Community composition of benthic invertebrates on underwater cultural heritage and coral reefs from Palau aquired May to November 2022

Website: https://www.bco-dmo.org/dataset/997105
Data Type: Other Field Results
Version: 1
Version Date: 2026-04-27

Project
» Collaborative Research: How do selection, plasticity, and dispersal interact to determine coral success in warmer and more variable environments? (Palau coral selection plasticity dispersal)

Contributors	Affiliation	Role
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Abstract
Ships, planes, and other vessels that come to rest on the seafloor introduce metals to the marine environment. Underwater cultural heritage (UCH) sites become important habitats for sessile invertebrates, but the materials they are made from can impact the composition of species living on them. We collected and analyzed images from three sites in Palau (two shipwrecks and one plane wreck from WWII) along with directly adjacent (1 – 5 m away) naturally-occurring coral reefs. We collected images of the sessile invertebrate fauna at each site using a Nikon D850 camera with a wide-angle lens, a GoPro Hero 7 with a wide-angle lens, and two Olympus TG-6 cameras. Wide-angle photography was used to record adult corals or other sessile invertebrates (≤ 5 cm diameter) in quadrats (0.34 ± 0.01 m2, mean ± SE). Olympus cameras were used for macro photography of young coral recruits (< 5 cm diameter), with each recruit being photographed individually to enable identification. Images were used to visually identify and count sessile invertebrates living on each wreck and the adjacent coral reefs. Coral species were identified to the genus level by comparison to published guides. Other sessile invertebrate species were identified to broad taxonomic categories (e.g., wire coral, sponge, tube worm).

Table of Contents

Coverage

Location: Palau
Spatial Extent: **N**:7.3367 **E**:134.5088333 **S**:7.2862 **W**:134.4108167
Temporal Extent: 2022-05-09 - 2022-11-10

Methods & Sampling

We collected images from three UCH sites and surrounding coral reefs in Palau (Micronesia, western Pacific). Sites were selected based on accessibility, depth (≤ 6 m), and proximity to naturally-occurring coral reefs. All UCH dated from WWII, meaning that at the time of sampling, structures had rested on the seafloor for approximately 80 years. In May 2022, we collected images from two World War II shipwrecks: the “Fish N Fins shipwreck” (henceforth FNF) was located near a dive shop by the same name, and the “Taoch shipwreck” was located in the Taoch region of Palau’s Rock Island Southern Lagoon. Unfortunately, the identity of these two shipwrecks is unknown. In November 2022, we collected images from an Aichi E13A “Jake” sea plane wreck (henceforth Plane) near Ngermid.

We collected images of the sessile invertebrate fauna at each site using a Nikon D850 camera with a wide-angle lens, a GoPro Hero 7 with a wide-angle lens, and two Olympus TG-6 cameras. Wide-angle photography was used to record adult corals or other sessile invertebrates (≤ 5 cm diameter) in quadrats (0.34 ± 0.01 m2, mean ± SE). Olympus cameras were used for macro photography of young coral recruits (< 5 cm diameter), with each recruit being photographed individually to enable identification. A size scale was included in images to show colony size and quadrat area.

Images were recorded in transects at each site. The FNF shipwreck was oriented in an upright position, was 30 m long, and stretched from the seafloor (4 m depth) to above the sea surface. Images were recorded in three transects on the starboard hull (4, 3, and 2 m depth), one transect along the starboard gunnel (1 m depth), one transect on the port side (2 - 4 m depth), and one transect on the deck of the ship (2 m depth). Each transect stretched the length of the ship, ~30 m. A coral reef interspersed with sandy sediment surrounded the FNF shipwreck on both sides. Coral heads and coral rubble occurred on the seafloor within 1 m of the shipwreck, so there was almost no gap between the shipwreck and the adjacent natural reef. Quadrats were recorded from the coral reef (4 m depth) in three transects, each 20 – 30 m in length: near the starboard side, near the port side, and near the bow of the shipwreck.

The Taoch shipwreck was oriented on its side and 30 m long. It rested on the seafloor at 6 m depth and stretched to 1 m depth. Images were collected in transects that stretched the length of the ship: three transects on the hull (6 m, 3 m, 1 m depth) and 2 transects on the deck (6 m, 4 m depth). The seafloor on the deck side of the shipwreck was blanketed by sand and punctuated by sparse coral heads. On the hull side of the wreck, there was an area of sand ~2–5 m wide, and then a dense coral reef sloped upward to shore. Quadrats were recorded from this sloping coral reef in transects running the length of the ship: two transects (6 m, 3 m) on the hull side of the shipwreck and one transect (6 m depth) on the deck side of the shipwreck.

The seaplane rested approximately in flight orientation on the seafloor at 2 m depth. Quadrats from this aircraft were photographed in 2 transects: along the fuselage (12 m long), and along the wings (15 m). A coral reef covered the limestone walls of the U-shaped bay where the plane wreck rested, with a gap of 1 – 5 m from the airplane. This surrounding coral reef was photographed in a single transect stretching around the tail of the aircraft (~20 m long, 2 m depth).

Data Processing Description

Images were used to visually identify and count sessile invertebrates living on each wreck and the adjacent coral reefs. Coral colonies were delineated based on margins – all polyps enclosed within contiguous, visible margins were counted as one colony, regardless of colony size. In a few cases, large coral colonies appeared in adjacent images, but these colonies were only counted in one image. Coral species were identified to the genus level by comparison to published guides (Erhardt and Knop, 2005; Veron *et al.*, 2016; Kelley, 2022). All coral identifications were updated to match the most recent available taxonomic revisions (Kelley, 2022). Other sessile invertebrate species were identified to broad taxonomic categories (e.g., wire coral, sponge, tube worm).

We also recorded metadata for each photo including its site, transect, and organism type (UCH adult, UCH juvenile, or Reef adult). We analyzed 493 photos from the FNF site (shipwreck and natural reef), 472 photos from the Taoch site, and 232 photos from the Plane site. Altogether, 5835 individuals were identified.

BCO-DMO Processing Description

* Converted Date field from "%d-%b-%y" format to "%Y-%m-%d" string format
* Converted Lat field from degrees-decimal_minutes format (with N/S directional) to decimal degrees

* Converted Long field from degrees-decimal_minutes format (with E/W directional) to decimal degrees
* Rounded Long field to 7 decimal places
* Renamed fields by replacing spaces with underscores across specified fields
* Organism names checked in World Register of Marine Species (WoRMS)
* Zipped images and added to landing page

[table of contents | back to top]

Data Files

File
997105_v1_shipwreck.csv (Comma Separated Values (.csv), 195.33 KB) MD5:231480d6eb60190ba2b9f91235d02087 Primary data file for dataset ID 997105, version 1

[table of contents | back to top]

Supplemental Files

File
Images.zip (ZIP Archive (ZIP), 4.57 GB) MD5:d0835b86e75f0561508c8b49e47296dd Raw images used to identify corals and other sessile invertebrates on ship wrecks, plane wrecks, and coral reefs in Palau.

[table of contents | back to top]

Related Publications

Erhardt, H., & Knop, D. (2005). Corals: Indo-Pacific field guide. IKAN-Unterwasserarchiv. https://isbnsearch.org/isbn/9783925919695
Methods

Kelley, R. (2022). Coral finder 2022: Indo-Pacific hard corals (5th ed.). BYOGUIDES https://byoguides.com/products/coral-finder
Methods

Meyer-Kaiser, K., Quintin, O. R., Mires, C. H., & Hansel, C. M. (in press). Community composition of sessile invertebrates on underwater cultural heritage differs from natural reefs in Palau. The Biological Bulletin
Results

Veron, J. E. N., Stafford-Smith, M. G., Turak, E., & DeVantier, L. M. (2016). Corals of the world (Version 0.01, beta) [Online database]. Australian Institute of Marine Science. http://www.coralsoftheworld.org/
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
Photo_Name	Picture name	unitless
Date	Sampling date	unitless

Site	Sampling site (FNF wreck, Taoch wrech, or Plane wreck)	unitless
Lat	Sampling latitude (south is negative)	decimal degrees
Long	Sampling longitude (west is negative)	decimal degrees
Category	UCH adult (organism > 5cm diameter living on the ship or plane wreck), UCH juvenile (coral < 5cm living on the ship or plane wreck), Reef adult (organism > 5 cm living on the adjacent naturally-occuring coral reef)	unitless
Transect	Code for which transect an image was recorded from (numbers are arbitrary)	unitless
Depth_m	Sampling depth	meters (m)
Acanthastrea	Number of Acanthastrea observed in the image	unitless
Acropora	Number of Acropora observed in the image	unitless
Cantharellus	Number of Cantharellus observed in the image	unitless
Coelastrea	Number of Coelastrea observed in the image	unitless
Ctenactis	Number of Ctenactis observed in the image	unitless
Cycloseris	Number of Cycloseris observed in the image	unitless
Cyphastrea	Number of Cyphastrea observed in the image	unitless
Echinopora	Number of Echinopora observed in the image	unitless
Dipsastraea	Number of Dipsastraea observed in the image	unitless
Favites	Number of Favites observed in the image	unitless
Fungia	Number of Fungia observed in the image	unitless
Galaxea	Number of Galaxea observed in the image	unitless

Goniastrea	Number of Goniastrea observed in the image	unitless
Goniopora	Number of Goniopora observed in the image	unitless
Heliofungia	Number of Heliofungia observed in the image	unitless
Alcyoniidae	Number of Alcyoniidae observed in the image	unitless
Leptastrea	Number of Leptastrea observed in the image	unitless
Leptoseris	Number of Leptoseris observed in the image	unitless
Lobophyllia	Number of Lobophyllia observed in the image	unitless
Millepora	Number of Millepora observed in the image	unitless
Montastraea	Number of Montastraea observed in the image	unitless
Montipora	Number of Montipora observed in the image	unitless
Mycedium	Number of Mycedium observed in the image	unitless
Oulophyllia	Number of Oulophyllia observed in the image	unitless
Oxypora	Number of Oxypora observed in the image	unitless
Pachyseris	Number of Pachyseris observed in the image	unitless
Paramontastraea	Number of Paramontastraea observed in the image	unitless
Parascolymia	Number of Parascolymia observed in the image	unitless
Pavona	Number of Pavona observed in the image	unitless
Pectinia	Number of Pectinia observed in the image	unitless
Phymastrea	Number of Phymastrea observed in the image	unitless

Physogyra	Number of Physogyra observed in the image	unitless
Platygyra	Number of Platygyra observed in the image	unitless
Plerogyra	Number of Plerogyra observed in the image	unitless
Pocillopora	Number of Pocillopora observed in the image	unitless
Porites	Number of Porites observed in the image	unitless
Sandalolitha	Number of Sandalolitha observed in the image	unitless
Sarcophyton	Number of Sarcophyton observed in the image	unitless
Stylaraea	Number of Stylaraea observed in the image	unitless
Stylocoeniella	Number of Stylocoeniella observed in the image	unitless
Symphyllia	Number of Symphyllia observed in the image	unitless
Trachyphyllia	Number of Trachyphyllia observed in the image	unitless
Unknown	Number of Unknown observed in the image	unitless
Ascidian	Number of Ascidian observed in the image	unitless
Sponge	Number of Sponge observed in the image	unitless
Wire_coral	Number of Wire_coral observed in the image	unitless
Oysters	Number of Oysters observed in the image	unitless
Giant_clam	Number of Giant_clam observed in the image	unitless
Tube_worm	Number of Tube_worm observed in the image	unitless
Anemone	Number of Anemone observed in the image	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Nikon D850 camera with a wide-angle lens
Generic Instrument Name	Camera
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	GoPro Hero 7 with a wide-angle lens
Generic Instrument Name	Camera
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	Olympus TG-6 cameras
Generic Instrument Name	Camera
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

[table of contents | back to top]

Project Information

Collaborative Research: How do selection, plasticity, and dispersal interact to determine coral success in warmer and more variable environments? (Palau coral selection plasticity dispersal)

Coverage: Palauan coral reefs

NSF Award Abstract:
Coral reefs host thousands of marine species, help protect coastlines from storm damage, generate tourism, and house fish used for human consumption. However, corals are vulnerable to increasing water temperatures, which can lead to coral death. One way for reefs to survive in warming oceans is for corals that are well-suited to warmer waters to repopulate reefs that have less temperature-tolerant individuals. For this strategy to succeed, however, the more temperature-tolerant corals need to be able to disperse to and survive in these different environments. This project takes advantage of reef systems in the Pacific nation of Palau that naturally experience a wide range in temperatures across short geographic distances. Using cutting-edge ecological and genomic techniques, the team of investigators is directly testing whether young corals from Palau's warmest reefs can successfully be carried by ocean currents to Palau's currently cooler reefs and subsequently survive and thrive in these habitats. Given the relevance of this research for the local ecology, the team is disseminating results to the Palauan government through a written report in conjunction with Palauan scientists who are interning with the team, and to the Palauan people through public presentations. As part of this work, the investigators are maintaining a blog and are organizing a music-lecture series combining dance, music, and science to promote awareness of the coral reef crisis across English and Spanish-speaking communities in the US. Results from this project are informing restoration and conservation practices of the Coral Conservation Consortium as well as other efforts worldwide.

A major question in evolutionary biology is how plasticity and adaptation interact to influence survival under novel environments. Understanding these processes is increasingly important as rising temperatures associated with climate change influence species globally. For marine organisms with pelagic larval phases, including reef-building corals, the post-settlement period constitutes a critical bottleneck for adaptation and plasticity, with the added complexity that the conditions experienced and time spent as larvae can incur carryover effects. This project leverages reefs in Palau that span a steep environmental gradient to study how

environmental variation drives selection and plasticity and to examine if dispersal between reefs limits success across habitats due to carryover effects. The investigators are testing the overarching hypothesis that corals from warmer and more variable environments are adapted to warmer temperatures and exhibit increased plasticity, but that dispersal between reefs incurs a fitness cost. The team integrates field and molecular techniques to: 1) investigate the degree of selection occurring on warmer and more variable reefs, 2) test whether corals transplanted to more variable environments improve their thermal tolerance through developmental plasticity, and 3) examine whether delays in metamorphosis required for dispersal across reefs comes at a fitness cost due to carryover effects.

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2048678

[table of contents | back to top]