Light data (transmission) from surveys conducted in St. John, US Virgin Islands in 2017

Website: https://www.bco-dmo.org/dataset/793561
Data Type: Other Field Results
Version: 1
Version Date: 2020-02-17

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

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Abstract

Light data (transmission) from surveys conducted in Great Lameshur Bay, St. John, US Virgin Islands in 2017. These data were used in Edmunds et al. (2019) in Figure 2.

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Coverage

Spatial Extent: **Lat**:18.310289 **Lon**:-64.723103
Temporal Extent: 2017-08-17 - 2017-11-30

Dataset Description

Light data (transmission) from surveys conducted in Great Lameshur Bay, St. John, US Virgin Islands in 2017. These data were used in Edmunds et al. (2019) in Figure 2. Related Datasets: All were used in Edmunds et al. (2019) Edmunds et al. MarBio 2019a: Light and rainfall data https://www.bco-dmo.org/dataset/793461 Edmunds et al. MarBio 2019a: Kd data https://www.bco-dmo.org/dataset/793571 Edmunds et al. MarBio 2019a: Data in support of energy budget calculations https://www.bco-dmo.org/dataset/793581

Methods & Sampling

The following methodology applies to this dataset in addition to other datasets published in Edmunds et al.

(2019).

Methodology:
This study was completed on the coral reefs of St. John, which have been the subjects of time-series analyses for 32 years. The measurements described herein originated from a schedule of instrument deployments initiated in 2014 to quantify variation in underwater physical environmental conditions, and ultimately, to facilitate testing for their role in driving changes in benthic community structure. As part of this schedule, rainfall was recorded throughout the year, and a light meter was placed in Great Lameshur Bay in August 2017, with the objective of leaving it immersed for 6–12 months. Three weeks later, the first of two Category 5 hurricanes impacted the island, with the second arriving 14 days later. The discovery in July 2018 that this meter had survived the storms, and had remained upright and functional, created the opportunity to describe underwater light during, and immediately after, two major storms.

Rainfall was recorded on the north shore of St. John at Windswept Beach (18° 21´ 20.95N, 64° 45´ 57.53W), where a 20.3 cm, Standard Rain Gauge (NOAA, National Weather Service) was mounted on a roof, 1.5 m above the ground. This rain gauge was ~ 6.7 km from the underwater light sensor, and was emptied and read on a daily basis.

Underwater light was recorded with a light meter (Compact LW, JFE Advantech Co., Ltd, Japan) fitted with a cosine-corrected sensor recording photosynthetically active radiation (PAR, 400-700 nm wavelength) as photosynthetic photon flux density (PPFD). The meter was equipped with a mechanical wiper that cleaned the sensor before every measurement, and it was mounted with the sensor at 19.1-m depth on the eastern side of Great Lameshur Bay (18° 18´ 37.04N, 64° 43´ 23.17W. The instrument was operated in burst mode during which 10 measurements were recorded every 180 minutes, with 30 seconds separating measurements within a burst. This sampling regime ensured that the battery would support a deployment of one year. The Compact LW meter is designed for oceanographic applications to 200-m depth, is fitted with a photodiode sensor, and has an accuracy of ± 4% (over 0–2,000 µmol photons m-2 s-1) and resolution of 0.1 µmol photons m-2 s-1. The sensors are calibrated by the manufacturer, with the calibration stable for at least 1 year. When the meter was deployed in August 2017, it had been used underwater for ~ 16 mo in previous deployments, and initial records of PPFD were similar to those previously recorded at the same depth and time of year in St. John, which suggested that the calibration had not appreciably drifted.

PPFD also was measured on the surface, using two cosine-corrected sensors (S-LIA-M003, Onset Computer Corporation) mounted ~ 4 m above sea level on the roof of the lab, ~ 0.875 km from the underwater sensor. The surface sensors were attached to weather stations (Micro Station Data Logger H21-002, Onset Computer Corporation) that recorded light every 5 minutes. The two sensors were calibrated by the manufacturers, and were operated in a paired mode to detect spurious records and sensor drift, and to guard against equipment malfunction.

Data Processing Description

Data were truncated to extend from 17 August to 30 November, which covered the impact of the two storms and represented the greatest period over which the in situ records of light were unaffected by fouling of the sensor. To provide context to the results from 2017, and evaluate the relative impact of the storms on underwater PPFD, comparisons were made to light recorded in 2016 over the same period of the year. Records of surface PPFD were integrated over each 5 minute measurement interval, and summed by day to calculate daily integrated PPFD (mol photons m-2 d-1). Underwater PPFD was averaged by burst, which occurred every 3 hours, and the values at ~13:00 hrs provided the maximum daily irradiance on most days. Average burst values of PPFD were integrated over each 180 minute burst interval within each day to estimate daily in situ, integrated PPFD (mol photons m-2 d-1). To compare these values with records obtained in 2016 at the same location, but at a higher frequency (with burst sampling every 60 minutes, the earlier records were sub-sampled to create a burst interval of 180 minutes, and thereafter, were processed the same way as the results from 2017. Daily underwater integrated PPFD values in 2017 were cumulatively summed by day after Hurricane Irma (6 September), and expressed as a percentage of PPFD recorded over the same periods in 2016 to calculate the cumulative depression of in situ light in 2017.

Estimates of the transmission of surface PAR to 19.1-m depth were constrained to measurements around noon, when the high angle of the sun ensured that most of the surface light passed through the air-water interface. When sun altitudes are > 46°, and wind speeds are < 5 m s-1, virtually all (~ 96%) surface light is transmitted across the air-water interface. The transmission of surface light to 19.1-m depth was calculated by day using the mean transmission recorded at 10:00 hrs and 13:00 hrs. PPFD measured at 19.1-m depth and on the surface at 13:00 hrs were also used to calculate the diffuse attenuation coefficient for PAR (Kd-PAR) using the equation representing the Beer-Lambert Law:

E_d (Z)= E_d (O^-) e^(-K_d × Z)

where Ed(Z) is the downwelling PPFD at Z m depth, Ed(O-) is downwelling PPFD just below the surface of the seawater, and Kd is the diffuse attenuation coefficient for downwelling irradiance; Ed(O-) was approximated from concurrent records of surface PPFD without correction for transmission across the air-water interface. This method of calculating Kd is prone to greater variance than the regression approach using downwelling PPFD quickly measured at multiple depths, but it allows a time-series of Kd to be obtained using a single instrument.

BCO-DMO Data Manager Processing Notes:
* Original data submitted as the first of two data tables in Excel sheet "Fig. 2" extracted to csv. See Data Files for the originally submitted Excel file.
* added a conventional header with dataset name, PI name, version date
* 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.
* Date format changed to ISO 8601 format YYYY-mm-dd.
* For interoperability, ISO_DateTime_UTC added to dataset in addition to timestamps in local time.

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Data Files

File
Data published in Edmunds et al. (2019) Excel File filename: Edmunds_MarBio_2019a_Data.xlsx (Microsoft Excel, 562.11 KB) MD5:a754a31fe776190529bcab10e79ad46b Excel file containing data published as figures in Edmunds et al. 2019 (doi: 10.1007/s00227-018-3459-z) FIG. 1 A = Date in 2016 and 2017 B = Daily rainfall (cm) recorded in each year' ND = no data - displayed in Panel A C = surface PA integrated over each day as mol quanta/m2/d - displayed in Panel B D = underwater maximum PAR recorded on each day at 19. 1 m depth as mmol quanta/m2/s - displayed in Panel C E = daily PAR integrated at depth mol quanta/m2/d FIG 2 A = Date B = time underwater h:m:s C = underwater light as µmol quanta/m2/s D = time on surface month/day/year h:m E = surface light as µmol quanta/m2/s F = % transmission of light to depth **note two values per day** H = time month/day/year h:m I = surface PAR as µmol quanta/m2/s J = underwater PAR as µmol quanta/m2/s K = Kd calculated from I and J as per text L = mean transmission to depth Energy Budget Energy budget calculated as per text requires estimate of mas light at 10 m depth as described in text A = day B = surface light µmol quanta/m2/s C = kd D = underwater light as µmol quanta/m2/s at 19.1 m E = underwater light as µmol quanta/m2/s at 10 m
marbio_2019a_fig2a.csv (Comma Separated Values (.csv), 14.21 KB) MD5:5cd13b6ed0f3c3940c5754e221c50119 Primary data file for dataset ID 793561
WHOAS: Edmunds_MarBio_2019a_Data.xlsx filename: Edmunds_MarBio_2019a_Data.xlsx (Microsoft Excel, 596.65 KB) MD5:8f209fc8205454e41d9bd635603a26af

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Related Publications

Edmunds, P. J., Tsounis, G., Boulon, R., & Bramanti, L. (2019). Acute effects of back-to-back hurricanes on the underwater light regime of a coral reef. Marine Biology, 166(2). doi:10.1007/s00227-018-3459-z
Results

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Parameters

Parameter	Description	Units
Underwater_Date_Local	Local date (AST,UTC-4) in ISO format yyyy-mm-dd	unitless
Underwater_Time_Local	Local time (AST,UTC-4) in ISO format HH:MM	unitless
Underwater_Light	Underwater PAR	micromoles per square meter per second (µmol quanta/m2/s)
Surface_DateTime_Local	Local date and time (AST,UTC-4) at the surface in ISO format yyyy-mm-dd HH:MM	unitless
Surface_Light	Surface PAR	micromoles per square meter per second (µmol quanta/m2/s)
Transmition_Percent	Mean light transmission percent to depth (two values per day)	percent
Surface_DateTime_ISO_UTC	Date time (UTC) at the surface in ISO format yyyy-mm-ddTHH:MMZ	unitless

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Instruments

Dataset-specific Instrument Name	Standard Rain Gauge
Generic Instrument Name	Automated Weather Station
Dataset-specific Description	A Standard Rain Gauge (NOAA, National Weather Service) was mounted on a roof 1.5 m above the ground.
Generic Instrument Description	Land-based AWS systems are designed to record meteorological information.

Dataset-specific Instrument Name	Compact LW
Generic Instrument Name	Light Meter
Dataset-specific Description	Underwater light was recorded with a light meter (Compact LW, JFE Advantech Co., Ltd, Japan) fitted with a cosine-corrected sensor recording photosynthetically active radiation (PAR, 400-700 nm wavelength) as photosynthetic photon flux density (PPFD).
Generic Instrument Description	Light meters are instruments that measure light intensity. Common units of measure for light intensity are umol/m2/s or uE/m2/s (micromoles per meter squared per second or microEinsteins per meter squared per second). (example: LI-COR 250A)

Dataset-specific Instrument Name	S-LIA-M003, Onset Computer Corporation
Generic Instrument Name	Light Meter
Dataset-specific Description	PPFD was measured on the surface, using two cosine-corrected sensors (S-LIA-M003, Onset Computer Corporation)
Generic Instrument Description	Light meters are instruments that measure light intensity. Common units of measure for light intensity are umol/m2/s or uE/m2/s (micromoles per meter squared per second or microEinsteins per meter squared per second). (example: LI-COR 250A)

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Project Information

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.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1801335

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