Carbon flux for the Caribbean giant barrel sponge Xestospongia muta (Sponge-loop)

Website: https://www.bco-dmo.org/dataset/685783
Data Type: experimental
Version:
Version Date: 2017-03-27

Project
» Testing the sponge-loop hypothesis for Caribbean coral reefs (Sponge_Loop)

Contributors	Affiliation	Role
Finelli, Christopher	University of North Carolina - Wilmington (UNC-Wilmington)	Principal Investigator
McMurray, Steven	University of North Carolina - Wilmington (UNC-Wilmington)	Co-Principal Investigator, Contact
Pawlik, Joseph	University of North Carolina - Wilmington (UNC-Wilmington)	Co-Principal Investigator
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Table of Contents

- Coverage
- Dataset Description
  - Methods & Sampling
  - Data Processing Description
- Data Files
- Related Publications
- Parameters
- Instruments
- Deployments
- Project Information
- Funding

Coverage

Spatial Extent: **Lat**:24.94972 **Lon**:-80.45361
Temporal Extent: 2013-05-01

Dataset Description

This dataset includes flux measurements of dissolved, particulate and total organic carbon associated with the Caribbean giant barrel sponge *Xestospongia muta* on Conch Reef, Key Largo, FL in June 2013.

Methods & Sampling

Suspension feeding by *Xestospongia muta* was investigated *in situ* on Conch Reef (24°56’59”N; 80°27’13”W), Key Largo, Florida in June of 2013. Food availability is known to vary temporally on Conch Reef (e.g. McMurray *et al.* 2016); therefore, a total of 32 individuals were haphazardly selected for study at 20 m depth over the course of 6 days (5-6 sponges day-1) to quantify feeding rates over a large natural range of food abundances. Individuals spanned a broad range of sizes, however only individuals with a single osculum were included.

A total of 1 L of both incurrent (ambient) and excurrent seawater was collected from each sponge over a 5 minute sampling interval with paired 100 mL syringes as previously described (McMurray *et al.* 2016). Following seawater sample collection, the dimensions of each sponge were measured and the morphology of *X. muta* was approximated as a frustum of a cone to obtain sponge volume estimates (McMurray, Blum & Pawlik 2008). Estimates of sponge pumping rates were derived from the equation $Q = 0.02\ V1.1$ ($P < 0.001$, $R2$ = 0.78; McMurray et al. 2014), where Q is the pumping rate (ml s-1) and V is sponge volume (cm3)

Particulate and dissolved organic carbon (POC and DOC, respectively) in incurrent and excurrent seawater was quantified as previously described (McMurray *et al.* 2016). Briefly, each sample was filtered through a 100 µm mesh and subsequently through a pre-combusted GF/F glass fiber filter. In the laboratory, POC on filters was measured using a CE Elantech NC2100 elemental analyzer; DOC in filtrate samples was measured using high temperature catalytic oxidation with a Shimadzu TOC 5050 analyzer. *Xestospongia muta* hosts symbiotic microbes which may contribute to DOC retention rates (Maldonado, Ribes & van Duyl 2012); therefore carbon flux estimates reported here consider the sponge as a holobiont.

To assess the effects of sponge feeding on POC and DOC, differences in the concentration of each food type between incurrent and excurrent seawater were analyzed using paired *t*-tests. For each sponge, POC and DOC consumed were calculated as the difference between the quantities of each food resource in incurrent and excurrent seawater samples. To investigate selective feeding on food resource types, and if relative foraging effort between food resources varied as a function of relative food availability (McMurray *et al.* 2016), the log10-transformed ratio of POC:DOC consumed was regressed against the log10-transformed ratio of incurrent POC:DOC concentration (van Leeuwen *et al.* 2013). A one-tailed *t*-test was used to test if the slope of this regression was greater than a slope of 1 to examine frequency-dependent food consumption.

Retention efficiency of each food resource was calculated as:

RE = (Cin - Cex)/Cin x 100

where *RE* is the retention efficiency (%), and *Cin* and *Cex* are the incurrent and excurrent quantities of each food resource (µM), respectively. The filtration rate for each food resource was calculated as:

FR = (Cin - Cex) x Q

where *FR* is the filtration rate (µmol C s-1). Ordinary least squares regression was used to examine how filtration rates for each food resource scaled with sponge size. Filtration rates were standardized by sponge volume to obtain specific filtration rates (µmol C s-1 L-1). The relationship between specific filtration rate and loge-transformed incurrent food abundance for each food resource was described by ordinary least squares regression.

These data were published in:
McMurray, S.E. 2015. The Dynamics of Sponge Populations and Benthic-pelagic Carbon Flux on Coral Reefs. Ph.D. Dissertation. University of North Carolina Wilmington.

Data Processing Description

Analyses were conducted with SAS (version 9.1.3 for Windows; SAS Institute) and SPSS (version 14.0.0 for Windows; SPSS) statistical software.

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- re-formatted date from m/d/yyyy to yyyy-mm-dd
- replaced DOCre (proportion) data with data*100 (percent)

[table of contents | back to top]

Data Files

File
carbon_flux.csv (Comma Separated Values (.csv), 5.71 KB) MD5:b4053c809a1e23d8699ad2c1c88e4ce6 Primary data file for dataset ID 685783

[table of contents | back to top]

Related Publications

Maldonado, M., Ribes, M., & van Duyl, F. C. (2012). Nutrient Fluxes Through Sponges. Advances in Sponge Science: Physiology, Chemical and Microbial Diversity, Biotechnology, 113–182. doi:10.1016/b978-0-12-394283-8.00003-5 https://doi.org/10.1016/B978-0-12-394283-8.00003-5
Methods

McMurray, S. E., Blum, J. E., & Pawlik, J. R. (2008). Redwood of the reef: growth and age of the giant barrel sponge Xestospongia muta in the Florida Keys. Marine Biology, 155(2), 159–171. doi:10.1007/s00227-008-1014-z
Methods

McMurray, S. E., Johnson, Z. I., Hunt, D. E., Pawlik, J. R., & Finelli, C. M. (2016). Selective feeding by the giant barrel sponge enhances foraging efficiency. Limnology and Oceanography, 61(4), 1271–1286. doi:10.1002/lno.10287
Methods

McMurray, S., Pawlik, J., & Finelli, C. (2014). Trait-mediated ecosystem impacts: how morphology and size affect pumping rates of the Caribbean giant barrel sponge. Aquatic Biology, 23(1), 1–13. doi:10.3354/ab00612
Methods

McMurray, S.E. 2015. The Dynamics of Sponge Populations and Benthic-pelagic Carbon Flux on Coral Reefs. Ph.D. Dissertation. University of North Carolina Wilmington.
Results

Van Leeuwen, E., Brännström, Å., Jansen, V. A. A., Dieckmann, U., & Rossberg, A. G. (2013). A generalized functional response for predators that switch between multiple prey species. Journal of Theoretical Biology, 328, 89–98. doi:10.1016/j.jtbi.2013.02.003
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
spongeid	unique identifier for each sponge sampled	unitless
watersampdate	date of water sample formatted as yyyy-mm-dd	unitless
spongevolume	volume of each sponge	cubic centimeters (cm3)
volflow	volume flow (i.e pumping rate) for each sponge	milliliters/second (ml/s)
DOCin	dissolved organic carbon in incurrent water samples	micromolar (uM)
DOCex	dissolved organic carbon in excurrent water samples	micromolar (uM)
DOCconsumed	dissolved organic carbon consumed by sponges	micromolar (uM)
DOCre	sponge retention efficiency for dissolved organic carbon	percent
frDOC	sponge filtration rate of dissolved organic carbon	micromoles/second (umol/s)
spFRdoc	specific sponge filtration rate of dissolved organic carbon	micromoles/second/liter (umol/s/L sponge)
POCin	particulate organic carbon in incurrent water samples	micromolar (uM)
POCex	particulate organic carbon in excurrent water samples	micromolar (uM)
POCconsumed	particulate organic carbon consumed by sponges	micromolar (uM)
POCre	sponge retention efficiency for particulate organic carbon	percent
frPOC	sponge filtration rate of particulate organic carbon	micromoles/second (umol/s)
spFRpoc	specific sponge filtration rate of particulate organic carbon	micromoles/second/liter (umol/s/L sponge)
TOCin	total organic carbon in incurrent water samples	micromolar (uM)
TOCex	total organic carbon in excurrent water samples	micromolar (uM)
TOCconsumed	total organic carbon consumed by sponges	micromolar (uM)
TOCre	sponge retention efficiency for total organic carbon	percent
frTOC	sponge filtration rate of total organic carbon	micromoles/second (umol/s)
spFRtoc	specific sponge filtration rate of total organic carbon	micromoles/second/liter (umol/s/L sponge)

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Shimadzu TOC 5050 analyzer
Generic Instrument Name	Elemental Analyzer
Dataset-specific Description	Used to measure DOC
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	CE Elantech NC2100 elemental analyzer
Generic Instrument Name	Elemental Analyzer
Dataset-specific Description	Used to measure POC
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

[table of contents | back to top]

Deployments

McMurray_UNCW

Website	https://www.bco-dmo.org/deployment/685796
Platform	UNCW
Start Date	2013-06-25
End Date	2013-06-30
Description	Carbon flux studies

[table of contents | back to top]

Project Information

Testing the sponge-loop hypothesis for Caribbean coral reefs (Sponge_Loop)

Coverage: Conch Reef, Key Largo, Florida, USA; Carrie Bow Cay, Belize

NSF Abstract:
Sponges are bottom-dwelling animals that dominate Caribbean reefs now that reef-building corals have been declining for decades. Sponges feed by filtering huge volumes of seawater, providing a mechanism for recycling organic material back to the reef. A new theory has been proposed called the "sponge-loop

hypothesis" that is potentially the most important new concept in marine ecology in many years, because it seeks to explain Darwin's Paradox: how do highly productive and diverse coral reefs grow in desert-like tropical seas? The sponge loop hypothesis proposes that sponges on coral reefs absorb the large quantities of dissolved organic carbon (molecules such as carbohydrates) that are released by seaweeds and corals and return it to the reef as particles in the form of living and dead cells, or other cellular debris. This project will use a rigorous set of techniques to test the sponge-loop hypothesis in the field on ten of the largest and most common sponges on Caribbean reefs. For each species, the contributions of particles and dissolved organic carbon to sponge nutrition will be measured, as well as the production of cellular particles in the seawater flowing out of the sponge. For selected sponge species, the concentration of dissolved organic carbon entering the sponge will be experimentally enhanced to determine the capacity of the sponge to absorb this potential food source, and to gauge its effect on the production of cellular particles. This project will provide STEM education and training for postdoctoral, graduate and undergraduate students and public outreach in the form of easily accessible educational videos. Further, this project is important for understanding the carbon cycle on coral reefs where the effects of climate change and ocean acidification may be tipping the competitive balance toward non-reef-building organisms, such as sponges.

The cycling of carbon from the water-column to the benthos is central to marine ecosystem function; for coral reefs, this process begins with photosynthesis by seaweeds and coral symbionts, which then exude a substantial portion of fixed carbon as dissolved organic carbon (DOC) that may be lost to currents and tides. But if sponges, with their enormous water filtering capacity, can return DOC from the water column to the reef, it would represent a major unrecognized source of carbon cycling. The "sponge-loop hypothesis" has the potential to transform our understanding of carbon cycling on coral reefs. Building on preliminary data from studies of the giant barrel sponge, this project will investigate each of the three components of the sponge-loop hypothesis for ten common barrel, vase and tube-forming species that span a range of associations with microbial symbionts, from high microbial abundance (HMA) to low microbial abundance (LMA) in the sponge tissue. Specifically, the experimental approach will include InEx techniques (comparative sampling of seawater immediately before and after passage through the sponge), velocimetry, and flow cytometry to determine whether each species consumes DOC and produces particulate organic carbon (POC) in the form of cellular detritus. Then, for species that consume DOC, the same techniques will be used in manipulative experiments that augment the amount of DOC from three categories (labile, semi-labile and refractory) to determine the types of DOC consumed by sponges. In addition to testing the sponge-loop hypothesis, this project will use molecular techniques to investigate the differences among HMA and LMA sponge species, targeting the microbial symbionts that may be responsible for DOC uptake.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1558580

[table of contents | back to top]