

Alkalinity and dissolved inorganic carbon (DIC) from sea water samples collected at coral reefs from equatorial central Pacific in 1973, 2012, 2015, and 2018

Website: <https://www.bco-dmo.org/dataset/936073>

Data Type: Cruise Results, Other Field Results

Version: 1

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Project

» [The Biophysics of Coral Reef Resilience: hydrodynamic and ecological drivers of coral survival under extreme heat](#) (Biophysics of Coral Reef Resilience)

Contributors	Affiliation	Role
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Abstract

This dataset includes total alkalinity (TA) and dissolved inorganic carbon (DIC), along with water temperature and salinity, to characterize the carbonate chemistry in the vicinity of 5 coral reef islands in the equatorial central Pacific. Discrete water samples were collected from June 7 – 18, 2012 and from September 5 – 26, 2015 at Kanton (2.8°S, 171.7°W), Enderbury (3.1°S, 171.1°W), Rawaki (3.7°S, 170.7°W) and Nikumaroro (4.7°S, 174.5°W), and from May 5 – 23, 2018 at Kanton, Rawaki, Nikumaroro, and Orona (4.5°S, 172.2°W) and at several open ocean sites. Some of the 2012 and 2015 water samples were also analyzed for nitrate, ammonium, phosphate and silicate concentrations. Also included in this dataset are TA, pH, DIC, salinity, and water temperature from samples collected from November 27 to December 4, 1973 at Kanton Island by Smith, S. V., and P. L. Jokiel (1978).

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Coverage

Location: Equatorial, central, South Pacific

Spatial Extent: N:0.009 E:-162.968 S:-4.687 W:-174.547

Temporal Extent: 1973-11-27 - 2018-05-23

Methods & Sampling

Location Information

Five coral reef islands in the equatorial, central, South Pacific.

1. Kanton Atoll (2.8°S, 171.7°W), is a 200 – 500 m wide barrier island surrounding a lagoon that is 14.5 km long and ~5 km wide. A single, 500 m wide channel connects the lagoon to the ocean. The complex pattern of shallow (~ 1 m deep) line (reticulate) reefs span the central portion of the lagoon with pools between the line reefs that are 10 – 26 m deep.
2. Enderbury Island (3.1°S, 171.1°W) is about 4.7 km long and 1.2 km wide, with coral reefs extending 50 m to 400 m offshore.
3. Rawaki Island (3.7°S, 170.7°W) is about 1.2 km long and 0.8 km wide with coral reefs surrounding much of the island.
4. Nikumaroro Island (4.7°S, 174.5°W) is a 300 – 800 m wide barrier island surrounding a lagoon that is about 5 km long and 0.8 km wide. A single, 170 m wide channel connects the lagoon to the ocean.
5. Orona (Hull) Atoll (4.5°S, 172.2°W) is a ~300 m wide barrier island surrounding a lagoon that is about 8 km long and 3 km wide.

For a more complete description of these islands, see Obura, D. (2011).

Samples Collected in 2012, 2015, and 2018

Samples from 2012, 2015, and 2018 were collected on three cruises to Kanton Island:

1. June 7-18, 2012: Pangaea Exploration, Emily Penn, vessel Seadragon, PI Anne Cohen
2. September 5-26, 2015: Vessels Nai'a and Hanse Explorer, cruise led by New England Aquarium, PIs Dr Randi Rojan, Dr Simon Thorrold, Dr Stuart Sandin
3. May 5-23, 2018: Pangaea Exploration, Captain Eric and Shanley Loss, vessel SeaDragon, PI Anne Cohen

Discrete water samples were collected using Niskin samplers, transferred to the appropriate bottles on site, shipped to Woods Hole Oceanographic Institution and analyzed to determine salinity, total alkalinity (TA), dissolved inorganic carbon (DIC), and in some cases nitrate, ammonium, phosphate and silicate concentrations. Unfiltered 250 mL bottle samples for carbonate chemistry were fixed with 100 μ L of a saturated HgCl_2 solution immediately upon collection to inhibit biological activity. TA analyses were performed with a Marianda Versatile Instrument for the Determination of Total inorganic carbon and titration Alkalinity (VINDTA 3C). The VINDTA 3C uses an open cell potentiometric titration for TA analysis. The TA measurements were standardized using in-house laboratory seawater standards calibrated using certified reference materials obtained from Andrew Dickson at Scripps Institution of Oceanography (Dickson et al. 2007). Analyses of replicate samples and of replicate independent working standards each day yielded a mean TA precision of approximately $\pm 1.5 \mu\text{mol kg}^{-1}$. Some water samples were also analyzed to determine nitrate, ammonium, phosphate, and silicate concentrations at the Woods Hole Oceanographic Institution Nutrient Analytical Facility using a four channel segmented flow AA3 HR Autoanalyzer. Bottle salinity was measured on a Guildline Autosol salinometer. Simultaneous water temperatures were measured using either a HOBO Temp Pro data logger or a Sontek Castaway CTD.

Samples Collected in 1973

From Smith and Jokiel (1978), the 1973 water samples were collected from a small skiff or by wading from shore. They were captured in 250-ml polyethylene bottles and maintained near collection temperature until they could be analyzed (average time ~ 6 hours). A Corning model 101 pH meter and a combination electrode were used for all pH and alkalinity measurements. Salinity was determined using a Plessey model 6230N laboratory conductivity salinometer.

Data Processing Description

For 1973 data, DIC was determined using the CO2SYS software (Lewis, E. et al. 1998).

BCO-DMO Processing Description

- Imported original files "PIPA_2012_watersamples.xlsx", "PIPA_2015_watersamples.xlsx", "PIPA_2018_watersamples.xlsx", and "SmithJokiel_1973_watersamples.xlsx" into the BCO-DMO system.
- Converted "Date (local)" field format (%m/%d/%Y) from "SmithJokiel_1973_watersamples.xlsx" to format represented in the other files (%d-%b-%y).
- Concatenated all files into one file, "joined_watersamples".
- Combined "Island" and "Location" fields into new field, "Site_description".
- Replaced "-" with blank value.
- Converted "Date (local)" field into UTC and Local date-time fields in ISO format ("Datetime.UTC", "Datetime.local").
- Added new field for an Ammonium flag to accommodate the "<0.034" string value.
- Removed "<0.034" string value from Ammonium column.
- Combined the "Salinity (0/00)" and "Salinity (psu)" fields.
- Renamed fields to comply with BCO-DMO naming conventions.
- Removed redundant columns: "Date (local)", "Time (local)", "Island", "Location", "Salinity (0/00)", "TA (millieq/l)".
- Saved the final file as "936073_v1_dic_pacific_reefs.csv".

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Data Files

File
936073_v1_dic_pacific_reefs.csv (Comma Separated Values (.csv), 42.28 KB) MD5:7cd69562f22c4247fc8e871e188bb2a6
Primary data file for dataset ID 936073, version 1

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Related Publications

Dickson, A.G.; Sabine, C.L. and Christian, J.R. (eds) (2007) Guide to best practices for ocean CO₂ measurement. Sidney, British Columbia, North Pacific Marine Science Organization, 191pp. (PICES Special Publication 3; IOCCP Report 8). DOI: <https://doi.org/10.25607/OBP-1342>

Methods

Lewis, E., Wallace, D., & Allison, L. J. (1998). Program developed for CO₂ system calculations (No. ORNL/CDIAC-105). Brookhaven National Lab., Dept. of Applied Science, Upton, NY (United States); Oak Ridge National Lab., Carbon Dioxide Information Analysis Center, TN (United States). doi: [10.2172/639712](https://doi.org/10.2172/639712)

Methods

Obura, D. (2011). Coral Reef Structure and Zonation of the Phoenix Islands. Atoll Research Bulletin, 589, 63–82. <https://doi.org/10.5479/si.00775630.589.63>

Methods

Smith, S. V., and P. L. Jokiel (1978). Water composition and biogeochemical gradients in the Canton atoll lagoon. Atoll Research Bulletin, 221, 15 – 54. <https://hdl.handle.net/10088/34113>

Methods

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Results

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Parameters

Parameter	Description	Units
Datetime.UTC	Date and time (UTC) of sample collection	unitless
Datetime_local	Date and time (local) of sample collection; GMT +13.	unitless
Lat_N	Latitude of sampling site, negative values = South	decimal degrees
Lon_E	Longitude of sampling site, negative values = West	decimal degrees
Site_description	Collection site description, includes island, general ocean location, type of water	unitless
Depth	Sample depth	meters (m)
Temperature	Water temperature	degrees Celsius
Salinity	Water salinity	practical salinity unit, psu
TA	Total alkalinity concentration	micromoles/kilogram
DIC	Dissolved inorganic carbon concentration	micromoles/kilogram
Nitrate	Nitrate, NO ₃	micromoles/liter
Ammonium	Ammonium, NH ₄	micromoles/liter
Ammonium_flag	Flag indicates whether Ammonium was above or below .034 micromoles/liter; data flag set as 1 (above .034 micromoles/liter) or 2 (below .034 micromoles/liter)	dimensionless
Phosphate	Phosphate, PO ₄	micromoles/liter
Silicate	Silicate, SiO ₄	micromoles/liter
pH	pH	unitless

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Instruments

Dataset-specific Instrument Name	Guildline Autosal salinometer
Generic Instrument Name	Autosal salinometer
Dataset-specific Description	Bottle salinity for 2012, 2015, and 2018 was measured on a Guildline Autosal salinometer.
Generic Instrument Description	The salinometer is an instrument for measuring the salinity of a water sample.

Dataset-specific Instrument Name	Corning model 101 pH meter and combination electrode
Generic Instrument Name	Benchtop pH Meter
Dataset-specific Description	For data collected in 1973, a Corning model 101 pH meter and a combination electrode were used for all pH and alkalinity measurements.
Generic Instrument Description	An instrument consisting of an electronic voltmeter and pH-responsive electrode that gives a direct conversion of voltage differences to differences of pH at the measurement temperature. (McGraw-Hill Dictionary of Scientific and Technical Terms) This instrument does not map to the NERC instrument vocabulary term for 'pH Sensor' which measures values in the water column. Benchtop models are typically employed for stationary lab applications.

Dataset-specific Instrument Name	VINDTA 3C
Generic Instrument Name	MARIANDA VINDTA 3C total inorganic carbon and titration alkalinity analyser
Dataset-specific Description	Total alkalinity (TA) analyses were performed with a Marianda Versatile Instrument for the Determination of Total inorganic carbon and titration Alkalinity (VINDTA 3C). The VINDTA 3C uses an open cell potentiometric titration for TA analysis.
Generic Instrument Description	The Versatile INstrument for the Determination of Total inorganic carbon and titration Alkalinity (VINDTA) 3C is a laboratory alkalinity titration system combined with an extraction unit for coulometric titration, which simultaneously determines the alkalinity and dissolved inorganic carbon content of a sample. The sample transport is performed with peristaltic pumps and acid is added to the sample using a membrane pump. No pressurizing system is required and only one gas supply (nitrogen or dry and CO ₂ -free air) is necessary. The system uses a Metrohm Titrino 719S, an ORION-Ross pH electrode and a Metrohm reference electrode. The burette, the pipette and the analysis cell have a water jacket around them. Precision is typically +/- 1 umol/kg for TA and/or DIC in open ocean water.

Dataset-specific Instrument Name	Niskin samplers
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Discrete water samples were collected using Niskin samplers
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

Dataset-specific Instrument Name	HOBO Temp Pro v2
Generic Instrument Name	Onset HOBO Pro v2 temperature logger
Dataset-specific Description	Simultaneous water temperatures in 2012, 2015, and 2018 were measured using either a HOBO Temp Pro data logger or a Sontek Castaway CTD.
Generic Instrument Description	The HOBO Water Temp Pro v2 temperature logger, manufactured by Onset Computer Corporation, has 12-bit resolution and a precision sensor for $\pm 0.2^{\circ}\text{C}$ accuracy over a wide temperature range. It is designed for extended deployment in fresh or salt water. Operation range: -40° to 70°C (-40° to 158°F) in air; maximum sustained temperature of 50°C (122°F) in water Accuracy: 0.2°C over 0° to 50°C (0.36°F over 32° to 122°F) Resolution: 0.02°C at 25°C (0.04°F at 77°F) Response time: (90%) 5 minutes in water; 12 minutes in air moving 2 m/sec (typical) Stability (drift): 0.1°C (0.18°F) per year Real-time clock: ± 1 minute per month 0° to 50°C (32° to 122°F) Additional information (http://www.onsetcomp.com/) Onset Computer Corporation 470 MacArthur Blvd Bourne, MA 02532

Dataset-specific Instrument Name	Plessey model 6230N
Generic Instrument Name	Salinometer
Dataset-specific Description	The samples collected in 1973 were tested for salinity using a Plessey model 6230N laboratory conductivity salinometer.
Generic Instrument Description	A salinometer is a device designed to measure the salinity, or dissolved salt content, of a solution.

Dataset-specific Instrument Name	Four channel segmented flow AA3 HR Autoanalyzer
Generic Instrument Name	Seal Analytical AutoAnalyser 3HR
Dataset-specific Description	Some water samples were also analyzed to determine nitrate, ammonium, phosphate, and silicate concentrations at the Woods Hole Oceanographic Institution Nutrient Analytical Facility (https://web.whoi.edu/nutrient/) using a four channel segmented flow AA3 HR Autoanalyzer.
Generic Instrument Description	A fully automated Segmented Flow Analysis (SFA) system, ideal for water and seawater analysis. It comprises a modular system which integrates an autosampler, peristaltic pump, chemistry manifold and detector. The sample and reagents are pumped continuously through the chemistry manifold, and air bubbles are introduced at regular intervals forming reaction segments which are mixed using glass coils. The AA3 uses segmented flow analysis principles to reduce inter-sample dispersion, and can analyse up to 100 samples per hour using stable LED light sources.

Dataset-specific Instrument Name	Sontek Castaway
Generic Instrument Name	SonTek CastAway-CTD
Dataset-specific Description	Simultaneous water temperatures in 2012, 2015, and 2018 were measured using either a HOBO Temp Pro data logger or a Sontek Castaway CTD.
Generic Instrument Description	The Sontek CastAway-CTD (manufactured by Xylem) is a handheld castable instrument that provides instantaneous profiles of temperature, salinity, and sound speed. Each cast is referenced with both time and location using its built-in GPS receiver. The CastAway software displays profiles of the casts in addition to mapping the locations of the data collection points. The CastAway-CTD has a 5 Hz response and sampling rate, accurate to 0.1 (PSS-78), 0.05° Celsius. Conductivity range is 0 to 100,000 µS/cm. Temperature range is -5° to 45° Celsius. Pressure range is 0 to 100 decibars. Further specs and information can be found on the manufacturer's website: https://www.xylem.com/en-us/brands/wtw/wtw-products/castaway-ctd/

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Project Information

The Biophysics of Coral Reef Resilience: hydrodynamic and ecological drivers of coral survival under extreme heat (Biophysics of Coral Reef Resilience)

Website: <http://www2.whoi.edu/site/cohenlab/>

Coverage: Central Tropical Pacific

NSF Award Abstract:

Coral reefs are among the most diverse ecosystems on the planet and support the livelihoods of hundreds of millions of people around the world. Ocean warming and intensifying heatwaves are killing coral reefs and there are urgent efforts underway to identify and protect those capable of surviving future warming. Coral reefs in the central equatorial Pacific have experienced three extreme heat events over the last two decades. Initial observational data obtained by the investigators show that coral mortality during each event was spatially variable, implying that some coral communities have developed resilience to thermal stress. In this study, the

investigators are examining the role of fine-scale variations in reef temperature and water flow in promoting coral resilience by providing opportunities for genetic adaptation, by protectively cooling corals through upwelling or internal waves, or by enhancing food supply. Results will provide novel insights into the mechanisms by which coral communities survive extreme heat and a new tool that allows scientists and coral reef managers to identify resilient reefs for protection. Additionally, this project is supporting an early-career scientist, graduate and undergraduate research, opportunities for high school students in the United States to participate in research, as well as participation by Kanton high school students. Outreach will be conducted through presentations and a variety of media, including film. The hydrodynamic model output will be made publicly available, and project outcomes will contribute to a universal map of coral thermal thresholds currently under development by the scientific community.

Ocean warming and intensifying heatwaves are devastating coral reefs across the global tropics. Consequently, a coordinated effort is underway to identify and protect coral communities that can survive these changes. This interdisciplinary team of investigators is combining oceanographic observations, 3-dimensional fine-scale hydrodynamic model simulations, benthic surveys, and biological assays to investigate the role of reef hydrodynamics in facilitating coral resilience to thermal stress on Kanton Island in the central equatorial Pacific. The investigators are testing the hypothesis that oceanographic and atmospheric forcing interact with reef bathymetry to induce predictable fine-scale heterogeneity in water temperature and flow across the reef. They are also testing the hypothesis that environmental heterogeneity, in turn, facilitates coral survival of extreme heat by providing opportunities for genetic adaptation, protective cooling, and/or enhanced food supply. Results will provide insights into the biophysical mechanisms underpinning reef resilience and a new tool with which to predict resilience across a broad range of coral reef ecosystems.

This project is supported with funds from the Biological and Physical Oceanography Programs.

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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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2049567

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