Coral community structure at pooled random sites between Cabritte Horn and White Point in St. John before and after five hurricanes from 1988–2017

Website: https://www.bco-dmo.org/dataset/750092
Data Type: Other Field Results
Version: 1
Version Date: 2018-11-28

Project
» RUI-LTREB Renewal: Three decades of coral reef community dynamics in St. John, USVI: 2014-2019 (RUI-LTREB)

Contributors	Affiliation	Role
Edmunds, Peter J.	California State University Northridge (CSUN)	Principal Investigator
Biddle, Mathew	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
These files contain data that support an analysis of the effects of two major hurricanes on coral reefs that have been extensively studied for more than three decades. Major tropical storms are destructive phenomena with large effects on the community dynamics of multiple biomes. On coral reefs, their impacts have been described for decades, leading to the expectation that future storms should have effects similar to those recorded in the past. This expectation relies on the assumption that storm intensities will remain unchanged, and the impacted coral reef communities are similar to those of the recent past; neither assumption is correct. These data support a study quantifying the effects of two category five hurricanes on the reefs of St. John, US Virgin Islands, where 31 y of time-series analyses reveal chronic coral mortality, increasing macroalgal abundance, and five major hurricanes that caused acute coral mortality. Contextualized by these trends, the effects of the most recent storms, Hurricanes Irma and Maria (September 2017), on coral cover were modest. While mean absolute coral cover declined 1–4% depending on site, these effects were not statistically discernable. Following decades of increasing abundance of macroalgae, this functional group responded to the recent hurricanes with large increases in abundance on both absolute and relative scales. Decades of chronic mortality have changed the coral assemblages of St. John to create degraded communities that are resistant to severe storms.

Table of Contents

Coverage

Spatial Extent: **Lat**:18.32 **Lon**:-64.723
Temporal Extent: 1995 - 2017

Dataset Description

The shallow reefs (≤ 14-m depth) of St. John have been subjects of time-series analyses since December 1987. Study plots first were established at 9-m depth at Yawzi Point, and at 14-m depth at Tektite, both of which provide examples of reefs dominated by *Orbicella annularis*. The initial sampling evaluated the impacts of coral

bleaching in 1987, and each site consisted of three, 10-m transects placed at a constant depth, parallel to one another (and 5-m apart), and permanently marked. Ten contiguous photoquadrats (1 × 1 m) have been recorded along each transect annually, and here results from 1988 (March) and 1989 (April and October) are used to evaluate the effects of Hurricane Hugo, from 1995 (May) and 1996 (May) to evaluate the effects of Hurricanes Luis and Marilyn, and from 2017 (July and November) to evaluate the effects of Hurricanes Irma and Maria. The damage from Hurricane Hugo at Yawzi Point was extensive, and to capture this spatial scale of damage, the analysis was expanded with four, unmarked 20-m transects. In 1989, these transects were recorded using Hi-8 video (Sony Corporation), but starting in 1992, they were recorded as contiguous photoquadrats using underwater cameras. Surveys of these 20-m transects from 1989 (October), 1995 (May), 1996 (May), and 2017 (July and November) are used here to expand the spatial scale of the present analysis.

Methods & Sampling

Photoquadrats at Yawzi Point and Tektite were recorded using cameras attached to a framer that held them perpendicular to the reef. A Nikonos V (35-mm format) was used from 1987-1999, and digital cameras thereafter, with 3.3 MP resolution from 2000–2006, 6.1 MP from 2006–2010, 12.1 MP in 2011, 16.2 from 2012–2015, and 36.3 MP from 2016–present. Cameras were fitted with a strobe (Nikonos SB 105) and the images resolved objects ≥ 1-cm diameter.

The analyses at Yawzi Point and Tektite were augmented in 1992 with six additional sites that were selected using random coordinates constrained to hard substrata. This sampling focused on a habitat where boulders and cliffs of igneous rock are common, mean coral cover has remained < 5%, and *Orbicella annularis* has not been common since at least 1992. Five sites are at 9-m depth, with one at 7-m depth (RS9), and they have been recorded annually. These sites serve as replicates of reefs between Cabritte Horn and White Point, and are analyzed as the pooled random sites (PRS). Results from 1995 (May) and 1996 (May) are used to evaluate the effects of Hurricanes Luis and Marilyn, and from 2017 (July and November) to evaluate the effects of Hurricanes Irma and Maria. Each site consists of a permanently marked transect at a constant depth that was 20-m long from 1992–1999 (n ~ 18 photoquadrats site^{-1}), but was extended to 40 m in 2000 when digital photography was implemented (n ~ 40 photoquadrats site^{-1}). Photoquadrats (0.5 × 0.5 m) were recorded at random positions along each transect (and re-randomized annually) using cameras (as described above) attached to a framer that held them perpendicular to the reef. Cameras were attached to two strobes (Nikonos SB 105), and resolved objects to at least 5-mm diameter.

Photoquadrats were analyzed by overlaying them with a grid of 200 randomly-located dots and identifying the substratum beneath each dot. Images were analyzed manually prior to 2005, from 2005–2011 using CPCe software, and from 2012 to present, using CoralNet software with manual annotations. With this approach, the abundance of each substratum type is defined by the total number of dots that occur on top of it in each image, and when expressed as a percentage of the dot population on each image, provides a measure of percentage cover (hereafter “cover”) (Menge 1976). Two resolutions were applied to the analyses, first to resolve three functional groups (FG), coral (combined cover of scleractinians), macroalgae (algae ≥ 1-cm high, mostly *Halimeda, Lobophora, Padina*, and *Dictyota*), and a combined category of crustose coralline algae, algal turf, and bare space (CTB). Second, scleractinians were resolved to the lowest taxonomic level possible, which was genera at Yawzi Point and Tektite, and a combination of species and genera at the PRS.

In addition to the hurricanes described herein, St. John also was impacted by Hurricane Lenny on 17 November 1999 (Table S1). However, underwater damage attributed to this storm was minor, probably due to the modest local wind speeds (150 km h^{-1}), and propagation of damaging waves east and south that reduced their impacts on the southern shore of St. John. The effects of Hurricane Lenny are not considered in the present analysis. Given the vagaries of fieldwork extending over 31 Years, it was not possible to standardize the timing of sampling that took place before and after each storm episode. Sampling took place 6 weeks after Hurricane Hugo, 8 months after Hurricane Luis, and 9 weeks after Hurricane Maria. Sampling after the two most recent storms was comparable to sampling after Hurricane Hugo with regards to the delay following the storms and, therefore, probably quantified mostly coral mortality directly attributable to physical damage, and blooms of macroalgae commensurate with the growth that is possible in two autumn months. The longer delay in sampling after Hurricanes Marilyn and Luis probably resulted in measurements of coral mortality that was caused both by direct physical damage and delayed-onset disease, as well as blooms of macroalgae that can grow over 8 months extending from autumn to spring.

Data Processing Description

Statistical approach.

To test for changes over time in the response of benthic communities to hurricanes, the three FG were tested in separate univariate models (in which the dependent variables were cover of coral, macroalgae, or CTB) for the effects of hurricanes (the fixed effect). The effects of Hurricane Hugo were evaluated relative to FG abundance in April 1989, and Hurricanes Luis and Marilyn, and Irma and Maria were each considered single storm episodes because they occurred in quick succession. Percentage cover was arcsine transformed, and the assumptions of normality and equal variance explored through graphical analysis of residuals. Planned contrasts were used to compare cover before and after each storm episode. Changes in absolute and relative coral cover along the four 20-m transects at Yawzi Point were compared between storm episodes using a Mann Whitney U-test. Multivariate community structure was compared before and after storms using non-metric multidimensional scale (nMDS) and Bray Curtis dissimilarities calculated for scleractinian abundance by lowest taxonomic resolution, and for FG. For PRS (both coral and FG), and FG at Yawzi Point and Tektite, data were square-root transformed. For coral cover at Yawzi Point and Tektite, pre-Hurricane Hugo data came from March 1988, and all were standardized and then square root transformed to address the dominance of the communities by Orbicella annularis. Univariate statistical analyses were completed using Systat 13, and multivariate statistics using PRIMER version 6.

BCO-DMO Processing Notes:

- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions

[table of contents | back to top]

Data Files

File
prs.csv (Comma Separated Values (.csv), 88.09 KB) MD5:5bec3c8f7ec67eb62a53d760af681bf9 Primary data file for dataset ID 750092

[table of contents | back to top]

Related Publications

Edmunds, P. J. (2019). Three decades of degradation lead to diminished impacts of severe hurricanes on Caribbean reefs. Ecology, 100(3), e02587. doi:10.1002/ecy.2587
Results

[table of contents | back to top]

Parameters

Parameter	Description	Units
Site	Study site; Polled random sites (6 sites)	unitless
Year	Sampling Year	unitless
Slide	quadrat number; ~ 18 prior to 2000; and ~ 40 after 2000. Each quadrat is 0.5 x 0.5 m in size	unitless
Timing	Timing; indicating before and after two episodes of major hurricanes	unitless
Orbicella_annularis	Orbicella_annularis percent cover	percent
Agaricia	Agaricia percent cover	percent
Dendrogyra	Dendrogyra percent cover	percent
Dichocoenia	Dichocoenia percent cover	percent
Diploria_labrynthiformes	Diploria_labrynthiformes percent cover	percent
D_strigosa	D_strigosa percent cover	percent
Eusmilia_fastigiata	Eusmilia_fastigiata percent cover	percent
Favia_fragum	Favia_fragum percent cover	percent
Madracis_decactis	Madracis_decactis percent cover	percent
Montastraea_cavernosa	Montastraea_cavernosa percent cover	percent
Orbicella_faveolata	Orbicella_faveolata percent cover	percent
Orbicella_franksi	Orbicella_franksi percent cover	percent
Meandrina_meandrites	Meandrina_meandrites percent cover	percent
Mussa	Mussa percent cover	percent
Porites_astreoides	Porites_astreoides percent cover	percent
Branching_Porites	Branching_Porites percent cover	percent
Stephanocoenia_intercepts	Stephanocoenia_intercepts percent cover	percent
Siderastrea_radians	Siderastrea_radians percent cover	percent
Siderastrea_siderea	Siderastrea_siderea percent cover	percent
All_Mycetophylla	All_Mycetophylla percent cover	percent
Acropora	Acropora percent cover	percent
CTB	combined category of crustose coralline algae; algal turf; and bare space percent cover	percent
Macroalgae	summation of macroalgae mostly in the genera Halimeda; Lobophora; Dictyota percent cover	percent
Coral	combined coral cover percent cover	percent

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	cameras
Generic Instrument Name	Camera
Dataset-specific Description	Photoquadrats at Yawzi Point and Tektite were recorded using cameras attached to a framer that held them perpendicular to the reef.
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

[table of contents | back to top]

Project Information

RUI-LTREB Renewal: Three decades of coral reef community dynamics in St. John, USVI: 2014-2019 (RUI-LTREB)

Website: http://coralreefs.csun.edu/

Coverage: USVI

Describing how ecosystems like coral reefs are changing is at the forefront of efforts to evaluate the biological consequences of global climate change and ocean acidification. Coral reefs have become the poster child of these efforts. Amid concern that they could become ecologically extinct within a century, describing what has been lost, what is left, and what is at risk, is of paramount importance. This project exploits an unrivalled legacy of information beginning in 1987 to evaluate the form in which reefs will persist, and the extent to which they will be able to resist further onslaughts of environmental challenges. This long-term project continues a 27-year study of Caribbean coral reefs. The diverse data collected will allow the investigators to determine the roles of local and global disturbances in reef degradation. The data will also reveal the structure and function of reefs in a future with more human disturbances, when corals may no longer dominate tropical reefs.

The broad societal impacts of this project include advancing understanding of an ecosystem that has long been held emblematic of the beauty, diversity, and delicacy of the biological world. Proposed research will expose new generations of undergraduate and graduate students to natural history and the quantitative assessment of the ways in which our planet is changing. This training will lead to a more profound understanding of contemporary ecology at the same time that it promotes excellence in STEM careers and supports technology infrastructure in the United States. Partnerships will be established between universities and high schools to bring university faculty and students in contact with k-12 educators and their students, allow teachers to carry out research in inspiring coral reef locations, and motivate children to pursue STEM careers. Open access to decades of legacy data will stimulate further research and teaching.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Environmental Biology (NSF DEB)	DEB-0841441
NSF Division of Environmental Biology (NSF DEB)	DEB-0343570
NSF Division of Environmental Biology (NSF DEB)	DEB-1350146
NSF Division of Ocean Sciences (NSF OCE)	OCE-1801335

[table of contents | back to top]