Summary sponge abundance on the coral reefs of St. John USVI from photoquadrats taken between 1992 and 2017

Website: https://www.bco-dmo.org/dataset/819397
Data Type: Other Field Results
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Project
» RUI-LTREB Renewal: Three decades of coral reef community dynamics in St. John, USVI: 2014-2019 (RUI-LTREB)
» Collaborative Research: Pattern and process in the abundance and recruitment of Caribbean octocorals (Octocoral Community Dynamics)

Contributors	Affiliation	Role
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Abstract
Sponge abundances on the shallow coral reefs of St. John, US Virgin Islands from 1992-2017. Data were extracted from legacy photoquadrats that are part of an ongoing time series, and sponge abundances were measured on two scales (1) number per quadrat (“Abundance”), and (2) estimated volume as cm3/0.25 cm2. Data are summed across taxa, and support Figure 3 in the paper published in Marine Biology (Edumunds et al., 2020).

Table of Contents

Coverage

Spatial Extent: **Lat**:18.315 **Lon**:-64.716
Temporal Extent: 1992 - 2017

Dataset Description

Sponge abundances on the shallow coral reefs of St. John, US Virgin Islands from 1992-2017. Data were extracted from legacy photoquadrats that are part of an ongoing time series, and sponge abundances were measured on two scales (1) number per quadrat (“Abundance”), and (2) estimated volume as cm3/0.25 cm2. Data are summed across taxa, and support Figure 3 in the paper published in Marine Biology (Edumunds et al., 2020).

Other datasets from Edmunds et al. (2020) are listed on the page https://www.bco-dmo.org/related-resource/819411.

Methods & Sampling

The following methodology was extracted from Edumunds et al. (2020), figure and table references below correspond to that publication. This methodology section applies to this dataset in addition to other datasets published in Edmunds et al. (2020).

Sponge abundance was determined using photoquadrats recorded annually since 1992, but here they were sub-sampled by years scattered uniformly across the 26 year study (described below). These photoquadrats are part of a time-series that was designed to quantify the coral community (Edmunds 2013, 2019). The project consists of six sites on hard substrata at 7–9-m depth that were randomly selected in 1992, permanently marked, and recorded using photoquadrats (0.5 × 0.5 m) positioned randomly along a single transect at each site. Photoquadrats were recorded in May 1992, June 1993, August 1994, May 1995-1997, and July or August thereafter. Prior to 2000, ~ 18 photoquadrats site-1 were recorded annually using 35-mm film (Kodachrome 64), but from 2000, ~ 40 photoquadrats site-1 have been recorded using digital cameras ranging in resolution from 3.3 MP to 36.3 MP. Cameras were fitted with two strobes (Nikonos, SB 105), and color slides were scanned (4000 dpi) for analysis.

Definitive identification of Caribbean sponges requires analysis of spicules and other skeletal characteristics (Rützler 1978). As this was impossible with photoquadrats, a consensus set of 23 sponges was identified using expert opinion. This set resolved 19 species, 3 sets of congeners that could not be distinguished to species, and an unknown category (Table S1). Most sponges were identified to species (66%, n = 9,608 pooled over the whole study), 4% were identified to genus, and 31% were assigned to the “unknown” category. Surveys on the adjacent island of St. Thomas suggested the total sponge diversity includes over 100 species (Gochfeld et al. 2020). Between 100 and 300 sponge species is typical for a localized area in which multiple sites are combined (Wulff 2016), with individual Caribbean sites being characterized by 51–67 species (Villamizar et al. 2013, Wulff 2006b, 2013).

To evaluate sponge density, photoquadrats were opened in Adobe Photoshop CS5.1 software, and the number of sponges counted. Individuals were defined by their contiguous areas of sponge biomass, which were separated from other sponges of the same taxon. This method potentially overestimates sponge density where algae, other taxa, or topographically complex surfaces obscured connections among pieces of a contiguous sponge. The limitations of planar photographs in quantifying benthic communities have been inherent in the method since it was first used in modern ecology (Loya 1972). These issues are unavoidable with planar images, but their magnitude depends on the quantity of macroalgae and the rugosity of the benthic surfaces. With regard to rugosity, the study sites were located on carbonate pavement (RS11, 5), or igneous substrata (RS15, 2), or a combination of the two (RS9, 6) (Fig. 1), which provided relatively smooth surfaces with limited ability to obscure sponges (Fig. 2). Analyses of rugosity at Europa Bay (RS11) and East Cabritte (~ 500 m from RS2) in 2014 revealed that the mean (± SE) topographic complexity at ~ 8-m depth was 1.16 ± 0.02 and 1.22 ± 0.02, respectively (Tsounis et al. 2018). The values for topographic complexity from St. John describe relatively flat communities (Fig. 2) that correspond to 40 year minimal values across the Caribbean, where rugosity declined from ~ 2.5 in 1969 to 1.2 in 2008 (over a depth range from the surface to > 20 m) (Alvarez-Filip et al. 2009).

Evaluating the ecological importance of sponge density (i.e., sponges per area) requires measurements of sponge biomass (Wulff 2001, 2016), which are unobtainable from planar photographs. However, sponge biomass can be estimated from sponge volume calculated from linear dimensions and the volumetric formulae of geometric shapes matching those of the sponges (after Wulff 2001). We sought approximations of sponge volumes using photoquadrats, assuming that the shape of each sponge could be inferred from a planar image and volumetrically approximated by geometric shapes (i.e., rods, disks, and spheres). The volumes of these shapes were estimated using linear dimensions obtained from the photographs using ImageJ software (Abramoff et al. 2004). In the few cases where sponges were conical (e.g., Ircinia campana), it was not possible to accurately estimate their volume and they were excluded from the analysis. As I. campana accounted for only 1% of all sponges, the bias attributed to this affect was trivial. The volume of encrusting sponges was estimated assuming they were disks 1.7-mm thick (based on mean thickness of 1.7 ± 0.2 mm (± SE, n = 23) of the encrusting sponges Chondrilla caribensis forma hermatypica, Spirastrella coccinea, S. hartmani, Clathria venosa, Placospongia cf. intermedia, Acarnus nicoleae, and Cliona caribbaea selected at random for measurement in shallow water on the reefs of Belize during May 2019). Sponge volumes were summed by genus within each quadrat to provide a single replicate measure.

To measure sponge density and volume in the ~ 5,000 photoquadrats from 1992 to 2017, the 26 year record was analyzed in 2–3 year intervals. All six sites were analyzed for sponge density, but three sites (White Point, Cabritte Horn, and Europa Bay) were selected to estimate sponge volume. The sites for volume estimates were selected to span the range of sponge abundances observed along this shore, and to provide a tractable task commensurate with the limited capacity to estimate organism volume from planar images.

Physical environmental conditions

As part of the ecological monitoring in this location (Edmunds 2013; Edmunds and Lasker 2016), seawater temperature and rainfall have been recorded since 1989. The records from 1990 to 2017 were used to explore their capacity to account for variation in multivariate sponge assemblage structure, as well as the multivariate community structure defined by sponges, scleractinians, octocorals, macroalgae, and CTB. Seawater temperature was recorded at ~ 9–14 m depth at Yawzi Point using Hobo loggers (± 0.2°C [U22-001, Onset Computer Co., MA]) that sampled every 10–15 minutes. Records were collapsed by day and used to calculate annual summaries of mean temperature, minimum temperature, maximum temperature, the number of hot days (i.e., > 29.3°C), and the number of cold days (i.e., ≤ 26.0°C). From 1992 to 2011, rainfall (cm y-1) was obtained from the Southeastern Regional Climate Center (http://www.sercc.com), which compiled data from a rain gauge in Cruz Bay (Station 671980). Where this record was incomplete, values were obtained from Catherinburg (Station 671348), East End (Station 672551), or a mean value for the missing months calculated from all other values for that same month (in Edmunds and Gray 2014). From 2012, rainfall was measured using a Standard Rain Gauge (NOAA, National Weather Service) deployed on the north shore of St. John (18° 21´ 20.95N, 64° 45´ 57.53W). Temporal variation in the regional-scale physical environment was evaluated through a de-trended index reflecting the effect of the Atlantic Multidecadal Oscillation (AMO) as reported in Kajtar et al. (2019) and provided courtesy of the first author. Hurricane effects were evaluated on a categorical scale assigning impact values to storms of 0 (no storm), 0.5 (minor impacts), and 1 (major impacts), and summing impacts within each year (after Gross and Edmunds 2015).

Blank values in this dataset indicate "not applicable."

Data Processing Description

Data analyzed with Systat 14 and PRIMER 6.

BCO-DMO Data Manager Processing notes:
* Data table extracted from Excel file "Data in Paper 23 July 2020 copy.xlsx" sheet "Figure 3" to csv.
* Various formatting in Year column changed to year in format yyyy.
* Column removed with heading "METADATA" which describes each of the pervious columns in the sheet. That information was added to the Parameters section of the metadata.
* added a conventional header with dataset name, PI name, version date
* blank values in this dataset are displayed as "nd" for "no data." nd is the default missing data identifier in the BCO-DMO system.
* modified parameter names to conform with BCO-DMO naming conventions (spaces, +, and - changed to underscores). Units in parentheses removed and added to Parameter Description metadata section.

[table of contents | back to top]

Data Files

File
edmunds2020_fig3.csv (Comma Separated Values (.csv), 3.74 KB) MD5:efe12b6ab219172fcad51f8935ddcb25 Primary data file for dataset ID 819397

[table of contents | back to top]

Related Publications

Abràmoff, M.D, Magalhães, P.J., Ram, S.J. 2004. Image processing with ImageJ. Biophotonics International 11(7): 36−42
Software

Alvarez-Filip L, Côté IM, Gill JA, Watkinson AR, Dulvy NK (2011) Region-wide temporal and spatial variation in Caribbean reef architecture: is coral cover the whole story? Glob Chang Biol 17:2470–2477. doi:10.1111/j.1365-2486.2010.02385.x
Methods

Edmunds, P. (2013). Decadal-scale changes in the community structure of coral reefs of St. John, US Virgin Islands. Marine Ecology Progress Series, 489, 107–123. doi:10.3354/meps10424
Methods

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
Methods

Edmunds, P. J., & Gray, S. C. (2014). The effects of storms, heavy rain, and sedimentation on the shallow coral reefs of St. John, US Virgin Islands. Hydrobiologia, 734(1), 143–158. doi:10.1007/s10750-014-1876-7
Methods

Edmunds, P., & Lasker, H. (2016). Cryptic regime shift in benthic community structure on shallow reefs in St. John, US Virgin Islands. Marine Ecology Progress Series, 559, 1–12. doi:10.3354/meps11900
Methods

Edmunds, P., Coblentz, M. & Wulff, J. (2020) A quarter-century of variation in sponge abundance and community structure on shallow reefs in St. John, US Virgin Islands. Marine Biology. accepted. doi: 10.1007/s00227-020-03740-8
Results

Gochfeld, D. J., Olson, J. B., Chaves-Fonnegra, A., Smith, T. B., Ennis, R. S., & Brandt, M. E. (2020). Impacts of Hurricanes Irma and Maria on Coral Reef Sponge Communities in St. Thomas, U.S. Virgin Islands. Estuaries and Coasts, 43(5), 1235–1247. doi:10.1007/s12237-020-00694-4
Methods

Gross, K., & Edmunds, P. J. (2015). Stability of Caribbean coral communities quantified by long-term monitoring and autoregression models. Ecology, 96(7), 1812–1822. doi:10.1890/14-0941.1
Methods

Kajtar, J. B., Collins, M., Frankcombe, L. M., England, M. H., Osborn, T. J., & Juniper, M. (2019). Global Mean Surface Temperature Response to Large-Scale Patterns of Variability in Observations and CMIP5. Geophysical Research Letters, 46(4), 2232–2241. doi:10.1029/2018gl081462 https://doi.org/10.1029/2018GL081462
Methods

Loya, Y. (1972). Community structure and species diversity of hermatypic corals at Eilat, Red Sea. Marine Biology, 13(2), 100–123. doi:10.1007/bf00366561 https://doi.org/10.1007/BF00366561
Methods

Rützler K (1978) Sponges in coral reefs. In: Stoddart DR, Johannes RE (ed) Coral reefs: research methods: monographs on oceanographic methodology 5. UNESCO, Paris, pp 299-313. https://hdl.handle.net/10088/7849
Methods

Villamizar, E., Díaz, M. C., Rützler, K., & De Nóbrega, R. (2013). Biodiversity, ecological structure, and change in the sponge community of different geomorphological zones of the barrier fore reef at Carrie Bow Cay, Belize. Marine Ecology, 35(4), 425–435. doi:10.1111/maec.12099
Methods

WULFF, J. L. (2006). Resistance vs recovery: morphological strategies of coral reef sponges. Functional Ecology, 20(4), 699–708. doi:10.1111/j.1365-2435.2006.01143.x
Methods

Wulff J (2016) Sponge contributions to the geology and biology of reefs: past, present, and future. In: Hubbard DK, Rogers CS, Lipps JH, Stanley GD Jr (ed) Coral reefs at the crossroads, 6th edn. Springer, Dordrecht, pp 103–126. doi:10.1007/978-94-017-7567-0_5
Methods

Wulff, J. (2001). Assessing and monitoring coral reef sponges: why and how?. Bulletin of Marine Science, 69(2), 831-846.
Methods

Wulff, J. (2013). Recovery of Sponges After Extreme Mortality Events: Morphological and Taxonomic Patterns in Regeneration Versus Recruitment. Integrative and Comparative Biology, 53(3), 512–523. doi:10.1093/icb/ict059
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
Months	Month in which raw data were collected (four letter month name or three letter abbreviation)	unitless
Months_2	Numerical month of survey (sequential number since start of survey)	unitless
Year	Year of sampling in format yyyy	unitless
Site	Site name	unitless
Abundance	Sponge abundance per 0.25m^ quadrat	sponges per 0.25 m^2 of reef
Volume	Volume of all sponges. This is volume of the sponges estimated from linear dimensions in the photograms and summed by quadrat. (sponge volume in cm3/ per 0.25 cm2 quadrat)	cm3

[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.

Collaborative Research: Pattern and process in the abundance and recruitment of Caribbean octocorals (Octocoral Community Dynamics)

Coverage: St. John, US Virgin Islands

NSF Award Abstract:
Coral reefs are exposed to a diversity of natural and anthropogenic disturbances, and the consequences for ecosystem degradation have been widely publicized. However, the reported changes have been biased towards fishes and stony corals, and for Caribbean reefs, the most notable example of this bias are octocorals ("soft corals"). Although they are abundant and dominate many Caribbean reefs, they are rarely included in studies due to the difficulty of both identifying them and in quantifying their abundances. In some places there is compelling evidence that soft corals have increased in abundance, even while stony corals have become less common. This suggests that soft corals are more resilient than stony corals to the wide diversity of disturbances that have been impacting coral corals. The best coral reefs on which to study these changes are those that have been studied for decades and can provide a decadal context to more recent events, and in this regard the reefs of St. John, US Virgin Islands are unique. Stony corals on the reefs have been studied since 1987, and the soft corals from 2014. This provides unrivalled platform to evaluate patterns of octocoral abundance and recruitment; identify the patterns of change that are occurring on these reefs, and identify the processes responsible for the resilience of octocoral populations. The project will extend soft coral monitoring from 4 years to 8 years, and within this framework will examine the roles of baby corals, and their response to seafloor roughness, seawater flow, and seaweed, in determining the success of soft corals. The work will also assess whether the destructive effects of Hurricanes Irma and Maria have modified the pattern of change. In concert with these efforts the project will be closely integrated with local high schools at which the investigators will host marine biology clubs and provide independent study opportunities for their students and teachers. Unique training opportunities will be provided to undergraduate and graduate students, as well as a postdoctoral researcher, all of whom will study and work in St. John, and the investigators will train coral reef researchers to identify the species of soft corals through a hands-on workshop to be conducted in the Florida Keys.

Understanding how changing environmental conditions will affect the community structure of major biomes is the ecological objective defining the 21st century. The holistic effects of these conditions on coral reefs will be studied on shallow reefs within the Virgin Islands National Park in St. John, US Virgin Islands, which is the site of one of the longest-running, long-term studies of coral reef community dynamics in the region. With NSF-LTREB support, the investigators have been studying long-term changes in stony coral communities in this location since 1987, and in 2014 NSF-OCE support was used to build an octocoral "overlay" to this decadal perspective. The present project extends from this unique history, which has been punctuated by the effects of Hurricanes Irma and Maria, to place octocoral synecology in a decadal context, and the investigators exploit a rich suite of legacy data to better understand the present and immediate future of Caribbean coral reefs. This four-year project will advance on two concurrent fronts: first, to extend time-series analyses of octocoral communities from four to eight years to characterize the pattern and pace of change in community structure, and second, to conduct a program of hypothesis-driven experiments focused on octocoral settlement that will uncover the mechanisms allowing octocorals to more effectively colonize substrata than scleractinian corals on present day reefs. Specifically, the investigators will conduct mensurative and manipulative experiments addressing four hypotheses focusing on the roles of: (1) habitat complexity in distinguishing between octocoral and scleractinian recruitment niches, (2) the recruitment niche in mediating post-settlement success, (3) competition in algal turf and macroalgae in determining the success of octocoral and scleractian recruits, and (4) role of octocoral canopies in modulating the flux of particles and larvae to the seafloor beneath. The results of this study will be integrated to evaluate the factors driving higher ecological resilience of octocorals versus scleractinians on present-day Caribbean reefs.

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 Environmental Biology (NSF DEB)	DEB-1350146
NSF Division of Ocean Sciences (NSF OCE)	OCE-1756678

[table of contents | back to top]