Sea surface temperatures at St. John, VI, and Mo'orea LTER sites, 1985-2020

Website: https://www.bco-dmo.org/dataset/832616
Data Type: Other Field Results
Version: 1
Version Date: 2020-12-02

Project
» Moorea Coral Reef Long-Term Ecological Research site (MCR LTER)
» LTREB Long-term coral reef community dynamics in St. John, USVI: 1987-2019 (St. John LTREB)
» RUI-LTREB Renewal: Three decades of coral reef community dynamics in St. John, USVI: 2014-2019 (RUI-LTREB)

Program
» Long Term Ecological Research network (LTER)

Contributors	Affiliation	Role
Edmunds, Peter J.	California State University Northridge (CSUN)	Principal Investigator
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Sea surface temperatures at St. John, VI, and Mo'orea LTER sites, 1985-2020. These data were accessed from the NOAA CRW site for SST as described in methods and reported in Fig. 4, Edmunds (2020, L&O).

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Coverage

Spatial Extent: **Lat**:-17.471 **Lon**:-149.808
Temporal Extent: 1985-01-01 - 2020-09-28

Dataset Description

Overview

The reefs in Mo'orea and St. John have been monitored for decades, and recent publications from these efforts provide the ecological background to fully interpret the present results. Coral cover (pooled among taxa) for all three habitats in Mo'orea, as well as St. John, are presented, with these data originating from photoquadrats (0.5 × 0.5 m) that have been recorded annually at permanent locations from 2005 to 2019. In brief, in Mo'orea, the three habitats were sampled at six sites around the island, with 40 photoquadrats/site at 10-m and 17-m depth on the fore reef, and 20 photoquadrats/bommie, and five bommies/site, in the back reef. In 2005, photoquadrats were randomly positioned along a ~ 50 m transect at 10-m and 17-m depth at each site on the fore reef, and thereafter were sampled in the same positions. Five photoquadrats were randomly positioned along four, 5-m transects along cardinal axes at each bommie every year. In St. John, the fringing reefs (at 7-9-m depth) were sampled at six sites, with 40 photoquadrats randomly positioned every year along a single 40-m transect at each site.

Photoquadrats from the fore reef and from St. John were analyzed using CoralNet Software, with 200 dots randomly located on each image, and the substratum beneath each dot identified. The photoquadrats in the back reef were analyzed with a coarser resolution in which the dominant substratum is each of 25 sub-squares in each photoquadrat was identified (i.e., providing 4% resolution). The cover of scleractinians (pooled among taxa) is presented using sites as replicates, and mean cover by year is used in tests of association with concurrent coral recruitment.

To test the hypotheses guiding the present study, coral recruitment was measured in Mo'orea and St. John using settlement tiles deployed from 2005 to 2019, and loggers were used to measure temperature. The immersion times of settlement tiles slightly differed between regions because the two sampling programs originally were designed for different purposes.

Methods & Sampling

Variation in coral recruitment

Unglazed terracotta tiles (15 ×15 × 1 cm) were used to evaluate coral recruitment, and these were secured horizontally and independently to the substratum with their rough side downwards. Each tile was attached to the reef using a stainless steel stud epoxied into non-living reef rock, and a ~ 1 cm gap was maintained beneath each tiles as a microhabitat favored by coral recruits. In St. John, 15 tiles were secured in clusters at each of five sites at ~ 5-m depth on fringing reefs between White Point and Cabritte Horn. In Mo'orea, 15 tiles were secured in clusters at each of 10-m and 17-m depth at two fore reef, and three back reef sites (~ 2-m depth), on the north shore. In each cluster, tiles were scattered haphazardly across the reef with spacing between them varying from a few centimeters to about a meter.

Tiles were seasoned in seawater (i.e., beneath the laboratory dock) for 6-12 months prior to use, and were deployed in fixed seasons. In Mo'orea, tiles were exchanged at the end of January (or early February) and the end of August (or early September), with the first deployment in August 2005 (back reef), August 2006 (10-m depth), and August 2008 (17-m depth); tiles were immersed for ~ 6 months. Freshly collected tiles were cleaned of organic material in dilute bleach in freshwater, dried, and scored for coral recruits using a dissecting microscope (× 40 magnification). Analyzed tiles were cleaned in hydrochloric acid, washed, and placed in seawater for seasoning until the next deployment. In St. John, tiles were exchanged in late July (or early August), with the first deployments in August 2006. Tiles were exchanged in January and August for the first two years, but after 2008, were exchanged annually. Tiles were immersed ~ 6 months in the first two years, but ~ 12 months thereafter, and were processed in an identical manner to those in Mo'orea. The sample size of tiles varied among years as a few were broken by storms, notably following Hurricanes Irma and Maria (September 2017) in St. John. Broken tiles were replaced at the next scheduled exchange date.

The top, bottom, and sides of tiles were screened by the author, and recruits were identified to family using primary literature and field guides. Recruits in Mo'orea were assigned to Pocilloporidae, Poritidae, Acroporidae, or "other", and in St. John to Poritidae, Agaricidae, Siderastreidae, Acroporidae, Faviidae, or "other"; these taxa reflect the resolution that was possible based on skeletal morphology. In Mo'orea, annual recruitment was estimated by summing mean recruitment between times within each year and site, and averaging between sites by habitat. Annual recruitment in St. John was estimated the same way for the first two years, but thereafter, was estimated from tiles immersed for 12 months.

Environmental conditions

In situ seawater temperature was measured using loggers. In Mo'orea, Sea-Bird 39s (± 0.002°C, Sea-Bird Electronics, Bellevue, WA) recording at 0.0083 Hz were deployed on the north shore (10-m depth, 20-m depth, and back reef), but the results from 10-m depth were augmented with results from a Hobo logger (U22-001, Onset Computer Corp., Bourne, MA) for 136 days from 18 August 2019. Data were average by day and summarized across years (2005-2019) by daily means (± 95% confidence interval). These records were characterized the thermal regime over the ~ 365 days sampled by the two batches of tiles deployed annually (1 September to 31 August). The thermal regime was described by the yearly mean, and the yearly mean variation calculated between consecutive days (day-day, D-D), weeks (week-week, W-W), or months (each lasting 4 weeks, month-month, M-M). Records from 20-m depth were used as a proxy for seawater temperature at 17-m depth (where tiles were located, but temperature was not recorded), and the two data sets were tested for congruence. Evidence of strong association of temperature between 10-m and 20-m depth, and differences between depths that were trivial

with respect to coral performance, were used as a rationale to characterize the temperature of the fore reef by records from 10-m depth.

In St. John, temperature was recorded at Yawzi Point (9-m depth) using a variety of loggers from 1989 to 2019. Most records were obtained using Hobo loggers (± 0.2°C) (U22-001) sampling at 0.0011 Hz. Data were summarized as above for Mo'orea, except that yearly rates were calculated between 1 August and 31 July, and D-D variation was not considered because it could not be resolved with the resolution of the loggers.

To gain insight into temporal variation in seawater temperature at a spatial scale larger than the locations of the temperature loggers, sea surface temperature (SST) recorded through remote sensing was evaluated. SST was obtained from the NOAA Coral Reef Watch (CRW) web site (https://coralreefwatch.noaa.gov/, accessed 28 September 2020) using Regional Virtual Stations for the Society Archipelago and the Virgin Islands. Each Virtual Station consists of a 5 × 5 km cell in which nighttime SST is reported, as calibrated to 20 cm depth, with the Society Archipelago station centered at -16.9500°, -151.3750°, 167 km northwest of Mo'orea, and the Virgin Islands station centered at 18.200°, -64.5500°, 22 km southeast of St. John. Daily SST was accessed from January 1985 to September 2020, and records were used evaluate the 95% confidence intervals for daily values across a year.

Statistical Analysis

One-way PERMANOVAs were used to compare recruitment, and year-year changes in recruitment, among habitats/regions; post-hoc, pair-wise contrasts were completed with permutational t-tests. Repeated measures (RM) PERMANOVAs were used to compare recruitment among years (RM factor) within habitats/regions. PERMANOVAs were prepared using square-root transformed data and resemblance matrices containing Bray-Curtis dissimilarities, and results are reported as Pseudo-F values and their permutational probabilities (pperm). Contingency tables were used to test for independence between outcomes of year-year changes in recruitment (increases versus decreases) for pairs of years with delays of 1, 2, and 3 years. Each contingency table was tested for independence using ??2 tests with Yates correction for small sample sizes. To evaluate whether short-term variation in recruitment (i.e., over 1 year) was an accurate predictor of future trends in recruitment, Pearson correlations were used to test for association between year-year changes in recruitment and subsequent linear trends for variation in recruitment over time.

Before testing the second hypothesis that motivated the present study (that recruitment is associated with temperature), the relationships between coral recruitment and coral cover were explored using least squares regression for linear and quadratic functions, with the best model selected using AICc. Analyses were completed for all corals, Poritidae and Pocilloporidae in Mo'orea, and for all corals and Poritidae in St. John, with these taxa selected based on their high abundance. Although it was reasonable to expect that the relationship between coral recruitment and coral abundance would not be well developed, in part because of the capacity for widespread dispersal of corals, under some conditions it can be well developed. Therefore evaluating the extent to which coral recruitment was associated with coral cover was a necessary step to evaluating the relationships between recruitment and temperature. The statistical approaches were similar to those used to explore the relationships between recruitment and temperature. Analyses were completed using recruitment and temperature recorded over concurrent 12-month periods, and were repeated with temperature lagged by one year (i.e., to test for associations with temperature recorded 12-24 months before). The lagging of temperature provided insight into the effects on adult corals that would produce larvae in the following year.

Statistical analyses were completed using Systat 13 software for parametric tests, and PERMANOVA+ for PRIMER for permutational tests.

Data Processing Description

BCO-DMO Data Manager Processing Notes:
- Original data submitted as in Excel file "Data in Paper 2 October 2020 copy.xlsx" sheet "SST Data" extracted to csv.
- added a conventional header with dataset name, PI name, version date
- added latitude and longitude columns: Moorea site 'fore reef LTER 2' (-17.471, -149.808) and for St. John: Tektite (18.31095, -64.72187)
- added Date column formatted as yyyy-mm-dd

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Data Files

File
sst.csv (Comma Separated Values (.csv), 1.32 MB) MD5:029aaa77576c077e73ccc2171143a29f Primary data file for dataset ID 832616

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Related Datasets

IsRelatedTo

Edmunds, P. J. (2020) **Coral cover at St. John, VI, and Mo'orea LTER sites, 1992-2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-12-02 doi:10.26008/1912/bco-dmo.832378.1 [view at BCO-DMO]

Edmunds, P. J. (2020) **Coral recruitment data to support the core analyses from Mo'orea and St. John, VI from 2006-2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-12-02 doi:10.26008/1912/bco-dmo.832431.1 [view at BCO-DMO]

Edmunds, P. J. (2020) **Coral recruitment locations on tiles (top, bottom, sides) at St. John, VI, and Mo'orea LTER sites, 1985-2020, for Edmunds (L&O, 2020).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-12-02 doi:10.26008/1912/bco-dmo.832447.1 [view at BCO-DMO]

Edmunds, P. J. (2020) **Coral taxonomic composition at St. John, VI, and Mo'orea LTER sites, 2017-2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-12-02 doi:10.26008/1912/bco-dmo.832468.1 [view at BCO-DMO]

Edmunds, P. J. (2020) **In situ temperature measurements at St. John, VI, and Mo'orea LTER sites, 1989-2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-12-02 doi:10.26008/1912/bco-dmo.832529.1 [view at BCO-DMO]

Edmunds, P. J. (2020) **Seawater temperature at 10 m and 20 m on the fore reef of Mo'orea, 2005-2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-12-02 doi:10.26008/1912/bco-dmo.832601.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Location	geographical sampling location: Mo'orea or St. John	unitless
lat	latitude; north is positive	decimal degrees
lon	longitude; east is positive	decimal degrees
Date	date; formatted as yyyy-mm-dd	unitless
Year	year	unitless
Month	month	unitless
Day	day	unitless
Temperature	sea surface temperature	degrees Celsius

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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

LTREB Long-term coral reef community dynamics in St. John, USVI: 1987-2019 (St. John LTREB)

Website: http://coralreefs.csun.edu/

Coverage: St. John, U.S. Virgin Islands; California State University Northridge

Long Term Research in Environmental Biology (LTREB) in US Virgin Islands:

From the NSF award abstract:
In an era of growing human pressures on natural resources, there is a critical need to understand how major ecosystems will respond, the extent to which resource management can lessen the implications of these responses, and the likely state of these ecosystems in the future. Time-series analyses of community structure provide a vital tool in meeting these needs and promise a profound understanding of community change. This study focuses on coral reef ecosystems; an existing time-series analysis of the coral community structure on the reefs of St. John, US Virgin Islands, will be expanded to 27 years of continuous data in annual increments. Expansion of the core time-series data will be used to address five questions: (1) To what extent is the ecology at a small spatial scale (1-2 km) representative of regional scale events (10's of km)? (2) What are the effects of declining coral cover in modifying the genetic population structure of the coral host and its algal symbionts? (3) What are the roles of pre- versus post-settlement events in determining the population dynamics of small corals? (4) What role do physical forcing agents (other than temperature) play in driving the population dynamics of juvenile corals? and (5) How are populations of other, non-coral invertebrates responding to decadal-scale declines in coral cover? Ecological methods identical to those used over the last two decades will be supplemented by molecular genetic tools to understand the extent to which declining coral cover is affecting the genetic diversity of the corals remaining. An information management program will be implemented to create broad access by the scientific community to the entire data set.

The importance of this study lies in the extreme longevity of the data describing coral reefs in a unique ecological context, and the immense potential that these data possess for understanding both the patterns of comprehensive community change (i.e., involving corals, other invertebrates, and genetic diversity), and the processes driving them. Importantly, as this project is closely integrated with resource management within the VI National Park, as well as larger efforts to study coral reefs in the US through the NSF Moorea Coral Reef LTER, it has a strong potential to have scientific and management implications that extend further than the location of the study.

RUI-LTREB Renewal: Three decades of coral reef community dynamics in St. John, USVI: 2014-2019 (RUI-LTREB)

Website: http://coralreefs.csun.edu/

Coverage: USVI

Describing how ecosystems like coral reefs are changing is at the forefront of efforts to evaluate the biological consequences of global climate change and ocean acidification. Coral reefs have become the poster child of these efforts. Amid concern that they could become ecologically extinct within a century, describing what has been lost, what is left, and what is at risk, is of paramount importance. This project exploits an unrivalled legacy of information beginning in 1987 to evaluate the form in which reefs will persist, and the extent to which they will be able to resist further onslaughts of environmental challenges. This long-term project continues a 27-year study of Caribbean coral reefs. The diverse data collected will allow the investigators to determine the roles of local and global disturbances in reef degradation. The data will also reveal the structure and function of reefs in a future with more human disturbances, when corals may no longer dominate tropical reefs.

The broad societal impacts of this project include advancing understanding of an ecosystem that has long been held emblematic of the beauty, diversity, and delicacy of the biological world. Proposed research will expose new generations of undergraduate and graduate students to natural history and the quantitative assessment of the ways in which our planet is changing. This training will lead to a more profound understanding of contemporary ecology at the same time that it promotes excellence in STEM careers and supports technology infrastructure in the United States. Partnerships will be established between universities and high schools to bring university faculty and students in contact with k-12 educators and their students, allow teachers to carry out research in inspiring coral reef locations, and motivate children to pursue STEM careers. Open access to decades of legacy data will stimulate further research and teaching.

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Program Information

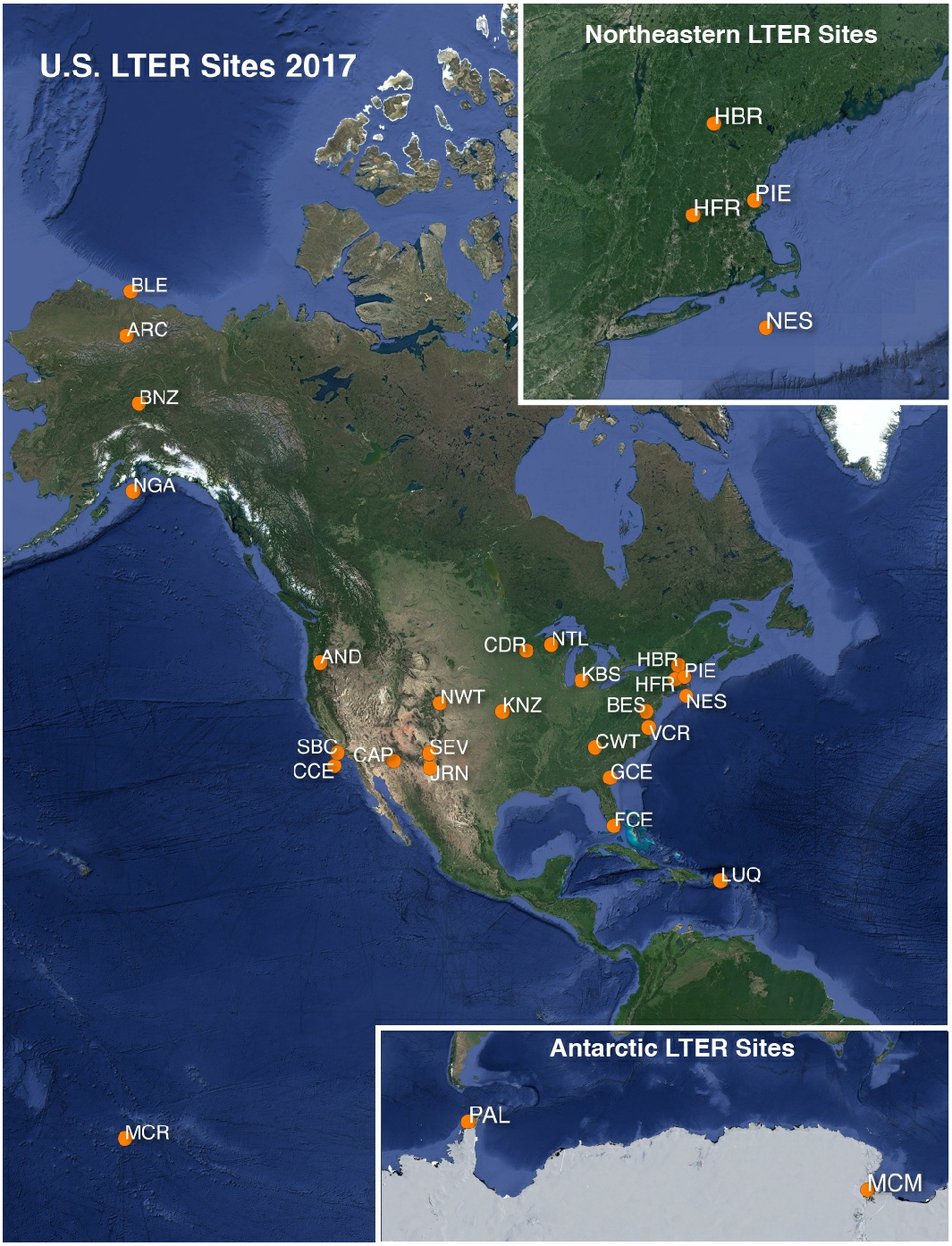
Long Term Ecological Research network (LTER)

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.



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

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 I
NES	Northeast U.S. Shelf LTE
NGA	Northern Gulf of Alaska I
PAL	Palmer Antarctica LTER
PIE	Plum Island Ecosystems LTER
SBC	Santa Barbara Coastal L
SEV	Sevilleta LTER
VCR	Virginia Coast Reserve L

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Funding

Funding Source	Award
NSF Division of Environmental Biology (NSF DEB)	DEB-0841441
NSF Division of Environmental Biology (NSF DEB)	DEB-0343570
NSF Division of Ocean Sciences (NSF OCE)	OCE-1026851
NSF Division of Ocean Sciences (NSF OCE)	OCE-1236905
NSF Division of Ocean Sciences (NSF OCE)	OCE-1415268
NSF Division of Environmental Biology (NSF DEB)	DEB-1350146
NSF Division of Ocean Sciences (NSF OCE)	OCE-1637396

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