Coral calcification (G) from six sites on the south coast of St. John, USVI from 1992 to 2019

Website: https://www.bco-dmo.org/dataset/897564
Data Type: Other Field Results
Version: 1
Version Date: 2023-06-14

Project
» LTREB Long-term coral reef community dynamics in St. John, USVI: 1987-2019 (St. John LTREB)
» RAPID: Hurricane Irma: Effects of repeated severe storms on shallow Caribbean reefs and their changing ecological resilience (Hurricane Irma and St. John Reefs)
» RUI-LTREB Renewal: Three decades of coral reef community dynamics in St. John, USVI: 2014-2019 (RUI-LTREB)
» RUI: Pattern and process in four decades of change on Caribbean reefs (St John Coral Reefs)

Contributors	Affiliation	Role
Edmunds, Peter J.	California State University Northridge (CSUN)	Principal Investigator
Perry, Chris T.	University of Exeter	Scientist
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Abstract
These data describe coral calcification (G) from 1992-2019 at six sites on the south coast of St. John. G was calculated from ReefBudget using coral density and size by taxon and quadrat. These data were published in Edmunds and Perry (2023).

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Coverage

Spatial Extent: **N**:18.3171 **E**:-64.7218 **S**:18.3067 **W**:-64.7328
Temporal Extent: 1992-01-01 - 2019-01-01

Methods & Sampling

Coral community calcification (G, kg $CaCO_3$ m^{-2} yr^{-1}) by site and year was calculated based on colony sizes that were measured as described above and used to calculate G summed by photoquadrat (i.e., photoquadrats were treated as statistical replicates). In the formulation applied herein, G provides an estimate of gross coral calcification, as we do not consider any source of dissolution and bioerosion. G is not equivalent to NCC because dissolution/bioerosion is not considered, and we do not evaluate calcification by taxa other than corals. First, the mean diameters of each coral colony in each quadrat (i.e., the mean colony diameter in planar view), were used to estimate the 3-dimensional colony size (i.e., the actual size of living tissue) based on taxon-specific rugosity for Caribbean corals (Equation 1, see supplemental file "Coral Calcification Equations"). Actual

tissue cover was required to accurately estimate colony-level calcification, because coral species differ in their 3-D shapes, which affects G depending on colony morphology.

See Equations in supplemental pdf file "Coral Calcification Equations".

The annual calcification (kg colony-1 yr-1) of corals in each photoquadrat was calculated by summing the CPi values by taxon. Values were standardized to a square meter to be consistent with a commonly used unit of G, kg CaCO3 m-2 yr-1, which can be converted to other units through stoichiometry (e.g., 1 kg CaCO3 m-2 yr-1 = 27.4 mmol CaCO3 m-2 d-1). In our calculations we assume that coral calcification rates are uniform with colony size (i.e., isometric). Work in Moorea has shown that some colony calcification rates increase rapidly up until colonies are ~10–15 cm diameter, but our assumption of isometry is currently necessary for Caribbean corals as the data necessary to parameterize the relationship between colony size and coral calcification currently is lacking for the corals in this region. However, given that nearly all colonies in our study are small (averaging < 6 cm) and remain small due to high demographic turnover, the use of taxon-specific calcification (i.e., independent of colony size) rate is less problematic than would be the case in Moorea. Our assumption of isometric coral calcification may render a conservative bias in our calculations of coral G. Using photoquadrats as statistical replicates, coral G (pooled among taxa) was compared among sites and years (Hypothesis 2) using a mixed effects, two way ANOVA in which site was a random effect, year was a fixed effect, and G was log(x +1) transformed to meet the assumptions of the statistical test. G was also averaged by site and year using values pooled among taxa and also by taxon, and the values were qualitatively compared over time for each site. They were also used to assess whether the taxa contributing to coral G varied within- or among- sites as a function of coral community composition and colony size.

Location: South coast of St. John, US Virgin Islands. 18.31644, -64.724528. Research conducted during annual field expeditions to research lab: The Virgin Islands Ecological Research Station.

Data come from six sites (Cabritte Horn, East Tektite, Neptune's Table, West Little Lameshur Bay, Europa Bay, White Point.) between White Point and Cabritte Horn. See supplemental file "Site List" for site names and locations as well as the site map (Fig. 1 of Edmunds, 2013).

Problems/Issues: Some irregular number of quadrats were samples at some sites in some years.

Funding note: The most recent funding for this time series was provided by NSF award OCE-2019992 for project "RUI: Pattern and process in four decades of change on Caribbean reefs." The "Project" and "Funding Sources" sections of this page list also include past awards that directly funded this dataset.

Data Processing Description

ReefBudget software to calculate G (Perry and Lange, 2019).

BCO-DMO Data Manager Processing notes:
* Sheet 1 from "Coral_G_1992_2019.xlsx" excel file imported into the BCO-DMO data system.
* Column names changed to conform with BCO-DMO naming conventions (only A-Za-z0-9 and underscores used).
* Supplemental site list imported and lat lon converted from degrees decimal minutes to decimal degrees and rounded to 5 decimal places.
* lat and lon columns added by using the site name as a key to join to the site list.
* Taxonomic names matched using the World Register of Marine Species Taxa match tool on 2023-06-30. Added supplemental file with associated LSIDs (see "Taxonomic Identifiers).

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Data Files

File
Coral Calcification (G) filename: 897564_v1_coral-calcification.csv (Octet Stream, 486.16 KB) MD5:15b1d65e5447be0b22ea556f6e88b957 Primary data table for dataset 897564 version 1.

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Supplemental Files

File
Coral Calcification Equations filename: Coral_calcification_equations.pdf (Octet Stream, 163.31 KB) MD5:9943346015e8be2affd26de56d58940b Equations section extracted from methods text.
Site List filename: site_list.csv (Octet Stream, 214 bytes) MD5:d3a0db43d29c24865f8cf9f6689f40f6 Site list for coral quadrat locations from 1992 to 2019. Parameter (Column name, description, units): Site name, Site name, unitless lat, Latitude, decimal degrees lon, Longitude, decimal degrees A map of these locations is available in Edmunds (2013, doi:10.3354/meps10424) as Figure 1 along with coordiates in degrees decimal minutes in the figure caption.
Taxonomic Identifiers filename: taxon_identifiers.csv (Octet Stream, 543 bytes) MD5:81cb86e52a56f2f9a6e858d14cb2b07d Table with the column name in the dataset, the taxon for that column, and the Life Science Identifiers (LSIDs).

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Related Publications

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., & Perry, C. (2023). Decadal-scale variation in coral calcification on coral-depleted Caribbean reefs. Marine Ecology Progress Series. https://doi.org/10.3354/meps14345
Results

Perry CT, Lange ID (2019) ReefBudget Caribbean v2: online resource and methodology. Retrieved from http://geography.exeter.ac.uk/reefbudget/
Software

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Related Datasets

IsRelatedTo

Edmunds, P. J., Perry, C. T. (2023) **Coral cover at six sites on the south coast of St. John, USVI from 1992 to 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-06-14 doi:10.26008/1912/bco-dmo.897544.1 [view at BCO-DMO]
Relationship Description: Datasets collected as part of the same study and support Edmunds and Perry (2023, doi: 10.3354/meps14345).

Edmunds, P. J., Perry, C. T. (2023) **Coral density from six sites on the south coast of St. John, USVI from 1992 to 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-06-14 doi:10.26008/1912/bco-dmo.897577.1 [view at BCO-DMO]
Relationship Description: Datasets collected as part of the same study and support Edmunds and Perry (2023, doi: 10.3354/meps14345).

Edmunds, P. J., Perry, C. T. (2023) **Coral sizes from six sites on the south coast of St. John, USVI**

from 1992 to 2019. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-06-14 doi:10.26008/1912/bco-dmo.897571.1 [view at BCO-DMO]
Relationship Description: Datasets collected as part of the same study and support Edmunds and Perry (2023, doi: 10.3354/meps14345).

IsSupplementedBy

Edmunds, P. J. (2023) **Coral photransect and settlement tile images from St. John, USVI 1987-2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-06-30 http://lod.bco-dmo.org/id/dataset/897659 [view at BCO-DMO]
Relationship Description: Supporting images for this dataset.

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Parameters

Parameter	Description	Units
Site	Site name (Cabritte Horn, East Tektite, Neptune's Table, West Little Lameshur Bay, Europa Bay, White Point)	unitless
lat	Site latitude	decimal degrees
lon	Site longitude	decimal degrees
Year	Year (1992-2019)	unitless
Image	alpha numeric identify for the photoqudrat from which the colony size and density data came that were used to calculate G	unitless
Orbicella_spp	Coral calcification (G) for coral taxon (Orbicella spp., LSID = urn:lsid:marinespecies.org:taxname:758259)	kilograms of calcium carbonate per meter squared per year (kg CaCO3 m-2 yr-1)
P_astreoides	Coral calcification (G) for coral taxon (Porites astreoides, LSID = urn:lsid:marinespecies.org:taxname:288889)	kilograms of calcium carbonate per meter squared per year (kg CaCO3 m-2 yr-1)
S_siderea	Coral calcification (G) for coral taxon (Siderastrea siderea, LSID = urn:lsid:marinespecies.org:taxname:207516)	kilograms of calcium carbonate per meter squared per year (kg CaCO3 m-2 yr-1)
A_agaricites	Coral calcification (G) for coral taxon (Agaricia agaricites, LSID = urn:lsid:marinespecies.org:taxname:287911)	kilograms of calcium carbonate per meter squared per year (kg CaCO3 m-2 yr-1)
Millepora_spp	Coral calcification (G) for coral taxon (Millepora spp., LSID = urn:lsid:marinespecies.org:taxname:205902)	kilograms of calcium carbonate per meter squared per year (kg CaCO3 m-2 yr-1)
M_cavernosa	Coral calcification (G) for coral taxon (Montastrea cavernosa, LSID = urn:lsid:marinespecies.org:taxname:764066)	kilograms of calcium carbonate per meter squared per year (kg CaCO3 m-2 yr-1)
P_porites	Coral calcification (G) for coral taxon (Porites porites, LSID = urn:lsid:marinespecies.org:taxname:207238)	kilograms of calcium carbonate per meter squared per year (kg CaCO3 m-2 yr-1)
Other	Coral calcification (G) for pooled taxa (all except the seven most common coral taxa: Orbicella spp., Porites astreoides, Siderastrea siderea, Agaricia agaricites, Millepora spp., Porites porites)	kilograms of calcium carbonate per meter squared per year (kg CaCO3 m-2 yr-1)

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Underwater Camera
Dataset-specific Description	Raw photographic data that generated colony size and density were generated by a variety of film and digital cameras from 1992-2019.
Generic Instrument Description	All types of photographic equipment that may be deployed underwater including stills, video, film and digital systems.

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Project Information

LTREB Long-term coral reef community dynamics in St. John, USVI: 1987-2019 (St. John LTREB)

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

Coverage: St. John, U.S. Virgin Islands; California State University Northridge

Long Term Research in Environmental Biology (LTREB) in US Virgin Islands:

From the NSF award abstract:
In an era of growing human pressures on natural resources, there is a critical need to understand how major ecosystems will respond, the extent to which resource management can lessen the implications of these responses, and the likely state of these ecosystems in the future. Time-series analyses of community structure provide a vital tool in meeting these needs and promise a profound understanding of community change. This study focuses on coral reef ecosystems; an existing time-series analysis of the coral community structure on the reefs of St. John, US Virgin Islands, will be expanded to 27 years of continuous data in annual increments. Expansion of the core time-series data will be used to address five questions: (1) To what extent is the ecology at a small spatial scale (1-2 km) representative of regional scale events (10's of km)? (2) What are the effects of declining coral cover in modifying the genetic population structure of the coral host and its algal symbionts? (3) What are the roles of pre- versus post-settlement events in determining the population dynamics of small corals? (4) What role do physical forcing agents (other than temperature) play in driving the population dynamics of juvenile corals? and (5) How are populations of other, non-coral invertebrates responding to decadal-scale declines in coral cover? Ecological methods identical to those used over the last two decades will be supplemented by molecular genetic tools to understand the extent to which declining coral cover is affecting the genetic diversity of the corals remaining. An information management program will be implemented to create broad access by the scientific community to the entire data set.

The importance of this study lies in the extreme longevity of the data describing coral reefs in a unique ecological context, and the immense potential that these data possess for understanding both the patterns of comprehensive community change (i.e., involving corals, other invertebrates, and genetic diversity), and the processes driving them. Importantly, as this project is closely integrated with resource management within the VI National Park, as well as larger efforts to study coral reefs in the US through the NSF Moorea Coral Reef LTER, it has a strong potential to have scientific and management implications that extend further than the location of the study.

RAPID: Hurricane Irma: Effects of repeated severe storms on shallow Caribbean reefs and their changing ecological resilience (Hurricane Irma and St. John Reefs)

Website: http://coralreefs.csun.edu

Coverage: St. John, US Virgin Islands

Coral reefs have long been recognized for their diversity, and unique functional roles, but these features have been undermined by decades of disturbances that cast doubt on their ability to survive. Against this backdrop, 2017 brought two hurricanes of unprecedented magnitude to the Caribbean, both of which damaged coral reefs that already were degraded compared to those of a few decades ago. While the impacts of these storms on some of the few coral reefs protected within the US National Park and National Monument systems is particularly unfortunate, it also creates unique opportunities to understand the impacts on coral reefs that have been studied in detail for decades. This project builds on these opportunities by leveraging 31 years of coral reef monitoring research, much of which has been supported by NSF, to describe the impacts of Hurricanes Irma and Maria on coral reefs in St. John, US Virgin Islands. That the analyses will reveal severe destruction is a forgone conclusion, but what remains unknown is how present-day reefs will respond to severe versions of a well-known disturbance (hurricanes), and how these effects will impact their long-term survival. Post-storm surveys and new analyses will be used to determine whether ongoing declines in coral abundance have influenced the way coral reefs respond to storms, notably to enhance post-storm mortality, and reduce the capacity to recover from such event. To achieve these outcomes, a team of researchers from California State University, Northridge, will use a cruise on the R/V Walton Smith to survey the reefs of St. John using photography and in-water counts to generate data that will be analyzed throughout 2018. The benefits of this research will extend beyond scientific discoveries to include leveraged support for other scientists participating in the cruise, evaluation of the status of natural resources in the VI National Park, the delivery of relief supplies from Miami to St. John, and the creation of unique research and training opportunities for graduate students who will participate in all phases of the project.

Coral reefs have undergone dramatic changes in community structure since they were first described in the 1950's, and the current onslaught of threats from rising temperature, declining seawater pH, storms, and numerous other events has cast doubt on their persistence in the Athropocene. With such profound changes underway, time-series analyses of community structure are on the cutting edge of contemporary studies of coral reefs. In the Caribbean, the impact of two category 5 hurricanes underscores why time-series are important, as they are the only means to describe the impact of such events, and critically, create the context for testing hypotheses regarding impacts and consequences of disturbances. This project addresses the impacts of Hurricanes Irma and Maria on the coral reefs of St. John, US Virgin Islands, which have been studied since the 1950's, and for the last 31 years largely with NSF LTREB support. This support provides descriptions of the population dynamics of the important coral, Orbicella annularis, and the coral community dynamics in adjacent habitats. Any study of the effects of these storms will demonstrate that large waves kill corals, but here intellectual merit is acquired through testing of general hypotheses: (1) storm impacts on O. annularis will be colony-density dependent, (2) delayed coral mortality will be accentuated compared to previous storms, (3) the resilience of coral communities to physical disturbances has declined since 1989, and (4) evolutionary rescue will mediate reef recovery for select corals through large initial population sizes, density-dependent population growth, and recruitment. These hypotheses will be tested using a 14 day cruise on the R/V Walton Smith to collect critical time-sensitive data, followed by a year of analysis of new and legacy photographic data.

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.

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 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
NSF Division of Ocean Sciences (NSF OCE)	OCE-2019992

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