Morphology and features of Millepora colonies at Cabritte Horn (St.John, US Virgin Islands) from 1992-2021

Website: https://www.bco-dmo.org/dataset/875553
Data Type: Other Field Results
Version: 1
Version Date: 2022-06-13

Project
» RUI: Pattern and process in four decades of change on Caribbean reefs (St John Coral Reefs)

Contributors	Affiliation	Role
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Abstract
These data describe the results of surveys of coral reefs at 10 meters depth at Cabritte Horn to evaluate the abundance and features of the calcareous hydrozoan, Millepora. The data are used to explore how the sheet-tree morphology has changed over time in response to environmental conditions.

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Coverage

Spatial Extent: **Lat**:18.3075 **Lon**:-64.7219
Temporal Extent: 1992-05-30 - 2021-07-23

Dataset Description

Features of *Millepora* species are examined along with environmental parameters to determine what affects morphology.

Methods & Sampling

This study was undertaken at Cabritte Horn on the south shore of St. John, US Virgin Islands across three decades.

Photographic quadrat sampling
Photographic sampling of quadrats (0.5 meters x 0.5 meters) was performed annually from 1992 to 2021 using cameras mounted on a framer at a fixed height above the reef. Color slide film was used from 1992–2000 (and digitized at 4000 dpi), with digital photography implemented in 2001. Photoquadrats were recorded at random positions along the transect, which was 20 meters long from 1992–1999 and 40 meters

long from 2000 onward when the sample size was increased to ~40 photoquadrats per year.

The photoquadrats were used to quantify *Millepora* abundance using ImageJ software (Abràmoff et al., 2004), and taxa were resolved to the *M. alcicornis*/*M. complanata* complex (hereafter described as *M. alcicornis*). As 99.8% of colonies were *M. alcicornis*, all colonies were considered to be a single species and described as *Millepora* sp. Areas of encrusting *Millepora* sp. were located in each photoquadrat, and outlined and measured for area with all pieces of encrusting sheets quantified separately. Because *Millepora* species' sheet forms meander across the substratum and are prone to fission, it was not always clear where colonies began or ended within photoquadrats. Colonies therefore were defined as areas of autonomous tissue, so portions of colonies that were partially within the photoquadrats were scored as separate colonies (although such cases were relatively uncommon).

To access images, see Related Publications section below for Coral Image Downloads and Viewer link (Cabritte Horn images under "Random Sites")

Morphology

Branches on each sheet were quantified as the number of proximal "roots" where they attached to the encrusting sheet, and as the number of distal growing points on each root. Branch fragments lying on the benthos were not counted. The size of *Millepora* sp. colonies was determined from the mean planar area of autonomous portions of sheets (cm^2), and roots and growing points were normalized to the sheet (Roots 100 cm^2 and Growing Points 100 cm^2) and colony (Roots per colony and growing points per colony); growing points were also expressed per root (Growing Points per root). The area of sheets were summed by quadrat and used to calculate the percentage cover of *Millepora* sp. (%). Occasionally *Millepora* sp. was found encrusting octocoral colonies on which they appeared as long branches with miniscule sites of basal attachment; such colonies were excluded from analyses of roots and growing points.

The capacity of *Millepora* species to exploit a sheet-tree morphology was quantified through the quotient of roots and growing points to the area of the sheet (Roots 100 cm-2 and Growing Points 100 cm-2). Quotients quantified the exploitation of "trees" relative to "sheets", but they have the limitation of not being able to distinguish between effects caused by the growth of new roots or growing points versus changes in absolute area of the sheets. The relationships between these quotients and environmental conditions (rainfall, seawater temperature, hurricanes) were evaluated using generalized additive models (GAMs) that supported tests for complex non-linear relationships with multiple predictors. GAMs were prepared using the mgcv package (version 1.8-34) (Wood, 2011; Wood, 2017) in R (version 4.0.5), accessed through the XLSTAT (version 2021.2.1, Addinsoft, Paris) add-in to Excel16.54 (Microsoft). Models were run using Gaussian errors, cubic splines, and variance components estimated by REML. Restricted Maximum Likelihood Models were restricted to three quantitative effects to enhance interpretation (Fisher et al., 2018), and the best model was identified from the lowest corrected Akaike Information Criterion (AICc) (Burnham & Anderson, 2004). Summary of model selection using GAMs is detailed in Table S2 of Edmunds (2022).

Environmental parameters

Rainfall values from thirty years of monthly rainfall measurements (in centimeters) are presented in a supplemental document. From 1991 to 2011 rainfall values were obtained from the Southeastern Regional Climate Center (www.sercc.com), which compiled data from a rain gauge in Cruz Bay, St. John (Station 671980). Where this record was incomplete, values were obtained from Catherinburg (Station 671348), East End (Station 672551), or through interpolation. From 2012 onward, rainfall was measured using a Standard Rain Gauge (NOAA, National Weather Service) deployed on the north shore of St. John (18.3558°N, -64.7660° W) at Station VI-SJ-3 (https://wys.cocorahs.org).

Seawater temperature was measured with loggers (primarily Onset Computer Corp., Hobo U22-001, ± 0.2°C) sampling at 0.0011Hz and located ~ 900 m from Cabritte Horn at Yawzi Point (Edmunds & Gray, 2014). Temperature was averaged by day and month to characterize the mean of the hottest three months prior to each sampling ("Temperature1", August–October, mean ± SE, n = 3), and between 31 July and the previous 1 August by study year ("Temperature2", mean ± SE, n = 12 months). Mean seawater temperatures can be accessed here: https://www.bco-dmo.org/dataset/875694, and in the Related Datasets section.

Hurricanes and intensity were evaluated as a qualitative effect. Ranks were assigned based on hurricane tracks (https://www.nhc.noaa.gov) in conjunction with local knowledge of wind speeds and impact. Years of major hurricanes were assigned a rank of one (1), and all other years a rank of zero (0). Major storms affecting the St.John study area include Hurricanes Marilyn (1995), Georges (1998), Lenny (1999), Earl (2010), Irma (2017) and Maria (2017) which occurred in the Fall (Sep-Nov). Since ecological sampling was performed in July/August, the impact of these Fall storms was first recorded in the photoquadrat images taken 8-10 months later (in the following calendar year). For example, Hurricanes Irma and Maria occurred in September 2017, but

any effect on the *Millepora* at Cabritte Horn was not detected until sampling took place in Summer of the subsequent year. Please refer to the "Hurricane ranking" file in the Supplemental Files section for additional details.

Data Processing Description

Statistical analyses
The morphology of *Millepora sp*. (log transformed), macroalgal cover (arcsine transformed), and temperature were compared among years using one way ANOVAs with Bonferonni post hoc analyses to compare between years (using Systat 13 software).

BCO-DMO processing
- converted Date to YMD format
- added columns for latitude and longitude
- added columns for location and camera type
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions

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Data Files

File
millepora_features.csv (Comma Separated Values (.csv), 194.16 KB) MD5:3e417805b1eaf068f855f1a0c5a15ef7 Primary data file for dataset ID 875553

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Supplemental Files

File
Hurricane ranking for St.John USVI from 1991-2021 filename: Hurricane_ranking_StJohn_USVI_1991-2021.csv (Comma Separated Values (.csv), 530 bytes) MD5:7ea23fa015d67a02dc435fa9c7d142f8 These data record the intensity of hurricane activity by year from 1991-2021 to help examine environmental influences on Millepora growth and morphology.
Rainfall for St.John USVI from 1991-2021 filename: Rainfall_StJohn_USVI_1991-2021.csv (Comma Separated Values (.csv), 5.53 KB) MD5:104248a4ec80772ba4ac66e926204dd5 Thirty years of monthly rainfall values (in centimeters) are compiled in this document. Rainfall values from 1991 to 2011 were obtained from the Southeastern Regional Climate Center (www.sercc.com), which compiled data from a rain gauge in Cruz Bay, St. John (Station 671980). Where this record was incomplete, values were obtained from Catherinburg (Station 671348), East End (Station 672551), or through interpolation. From 2012, rainfall was measured using a Standard Rain Gauge (NOAA, National Weather Service) deployed on the north shore of St. John (18.3558°N, -64.7660° W) (station VI-SJ-3, https://wys.cocorahs.org). Rainfall was summarized by calendar year (cm y-1), and used in the present analyses summarized from 31 July to the previous 1 August by study year.

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Related Publications

Addinsoft (2021). XLSTAT statistical and data analysis solution. New York, NY/ Paris, France. https://www.xlstat.com
Software

Burnham, K. P., & Anderson, D. R. (2004). Multimodel Inference. Sociological Methods & Research, 33(2), 261–304. https://doi.org/10.1177/0049124104268644
Methods

Cifelli, R., Doesken, N., Kennedy, P., Carey, L. D., Rutledge, S. A., Gimmestad, C., & Depue, T. (2005). The Community Collaborative Rain, Hail, and Snow Network: Informal Education for Scientists and Citizens. Bulletin of the American Meteorological Society, 86(8), 1069–1078. https://doi.org/10.1175/bams-86-8-1069 https://doi.org/10.1175/BAMS-86-8-1069
Methods

Edmunds P. J. (2022). Persistence of a sessile benthic organism promoted by a morphological strategy combining sheets and trees. Proceedings. Biological sciences, 289(1978), 20220952. https://doi.org/10.1098/rspb.2022.0952
Results

Fisher, R., Wilson, S. K., Sin, T. M., Lee, A. C., & Langlois, T. J. (2018). A simple function for full-subsets multiple regression in ecology with R. Ecology and Evolution, 8(12), 6104–6113. Portico. https://doi.org/10.1002/ece3.4134
Methods

National Hurricane Center. NOAA and NWS (National Oceanic and Atmospheric Administration and the National Weather Service) National Hurricane Center and Central Pacific Hurricane Center at https://www.nhc.noaa.gov/.
Methods

R Core Team (2021). R: A language and environment for statistical computing. R v4.0.5. (March 2021) R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/
Software

SERCC Precipitation Summaries at https://sercc.com/. Southeast Regional Climate Center, University of North Carolina at Chapel Hill, Department of Geography
Methods

Systat Software, Inc. (n.d.). SYSTAT - Powerful Statistical Analysis and Graphics Software Available from https://systatsoftware.com/products/systat/.
Software

Wood, S. N. (2010). Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. Journal of the Royal Statistical Society: Series B (Statistical Methodology), 73(1), 3–36. https://doi.org/10.1111/j.1467-9868.2010.00749.x
Methods

Wood, S. N. (2017). Generalized Additive Models. https://doi.org/10.1201/9781315370279
Methods

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Related Datasets

IsRelatedTo

Edmunds, P. J. (2022) **Abundance and percent cover of Millepora species at Cabritte Horn (St.John, US Virgin Islands) from 1992-2021.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-06-09 doi:10.26008/1912/bco-dmo.875524.1 [view at BCO-DMO]

Edmunds, P. J. (2022) **Abundance and percent cover of macroalgae at Cabritte Horn (St.John, US Virgin Islands) from 1992-2020.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-06-10 doi:10.26008/1912/bco-dmo.875543.1 [view at BCO-DMO]
Relationship Description: Data on percent cover of macroalgae was used in GAMs to determine effects on Millepora morphology

IsSupplementedBy

Edmunds, P. J. (2022) **Daily seawater temperature at Yawzi Point (St.John USVI) from 1991-2021.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-06-15 doi:10.26008/1912/bco-dmo.875694.1 [view at BCO-DMO]
Relationship Description: Seawater temperatures from USVI were used to evaluate environmental effects on

Millepora morphology

NSF Coral Reef Time Series, Virgin Islands. (2022). Raw Coral Image Downloads and Viewer. Retrieved March 25, 2022, from https://coralreefs.csun.edu/data/coral-image-viewer/

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Parameters

Parameter	Description	Units
Latitude	Latitude	decimal degrees
Longitude	Longitude	decimal degrees
Sampling_Date	Date of photographic quadrat sampling	unitless
Quadrat_number	Quadrat number	unitless
Area_Millepora	Area of Millepora in each image	square centimeters (cm^2)
Number_Roots	Number of Millepora roots in each image	number
Number_Growing_Points	Number of growing points of Millepora in each image	number
Roots_per_area	Number of roots per 100 square centimeters of encrusting Millepora base	number per area (number/100cm^2)
GP_per_area	Number of growing points per 100 square centimeters of encrusting Millepora base	number per area (number/100cm^2)
GP_per_Root	Number of growing points per root of Millepora	number
Location	Geographical location	unitless
Camera	Type of camera and lens used for photographic quadrat sampling	unitless

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Instruments

Dataset-specific Instrument Name	Nikonos V film camera
Generic Instrument Name	Camera
Dataset-specific Description	A Nikonos V film camera with 28 mm lens was used in the years 1992-2000
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	Nikon Coolpix 990
Generic Instrument Name	Camera
Dataset-specific Description	A Nikon Coolpix 990 digital camera with 8-24 mm lens was used in the years 2001-2005
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	Nikon DSLR digital camera
Generic Instrument Name	Camera
Dataset-specific Description	A Nikon DSLR D70/DX digital camera with 18-70 mm lens was used in the years 2006-2010 A Nikon DSLR D90/DX digital camera with 18-70 mm lens was used in the year 2011 A Nikon DSLR D7000/DX digital camera with 18-70 mm lens was used in the years 2012-2015 A Nikon DSLR D810/FX digital camera with 18-35 mm lens was used in the years 2016-2021
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

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Project Information

RUI: Pattern and process in four decades of change on Caribbean reefs (St John Coral Reefs)

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

Coverage: United States Virgin Islands, St. John: 18.318, -64.7253

NSF Award Abstract:
The coral reef crisis refers to the high rates of death affecting tropical reef-building corals throughout the world, and the strong likelihood that coral reefs will become functionally extinct within the current century. Knowledge of these trends comes from the monitoring of coral reefs to evaluate their health over time, with the most informative projects providing high-resolution information extending over decades. Such projects describe both how reefs are changing, and answer questions addressing the causes of the changes and the form in which reefs will persist in the future. This project focuses on coral reefs in United States waters, specifically around St. John in the US Virgin Islands. These reefs are protected within the Virgin Islands National Park, and have been studied more consistently and in greater detail than most reefs anywhere in the world. Building from 33 years of research, this project extends monitoring of these habitats by another five years, and uses the emerging base of knowledge, and the biological laboratory created by the reefs of St. John, to address the causes and consequences of the bottleneck preventing baby corals from repopulating the reefs. The work is accomplished with annual expeditions, staffed by faculty, graduate students, undergraduates, and

teachers, coupled with analyses of samples at California State University, Northridge, and Florida State University, Tallahassee. The students and teachers assist with the research goals at the center of this project, but also engage in independent study and integrate with the rich and diverse societal context and natural history of the Caribbean. The scope of the science agenda extends to schools in California, where students are introduced to the roles played by marine animals in ecosystem health, concepts of long-term change in the biological world, and the role of science engagement in promoting positive environmental outcomes. In addition to generating a wide spectrum of project deliverables focusing on scientific discovery, the project promotes STEM careers and train globally aware scientists and educators capable of supporting the science agenda of the United States in the 21st Century.

This project leverages one of the longest time-series analyses of Caribbean coral reefs to extend the time-series from 33 to 38 years, and it tests hypotheses addressing the causes and consequences of changing coral reef community structure. The project focuses on reefs within the Virgin Islands National Park (VINP) and along the shore of St. John, US Virgin Islands, and is integrated with stakeholders working in conservation (VINP) and local academia (University of the Virgin Islands). Beginning in 1987, the project has addressed detail-oriented analyses within a small spatial area that complements the large-scale analyses conducted by the VINP. The results of these efforts create an unrivaled context within which ecologically relevant hypotheses can be tested to elucidate mechanisms driving ecological change. Building from image- and survey- based analyses, 33 years of data reveal the extent to which these reefs have transitioned to a low-abundance coral state, and the importance of the bottleneck preventing coral recruits from contributing to adult size classes. The intellectual merits of this project leverage these discoveries to address eight hypotheses: (H1) long-term changes are defining a cryptic regime change, with the low coral abundance reinforced by, (H2) enhanced community resilience, (H3) low post-settlement success, (H4) negative effects of peyssonnelid algal crusts (PAC) on juvenile corals, (H5) inability of juvenile corals to match their phenotypes to future conditions, (H6) impaired population growth caused by reduced genetic diversity, (H7) the premium placed on PAC-free halos around Diadema sea urchins for coral recruitment, and (H8) biotic homogenization occurring on a landscape-scale.

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.

Related Projects:

- Affiliated with MCR-LTER - https://www.bco-dmo.org/project/2222
- Serves as a new project that builds on NSF DEB-1350146 - RUI-LTREB Renewal: Three decades of coral reef community dynamics in St. John, USVI: 2014-2019 - https://www.bco-dmo.org/project/734983
- Overlaps with OCE 17-56678 (which focuses on soft corals with H. Lasker) - Collaborative Research: Pattern and process in the abundance and recruitment of Caribbean octocorals - https://www.bco-dmo.org/project/752508
- LTREB Long-term coral reef community dynamics in St. John, USVI: 1987-2019 - https://www.bco-dmo.org/project/2272
- RUI: Pattern and process in four decades of change on Caribbean reefs - https://www.bco-dmo.org/project/835192
- RAPID: Hurricane Irma: Effects of repeated severe storms on shallow Caribbean reefs and their changing ecological resilience - https://www.bco-dmo.org/project/722163

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2019992

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