Model output (carbonate production and erosion rates) from field data collected in Majuro and Kiritimati in 2019

Website: https://www.bco-dmo.org/dataset/856943
Data Type: model results
Version: 1
Version Date: 2021-08-02

Project
» Adjustment of western Pacific Ocean coral reefs to sea-level rise and ocean warming (Coral Reef Adjustment)

Contributors	Affiliation	Role
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Abstract
Carbonate production and erosion rates from field data collected in Majuro and Kiritimati in 2019. This dataset includes output of the model run. The input data files and R scripts are included in the supplemental .zip file and from the BCO-DMO Github repository (https://github.com/BCODMO/Pacific/releases/tag/1.0)

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Coverage

Spatial Extent: **N**:7.22336 **E**:-157.54984 **S**:1.7749 **W**:171.34102
Temporal Extent: 2019-06-17 - 2019-07-22

Dataset Description

R scripts and related data are available in a .zip file: Pacific_Repo_1.0.zip
These files are also available in the following GitHub repository: Pacific (release 1.0)

Acquisition Description

Details of field methods and data analysis are published in van Woesik & Cacciapaglia (2021).

A stratified random sampling approach was used to survey the reefs of Majuro (7.0667° N, 171.2667° E) and Kiritimati (1.8721° N, 157.4278° W), by randomly selecting 24 study sites at each island using the package 'sp' in R. In both locations, a stratified random sampling approach was used to survey the reefs for carbonate production by randomly selecting 24 sites on each island, with the exception of Kiritimati

where only 22 of the 24 sites were surveyed because of inclement weather. At both locations, the sites were stratified as either (i) outer reefs, or (ii) patch reefs in lagoons. The number of sites sampled per habitat varied according to the area of available habitat at each location. The investigators were particularly interested in determining the potential of shallow-water reef carbonate production, and therefore focused surveys between 2–5 m. Majuro was surveyed from 6/17/2019 to 7/6/2019 and Kiritimati was surveyed from 7/10/2019 to 7/22/2019.

Processing Description

BCO-DMO Processing:
Originally submitted GitHub repository https://github.com/rvanwoesik/Pacific forked to https://github.com/BCODMO/Pacific and tagged with release 1.0, which corresponds with this dataset submission. The original repository may have continued updates.

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Related Publications

Van Woesik, R., & Cacciapaglia, C. W. (2021). Thermal stress jeopardizes carbonate production of coral reefs across the western and central Pacific Ocean. PLOS ONE, 16(4), e0249008. doi:10.1371/journal.pone.0249008
Results

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Parameters

Parameter	Description	Units
country	country of site	unitless
state	state of study site	unitless
locat	Reef habitats stratified as either 'outer', 'inner', or 'patch' reef	unitless
NP	Net carbonate production including all erosion, sedimentation, and production of carbonate at each site	kilograms calcium carbonate per year (kg CaCO3 yr-1)
GP	Gross carbonate production, excluding all sedimentation and erosional forces, at each site	kilograms calcium carbonate per year (kg CaCO3 yr-1)
BFj	Biological erosion caused by parrotfishes at each site	kilograms calcium carbonate per year (kg CaCO3 yr-1)
BUj	Biological erosion caused by sea urchins at each site	kilograms calcium carbonate per year (kg CaCO3 yr-1)
lon	longitude	decimal degrees East
lat	latitude	decimal degrees North

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Project Information

Adjustment of western Pacific Ocean coral reefs to sea-level rise and ocean warming (Coral

Reef Adjustment)

Coverage: Western Pacific: Palau, Yap, Pohnpei, Kosrae, Republic of the Marshall Islands, Kiribati

NSF Award Abstract:
Increases in ocean temperatures and sea-level rise are threatening coral reef ecosystems worldwide. Indeed, some island nations are no more than 1 m above modern sea level. Yet, building sea walls on tropical coasts, to keep out the ocean, as they do in the Netherlands, is a substantial economic burden on small-island nations. Healthy coral reefs, however, have the capacity to lay down sufficient calcium carbonate to grow vertically and keep up with sea-level rise, as they did in the geological past. By contrast, damaged coral reefs do not have the capacity to keep up with sea-level rise, making the coastal communities vulnerable, and inflicting a large economic burden on the coastal societies to build sea walls. In addition, and very recently, coral reefs are being subjected to high water temperatures that are causing considerable damage to corals. This study will ask some critical questions: Are coral reefs in the western Pacific Ocean keeping up with sea-level rise? Where are reefs keeping up with sea-level rise, and what is preventing reefs in some localities from keeping up? This study will also examine whether geographical differences in ocean temperatures influence the capacity of reefs to keep up with sea-level rise. Where coral reefs cannot keep up with sea-level rise, these natural storm barriers will disappear, resulting in the loss of habitable land for millions of people worldwide. The broader impacts of the study will focus on training a post-doctoral researcher, and developing and running one-week training workshops in the proposed study locations in Palau, Yap, Chuuk, Pohnpei, Kosrae, Majuro, and Kiribati. The investigators will work with local stakeholders on the various islands, focusing on connecting science to management practices to reduce local stressors to coral reefs.

Coral reefs are one of the world's most diverse and valuable marine ecosystems. Since the mid-Holocene, some 5000 years ago, coral reefs in the Pacific Ocean have been vertically constrained by sea level. Contemporary sea-level rise is releasing these constraints, providing accommodation space for vertical reef expansion. Yet recently corals have been repeatedly subjected to thermal-stress events, and we know little about whether modern coral reefs can "keep up" with projected future sea-level rise as the ocean temperatures continue to increase. This study will examine whether and where coral reefs are keeping up with sea-level rise across a temperature gradient in the Pacific Ocean, from Palau in the west to Kiribati in the east. The spatial differences in the capacity to keep up with sea level will be explored, and it is hypothesized that differential rates of coral growth and capacity to keep up with sea-level rise will be a function of regional temperatures, local water-flow rates, and land-use. One of the major tasks of this study is to determine the contribution of the various components of each reef to potential carbonate production, across the geographical temperature gradient. The investigators will quantify the rates of carbonate production, by corals and calcareous algae, and the rates of carbonate destruction, by reef eroders, by measuring the space occupied by each benthic component at each study site. The team will then sum that information to interpret the overall capacity of the reef to produce carbonate. At each study site mobile benthic eroders will be estimated, as counts and size measurements of echinoids and herbivorous fishes. The investigators will measure the densities of the different coral species, from different habitats, and develop models that relate the coral morphologies with the potential rate of carbonate deposition. This study will assess the contribution of sea surface temperature, flow rates, and land-use practice to the capacity of reefs to keep up with sea-level rise. Two different approaches will be used to predict the relationship between carbonate production and sea-level rise. The first model will assume that the capacity of vertical reef accretion is directly related to the extension of Porites microatolls at the various island locations. The second model will take a hierarchical Bayesian approach to examine reef growth, which depends on the presence and density of calcifying organisms, and on physical, chemical, and biological erosional processes.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1657633

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