Sea urchin size, density, and species from transects surveyed in Palau, Yap, the Federated States of Micronesia, Majuro, and Kiritimati from 2017 to 2019

Website: https://www.bco-dmo.org/dataset/737514
Data Type: Other Field Results
Version: 3
Version Date: 2021-07-14

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
As part of the reef-composition survey of Palau, Yap, the Federated States of Micronesia, Majuro, and Kiritimati, the erosion to a reef caused by sea urchins was estimated using field surveys, which captured the density and size of sea urchins in transects.

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Coverage

Spatial Extent: **N**:9.65683 **E**:-157.54984 **S**:1.7749 **W**:171.34102
Temporal Extent: 2017-06-02 - 2019-07-22

Dataset Description

These data were published in van Woesik & Cacciapaglia (2018), van Woesik & Cacciapaglia (2019), and van Woesik & Cacciapaglia (2021).

Methods & Sampling

Palau and Yap:
Sea urchins were measured for test diameter and classified as either *Diadema*, *Echinometra*, and 'other' in transects. Survey depth was maintained between 2 to 5 meters, to examine the potential of shallow-water reef-carbonate production. Urchins were identified in 10 m long by 60 cm wide transects, 30 cm either side of the 10 m tape. Each urchin’s test diameter was measured in the field. Surveys in Palau were conducted in June 2 to June 24, 2017, and from June 25 to July 6, 2017 in Yap.

Federated States of Micronesia (FSM):
Twenty-four study sites were randomly selected in each of Pohnpei (6.2°N, 158.2°E) and Kosrae (5.3°N, 162.9°E) FSM using a randomly stratified sampling approach with the package sp in R. In Pohnpei, reefs were stratified as inner reefs, patch reefs, and outer reefs. In Kosrae, we only stratified the reefs as either inner reefs or outer reefs (because of the lack of patch reefs). Sample size of each strata was determined by calculating the geographic area of each reef type, using the area function from the R package raster, and allocating the number of sites in accordance with the area estimates. Reef surveys focused on the 2–5 meters depth contour to estimate shallow-water carbonate production.

Six, 10 m transects, using a modified line-intercept technique that followed the reef substrate, were used to measure the benthic composition for every centimeter, at each site of the 48 sites. A few meters gap was allocated between the ends of the transects to ensure no overlap of substrate between transects. The urchins were recorded as *Echinometra*, *Diadema*, and 'Other', and the diameter of each echinoid test was measured to the nearest 0.5 cm.

Majuro (Republic of the Marshall Islands) and Kiritimati (Republic of Kiribati):
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.

Data Processing Description

BCO-DMO Data Manager Processing Notes:
Version 1:
- This dataset was originally submitted to BCO-DMO as files;
- added column called location with values (Palau|Yap);
- added a conventional header with dataset name, PI name, version date;
- modified parameter names to conform with BCO-DMO naming conventions;
Version 2:
- 2020-09-10: appended data from sites in Federated States of Micronesia (FSM);
- replaced 'NA' and 'na' with 'nd' as missing data identifier.
Version 3:
- 2021-07-14: appended data from Kiritimati & Majuro sites.

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Data Files

File
urchins.csv (Comma Separated Values (.csv), 98.63 KB) MD5:7711483ffe8c1f6ec61a4c4132a2cc82 Primary data file for dataset ID 737514

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Related Publications

Van Woesik, R., & Cacciapaglia, C. W. (2018). Keeping up with sea-level rise: Carbonate production rates in Palau and Yap, western Pacific Ocean. PLOS ONE, 13(5), e0197077. doi:10.1371/journal.pone.0197077 *Results*

Van Woesik, R., & Cacciapaglia, C. W. (2019). Carbonate production of Micronesian reefs suppressed by

thermal anomalies and Acanthaster as sea-level rises. PLOS ONE, 14(11), e0224887. doi:10.1371/journal.pone.0224887
Results

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 survey	unitless
site_num	Site number given to each surveyed site on each island	unitless
study_site	Site letter given to each study locality on each island	unitless
transect	Transect replicate out of 6	unitless
species	The genus of urchin found in the transect. NA indicates no urchins found in the transect. “other” means that the urchin found was not an Echinometra nor a Diadema.	unitless
diameter	Diameter of sea urchin test	centimeters (cm)
State	State of survey	unitless

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Deployments

vanWoesik_Yap_2017

Website	https://www.bco-dmo.org/deployment/744604
Platform	shoreside Yap
Start Date	2017-06-25
End Date	2017-07-06

vanWoesik_Palau_2017

Website	https://www.bco-dmo.org/deployment/744578
Platform	shoreside Palau
Start Date	2017-06-02
End Date	2017-06-24

vanWoesik_FSM_2018

Website	https://www.bco-dmo.org/deployment/823334
Platform	shoreside Micronesia
Start Date	2018-06-24

vanWoesik_Kiritibati_2019

Website	https://www.bco-dmo.org/deployment/855679
Platform	Kiritimati
Description	Kiritimati (1.8721° N, 157.4278° W)

vanWoesik_Majuro_2019

Website	https://www.bco-dmo.org/deployment/855678
Platform	shoreside_Majuro
Description	reefs of Majuro (7.0667° N, 171.2667° E)

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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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