Suspended particle total mercury and monomethylmercury in the California Current Ecosystem (CCE) determined from samples collected on R/V Roger Revelle cruise RR2105 (P2107) in July to August 2021

Website: https://www.bco-dmo.org/dataset/926959
Data Type: Cruise Results
Version: 1
Version Date: 2024-05-14

Project
» California Current Ecosystem Long Term Ecological Research site (CCE LTER)
» Collaborative Proposal: Unravelling the Oceanic Dimethylmercury Cycle (DMHg in the Ocean)

Programs
» Ocean Carbon and Biogeochemistry (OCB)
» Long Term Ecological Research network (LTER)

Contributors	Affiliation	Role
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Abstract
This dataset includes concentrations of suspended particulate total mercury and monomethylmercury from 8 upwelling stations and 5 offshore stations (13 stations in total, 2-4 depths per station), during the 2021 CCE LTER Process Cruise (P2107), from July 17th to Aug 9th. Suspended particle samples (1 and 51 micrometers (µm)) were collected with a multiple-unit large-volume in situ filtration system. Sampling depths were from the surface (10 meters) to the deep ocean as deep as 1000 meters.

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Coverage

Location: Central California coast/upwelling and offshore
Spatial Extent: **N**:36.52 **E**:-120.53 **S**:34.47 **W**:-130.56
Temporal Extent: 2021-07-17 - 2021-08-09

Methods & Sampling

Suspended particles were collected using McLane Research in-situ pumps (WTS-LV) using modified, two-layer filter holders. The top filter holder layer was loaded with a 51-micrometer (µm) polyester mesh filter to collect large-size fraction particles (LSF). The other filter holder layer was loaded with a pre-combusted GF/F glass microfiber filter (Whatman) to collect small-size fraction particles (SSF, 1-51 µm). Filter holders were acid-leached before use, and GF/F filters were additionally combusted at 450 degrees Celsius (°C) for 4 hours. Sinking particles were collected by sediment traps.

Total mercury (THg) and monomethylmercury (MMHg) in suspended and sinking particles were determined by digesting filter portions in nitric acid (2N, trace mental grade, Fisher) for 4 hours at 60°C constant water bath with intermittent sonication. For THg determination, digestates were oxidized with bromine monochloride for at least 2 hours and pre-reduced with hydroxylamine hydrochloride. Subsamples were then reduced with stannous chloride, and the evolved Hg0 concentrations were determined by dual gold amalgamation cold vapor atomic fluorescence spectrometry (CVAFS) with a Tekran 2600 against both gaseous Hg0 and aqueous Hg2+ standards. MMHg determination used a direct ethylation method. Digestates were treated with ascorbic acid, buffered with acetate, and neutralized with potassium hydroxide (KOH; 45%) to pH between 4 and 5. Sodium tetraethylborate (1%, in 2% KOH) was added in digestates reacting for 20 minutes prior to analysis by CVAFS. The method detection limits for THg and MMHg were 26.5 femtomolar (fM) and 3.3 fM in the SSF, and 0.75 fM and 0.24 fM in the LSF, respectively.

For carbon (C) mass determination in the SSF and LSF, filters were packed into a tin capsule and analyzed for particulate carbon mass and measured using Carlo Erba 1108 elemental analyzer coupled to a Thermo Finnigan Delta Plus XP IRMS at University of California, Santa Cruz. The analytical precision of C % is 0.65% in the SSF and 1.1% in the LSF based on the organic standards IU Acetanilide and USGC41.

Data Processing Description

Microsoft Excel was used for data processing.

We used the GEOTRACES Quality Flag Policy to reflect our data quality:
"1" represents good value;
"4" represents bad value due to errors in sampling;
"6" represents data value below the instrument detection limit;
"9" represents missing data / no data value.

BCO-DMO Processing Description

- Imported original file "P2107_Part_Hg_BCODMO.xlsx" into the BCO-DMO system.
- Marked "n/a" as a missing data value (missing data are empty/blank in the final CSV file).
- Renamed fields to comply with BCO-DMO naming conventions.
- Created date-time fields in ISO8601 format in local and UTC time zones.
- Saved the final file as "926959_v1_suspended_partic_totalhg_and_monomethylhg_cce.csv".

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Data Files

File	
926959_v1_suspended_partic_totalhg_and_monomethylhg_cce.csv Primary data file for dataset ID 926959, version 1	(Comma Separated Values (.csv), 5.71 KB) MD5:a8ad76c2ab4be81a522990684590bc98

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Related Publications

Bowman, K. L., Hammerschmidt, C. R., Lamborg, C. H., & Swarr, G. (2015). Mercury in the North Atlantic Ocean: The U.S. GEOTRACES zonal and meridional sections. Deep Sea Research Part II: Topical Studies in Oceanography, 116, 251–261. doi:10.1016/j.dsr2.2014.07.004
Methods

Cui, X., Adams, H. M., Song, Y., Stukel, M. R., Schartup, A. T., & Lamborg, C. H. (2024). Upwelling Enhances Hg Particle Scavenging in the California Current Ecosystem. https://doi.org/10.21203/rs.3.rs-4102885/v1
Results

Munson, K. M., Babi, D., & Lamborg, C. H. (2014). Determination of monomethylmercury from seawater with ascorbic acid-assisted direct ethylation. Limnology and Oceanography: Methods, 12(1), 1–9. doi:10.4319/lom.2014.12.1
Methods

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Parameters

Parameter	Description	Units
Cruise_ID	Cruise id; UNOLS cruise ID is RR2105	unitless
Cruise_Name	Cruise name	unitless
Station_Name	Name of the sampling station	unitless
ISO_DateTime_PDT	Sampling date and time in ISO 8601 format; time zone = PDT (UTC-7:00)	unitless
ISO_DateTime_UTC	Sampling date and time in ISO 8601 format; time zone = UTC	unitless
Latitude	Station latitude, south is negative	decimal degrees
Longitude	Station longitude, west is negative	decimal degrees
Cast_Number	Cast number	unitless
Depth_m	Sample depth	meters (m)
tHg_CONC_SSF_fM	Concentrations of total mercury in small size fraction particle; limit of detection = 26	femtomolar (fM)
tHg_CONC_SSF_FLAG	Data flag, following the GEOTRACES Quality Flag Policy (see "Processing Description" for definitions)	unitless
tHg_CONC_LSF_fM	Concentrations of total mercury in large size fraction particle; limit of detection = 0.75	femtomolar (fM)
tHg_CONC_LSF_FLAG	Data flag, following the GEOTRACES Quality Flag Policy (see "Processing Description" for definitions)	unitless
MMHg_CONC_SSF_fM	Concentrations of total monomethylmercury in small size fraction particle; limit of detection = 3	femtomolar (fM)
MMHg_CONC_SSF_FLAG	Data flag, following the GEOTRACES Quality Flag Policy (see "Processing Description" for definitions)	unitless
MMHg_CONC_LSF_fM	Concentrations of total monomethylmercury in large size fraction particle; limit of detection = 0.24	femtomolar (fM)
MMHg_CONC_LSF_FLAG	Data flag, following the GEOTRACES Quality Flag Policy (see "Processing Description" for definitions)	unitless
Carbon_CONC_SSF_ug_L	Concentrations of total carbon in small size fraction particle	microgram per liter (ug/L)
Carbon_CONC_SSF_FLAG	Data flag, following the GEOTRACES Quality Flag Policy (see "Processing Description" for definitions)	unitless
Carbon_CONC_LSF	Concentrations of total carbon in large size fraction particle	microgram per liter (ug/L)
Carbon_CONC_LSF_FLAG	Data flag, following the GEOTRACES Quality Flag Policy (see "Processing Description" for definitions)	unitless

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Instruments

Dataset-specific Instrument Name	Carlo Erba 1108 elemental analyzer
Generic Instrument Name	Carlo-Erba EA-1108 elemental analyzer
Generic Instrument Description	An elemental analyzer that simultaneously determines the total carbon, hydrogen, nitrogen, and sulfur in a small solid or liquid sample. A sample is put into a tin capsule that is placed in the combustion tube. Here, the sample is in an oxygen-rich gas stream, which causes flash combustion of the tin capsule, and in turn, the sample is rapidly combusted. The resulting gases are separated on a packed gas chromatography column and quantified using a thermal conductivity detector. The instrument was originally manufactured by Carlo-Erba, which has since been replaced by Thermo Scientific (part of Thermo Fisher Scientific). This model is no longer in production. It is also possible to determine oxygen with a modification to the systems configuration. Analysis times: CHN in 7 min, S in 5 min and O in 6 min. Range: 10 ppm to 100%.

Dataset-specific Instrument Name	Thermo Finningan Delta Plus XP IRMS
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	McLane Research in-situ pumps (WTS-LV)
Generic Instrument Name	McLane Large Volume Pumping System WTS-LV
Generic Instrument Description	The WTS-LV is a Water Transfer System (WTS) Large Volume (LV) pumping instrument designed and manufactured by McLane Research Labs (Falmouth, MA, USA). It is a large-volume, single-event sampler that collects suspended and dissolved particulate samples in situ. Ambient water is drawn through a modular filter holder onto a 142-millimeter (mm) membrane without passing through the pump. The standard two-tier filter holder provides prefiltering and size fractioning. Collection targets include chlorophyll maximum, particulate trace metals, and phytoplankton. It features different flow rates and filter porosity to support a range of specimen collection. Sampling can be programmed to start at a scheduled time or begin with a countdown delay. It also features a dynamic pump speed algorithm that adjusts flow to protect the sample as material accumulates on the filter. Several pump options range from 0.5 to 30 liters per minute, with a max volume of 2,500 to 36,000 liters depending on the pump and battery pack used. The standard model is depth rated to 5,500 meters, with a deeper 7,000-meter option available. The operating temperature is -4 to 35 degrees Celsius. The WTS-LV is available in four different configurations: Standard, Upright, Bore Hole, and Dual Filter Sampler. The high-capacity upright WTS-LV model provides three times the battery life of the standard model. The Bore-Hole WTS-LV is designed to fit through a narrow opening such as a 30-centimeter borehole. The dual filter WTS-LV features two vertical intake 142 mm filter holders to allow simultaneous filtering using two different porosities.

Dataset-specific Instrument Name	Cold vapor atomic fluorescence spectrometry (Tekran 2500/2600)
Generic Instrument Name	Tekran 2500 CVAFS mercury detector
Generic Instrument Description	Tekran 2500 Total Mercury Analysis System (not automated; cold vapor atomic fluorescence spectrometry)

Dataset-specific Instrument Name	Cold vapor atomic fluorescence spectrometry (Tekran 2500/2600)
Generic Instrument Name	Tekran 2600 Automated Total Mercury Analyzer series
Generic Instrument Description	The Tekran 2600 is a total Mercury (Hg) analysis system that can measure sub-picogram quantities of mercury in water, soil, vegetation, and other sample matrices. The system utilizes a Cold Vapour Atomic Fluorescence Spectroscopy (CVAFS) detector. The 2600-IVS (In-Vial Sparging) model is reconfigured for direct in-vial sparging sample introduction, and the 2600-NG (Natural Gas) model is designed for the analysis of gas phase sample cartridges. The system is capable of multiple method configurations: Dual stage gold preconcentration (EPA Method 1631); Direct measurement without preconcentration (EPA Method 245.7); Air sample analysis on gold traps (EPA Compendium Method IO-5); and Natural gas analysis on gold traps (ASTM D-6350, ISO 6978). It has a guaranteed minimum detection limit of < 0.05 nanograms per liter (ng/L). In clean room environments, with low mercury blanks, minimum detection limits as low as 0.02 ng/L are achievable. See: https://www.tekran.com/products/laboratory/tekran-model-2600-automated-t...

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Deployments

RR2105

Website	https://www.bco-dmo.org/deployment/926884
Platform	R/V Roger Revelle
Start Date	2021-07-13
End Date	2021-08-13
Description	California Current Ecosystem Long Term Ecological Research Process Cruise, CCE LTER III. Also referred to as "P2107". See more information from R2R: https://www.rvdata.us/search/cruise/RR2105

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Project Information

California Current Ecosystem Long Term Ecological Research site (CCE LTER)

Website: http://cce.lternet.edu/

Coverage: California coastal current

From ccelter.edu:
The California Current System is a coastal upwelling biome, as found along the eastern margins of all major ocean basins. These are among the most productive ecosystems in the world ocean. The California Current Ecosystem LTER (32.9 degrees North, 120.3 degrees West) is investigating nonlinear transitions in the California Current coastal pelagic ecosystem, with particular attention to long-term forcing by a secular warming trend, the Pacific Decadal Oscillation, and El Nino in altering the structure and dynamics of the pelagic ecosystem. The California Current sustains active fisheries for a variety of finfish and marine invertebrates, modulates weather patterns and the hydrologic cycle of much of the western United States, and plays a vital role in the economy of myriad coastal communities.

LTER Data:
The California Current Ecosystem (CCE) LTER data are managed by and available directly from the CCE project data site URL shown above. If there are any datasets listed below, they are data sets that were collected at or near the CCE LTER sampling locations, and funded by NSF OCE as ancillary projects related to the CCE LTER core research themes.

NSF Award Abstract (OCE-2224726):
Coastal upwelling regions are found along the eastern boundaries of all ocean basins and are some of the most productive ecosystems in the ocean. This award is supporting the California Current Ecosystem Long Term Ecological Research (CCE LTER) site in a major upwelling biome. It leverages the 73-year California Cooperative Oceanic Fisheries Investigations (CalCOFI) program which provides essential information characterizing climate variability and change in this system. The CCE LTER addresses two over-arching questions: What are the mechanisms leading to ecological transitions in a coastal pelagic ecosystem? And what is the interplay between changing ocean climate, community structure, and ecosystem dynamics? The investigators are working towards diagnosing mechanisms of ecosystem change and developing a quantitative framework for forecasting future conditions and how these might affect the management of key living marine resources, including numerous fishes, invertebrates, marine mammals, and seabirds. They are training graduate and undergraduate students, as well as providing educational opportunities for teachers. Public programs and outreach efforts in collaboration with the Birch Aquarium at Scripps Institution of Oceanography are increasing public awareness and understanding of climate effects on coastal pelagic communities and connecting the public to cutting-edge ocean research.

This project is adding to understanding of the mechanisms underlying abrupt ecological transitions with three interrelated foci: (1) investigation of marine heatwaves and resultant multiple stressors on organisms and communities, (2) elucidation of ecological stoichiometry and the response of multiple trophic levels to altered elemental ratios of source nutrients, and (3) analysis of top-down pressures mediated by a diverse suite of organisms. It is sustaining multi-scale measurements of five core LTER variables and responses to ocean warming, increased stratification, acidification, deoxygenation, and altered nutrient stoichiometry in the Northeast Pacific. The investigators are using long-term, spatially-resolved time series at multiple spatial scales to evaluate community shifts at multiple temporal scales, with new measurements allowing interrogation at finer taxonomic levels. They are conducting in situ multi-factorial experiments (temperature, macronutrients, micronutrients, light, grazing) in combination with genomic and transcriptomic analyses. These will complement time series measurements, inform next-generation biogeochemical models, and test hypotheses related to ecological stoichiometry and marine heatwaves. The team is also using a suite of imaging techniques, molecular and morphological methods, and active and passive acoustic approaches to quantify vertical structure and cooccurrence of organisms across trophic levels and test hypotheses about top-down control of the ecosystem.

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.

This project is supported by continuing grants with name variations:

- LTER: Nonlinear transitions in the California Current Coastal Pelagic Ecosystem
- Ecological Transitions in the California Current Ecosystem: CCE-LTER Phase II
- LTER: CCE-LTER Phase III: Ecological Transitions in an Eastern Boundary Current Upwelling Ecosystem
- LTER: Ecosystem controls and multiple stressors in a coastal upwelling system - CCE IV

Collaborative Proposal: Unravelling the Oceanic Dimethylmercury Cycle (DMHg in the Ocean)

Coverage: Monterey Bay, California Current, Greenland

NSF Award Abstract:
This project will study how dimethylmercury is formed and removed in the oceans. Dimethylmercury is a naturally occurring compound. It is thought to be formed when man-made mercury is converted into monomethylmercury, a toxin that accumulates in fish. Despite representing a large fraction of mercury in the oceans, the origin and fate of dimethylmercury is not known. This research will use state-of-the-art analytical, genomic and modeling tools to address this information gap. It will also train graduate and undergraduate students to use field, experimental, and modeling methods. The results will be used in predictive models to forecast future trends in the oceanic mercury cycle. These models are needed to evaluate the effectiveness of international actions that seek to reverse increasing trends in the bioaccumulation of monomethylmercury in fish.

Methylated mercury species in the ocean are formed in sediment and the water column from inorganic divalent mercury delivered from the atmosphere and rivers. The putative mechanism is a two-step process during which monomethylmercury is formed first, followed by slow methylation into dimethylmercury. The first step, biomethylation of divalent mercury into monomethylmercury, is relatively well-studied in sediment and known to be driven by sulfate- and iron-reducing bacteria and methanogens. The mechanism for monomethylmercury formation in the water column is less well understood, and the process of dimethylmercury formation in sediment or seawater is essentially unknown. Until recently, it was assumed that dimethylmercury represented a small enough fraction of the methylated and total mercury (the sum of all mercury species) pools to be insignificant in the global mercury cycle. Recent measurements, however, show that dimethylmercury levels in seawater can be in the same range as the other mercury species. This project will identify the biological and chemical methylating agents involved in the formation of dimethylmercury. Further, it will test the impact of varying biogeochemical conditions on dimethylmercury production. Results will be used to update the mercury module of the MIT General Circulation Model (MITgcm, a global biogeochemical model, and analyze the impacts of dimethylmercury production and degradation on monomethylmercury concentrations.

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.

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Program Information

Ocean Carbon and Biogeochemistry (OCB)

Website: http://us-ocb.org/

Coverage: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO_2 and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

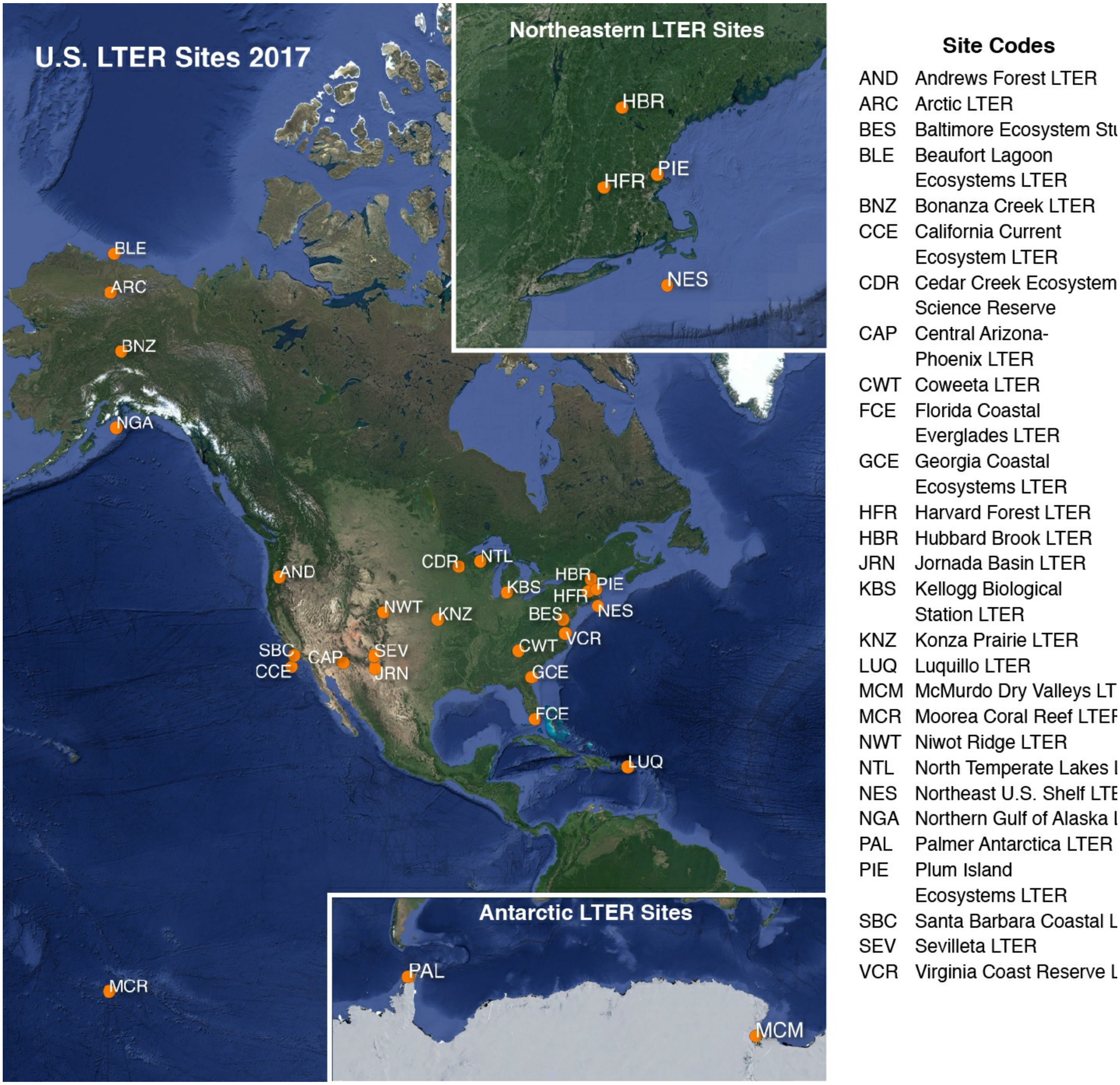
Long Term Ecological Research network (LTER)

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 St
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 LTE
NWT	Niwot Ridge LTER
NTL	North Temperate Lakes
NES	Northeast U.S. Shelf LT
NGA	Northern Gulf of Alaska
PAL	Palmer Antarctica LTER
PIE	Plum Island Ecosystems LTER
SBC	Santa Barbara Coastal
SEV	Sevilleta LTER
VCR	Virginia Coast Reserve

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-1637632
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023046

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