors. New studies answer three focal questions: (1) How do different disturbance types, which either remove (storms) or retain (heat waves) dead coral skeletons, affect community dynamics, abrupt changes in ecological state, and resilience? (2) How do local stressors interact with new disturbance regimes to create spatial heterogeneity in community dynamics, ecosystem processes, and spatial resilience? And (3) What attributes of coral and coral reef communities influence their capacity to remain resilient under current and future environmental conditions? These questions provide an unparalleled opportunity to test hypotheses and advance theory regarding ecological resilience and the causes and consequences of abrupt ecological change, which is broadly relevant across aquatic and terrestrial ecosystems.

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.

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 environmental 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 caliendrum*. 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 PANGEA: doi.pangaea.de/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 PANGEA: doi.pangaea.de/10.1594/PANGAEA.831612
brooded coral larvae 2 - carbonate chemistry
brooded coral larvae 2 - larval release March 2003-2008
brooded coral larvae 2 - respiration_photosyth_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 caliendrum* under ambient and elevated pCO2. Journal Experimental Marine Biology and Ecology 443: 33-38 Data also at PANGEA: doi: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 PANGEA: doi: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 PANGEA: doi: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.
CoralLarvae_comparison_respir
CoralLarvae_release
CoralLarvae_respir
CoralLarvae_size
- Download complete data for this publication (Excel file)

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Program Information

Long Term Ecological Research network (LTER)

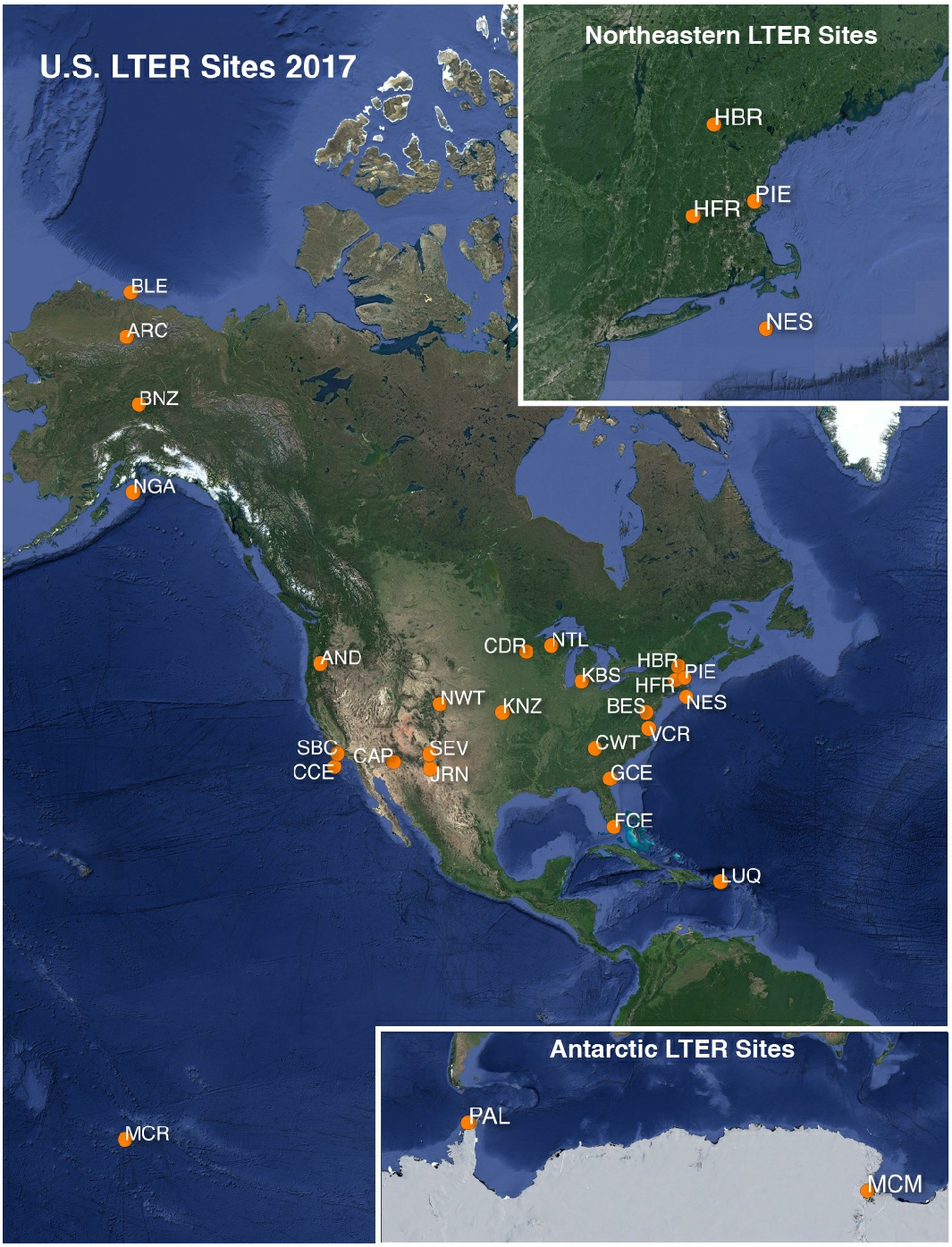
Website: http://www.lternet.edu/

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.



Site Codes

AND	Andrews Forest LTER
ARC	Arctic LTER
BES	Baltimore Ecosystem Stu
BLE	Beaufort Lagoon Ecosystems LTER
BNZ	Bonanza Creek LTER
CCE	California Current Ecosystem LTER
CDR	Cedar Creek Ecosystem Science Reserve
CAP	Central Arizona-Phoenix LTER
CWT	Coweeta LTER
FCE	Florida Coastal Everglades LTER
GCE	Georgia Coastal Ecosystems LTER
HFR	Harvard Forest LTER
HBR	Hubbard Brook LTER
JRN	Jornada Basin LTER
KBS	Kellogg Biological Station LTER
KNZ	Konza Prairie LTER
LUQ	Luquillo LTER
MCM	McMurdo Dry Valleys LT
MCR	Moorea Coral Reef LTEF
NWT	Niwot Ridge LTER
NTL	North Temperate Lakes L
NES	Northeast U.S. Shelf LTE
NGA	Northern Gulf of Alaska L
PAL	Palmer Antarctica LTER
PIE	Plum Island Ecosystems LTER
SBC	Santa Barbara Coastal L
SEV	Sevilleta LTER
VCR	Virginia Coast Reserve L

2017 LTER research site map obtained from https://lternet.edu/site/lter-network/

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Funding

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

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