Sponge mesocosm data testing effects of temperature and dissolved oxygen on sponge filtration from experiments conducted in November of 2024 at Newfound Harbor Marine Institute, FL

Website: https://www.bco-dmo.org/dataset/969125
Data Type: experimental
Version: 1
Version Date: 2025-07-17

Project
» RAPID: Consequences of Rapid Environmental Change on Pelagic-to-Benthic Coupling by Sponges on the Continental USAs only Barrier Reef Ecosystem (Temp & DO Effects on Sponges)

Contributors	Affiliation	Role
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Abstract
This dataset contains data from mesocosm experiments conducted in November of 2024 at Newfound Harbor Marine Institute (NHMI) on the southern tip of Big Pine Key, Florida. This dataset contains the data from the mesocosm experiments described in the following study description. See the "Related Datasets" section for more datasets from this study. Study description: Climate change is quickly altering marine environments by increasing sea surface temperatures and decreasing dissolved oxygen (DO) levels. Although these effects have been well-studied on the declining corals, the impact of temperature and dissolved oxygen extremes on the functional roles of sponges remains primarily unexamined. This study, conducted in the Lower Florida Keys, FL (USA) had two objectives: (1) compare sponge abundance and size distributions on hardbottom before and after the summer 2023 heatwave, and (2) investigate the filtration capacity of eight common sponge species from the Florida Keys with different morphologies (tubular vs. spherical) and microbial associations (HMA vs LMA) in mesocosms that simulated elevated temperature and hypoxic conditions for ~45 minutes. Field surveys by divers at the same 24 sites in May 2023 and June 2024 revealed that the abundance and size of spheroid sponges (e.g., Speciospongia vesparium, Hippospongia lachne) declined after the heatwave, but no noticeable effects were detected among the other species surveyed. The mesocosm experiments revealed tubular and LMA sponges consistently exhibited higher filtration efficiency of high nucleic acid (HNA) bacteria than spherical and HMA sponges under most treatment conditions. Elevated temperatures (2.5 to 5°C above ambient) significantly reduced HNA bacteria filtration capacity in spherical and HMA sponges (-43.6% ± 5.1 to -21.5% ± 4.4), whereas LMA tubular sponges were unfazed (-52.3% ± 11.6% to -62.6% ± 8.8%). The findings imply that future reef communities may shift toward more sponge dominance, particularly by heat and hypoxia-resistant, fast-growing LMA species, potentially altering ecosystem functions like water quality regulation, nutrient cycling, and habitat structure.

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Coverage

Location: mesocosm experiments conducted in the Florida Keys, Florida USA
Spatial Extent: **Lat**:24.6468884 **Lon**:-81.389175
Temporal Extent: 2024-11-03 - 2024-11-21

Dataset Description

See "Related Datasets" for other data from this study

Methods & Sampling

Mesocosm experimental design summary:

The effect of elevated seawater temperature and lower DO on four common offshore sponge species (Amphimedon compressa, Ircinia strobilina, Iotrochota birotulata, and Niphates digitalis) and four common inshore sponges (Spheciospongia vesparium, Ircinia felix, Cinachyrella alloclada, and Niphates erecta, see supplemental file "mesocosm_species_list.csv") was tested in a nearly orthogonal design that included two sponge morphologies (spherical and tubular) and two microbial associations (HMA or LMA). For simplicity, vase-like morphologies are categorized as tubular. The experiments were performed as a repeated measures design with four replicates per treatment group. Each sponge replicate tested was ~ 200 ml to control for sponge volume. For smaller sponges (C. alloclada, N. erecta, and N. digitalis), different individuals were grouped together per replicate to ensure that sponge biomass was constant.

Study objectives:

Objective 1: Assess changes in sponge community structure resulting from the current heatwave across an inshore-to-offshore gradient and an Upper Keys-to-Lower Keys gradient for which we have pre-event data, and to do so in the context of GOLT predictions.

* See "Related datasets" section for field data related to objective 1 (sponge size and abundance datasets).

Objective2: Test whether elevated seawater temperatures and low DO affect the filtering of microbes, consumption of DOM, or fixation of nitrogen by sponges that differ in phylogeny, morphology, microbiome, or habitat of origin.

Methods: We measured in experimental mesocosms changes in seawater concentrations of various planktonic components and water chemistry caused by sponge filtration under different temperature and DO regimes and among sponges representing different habitats, morphological types, and microbiomes.

The sponge species used in the experiment included those taxa that are most abundant on the inshore and offshore regions of the Florida Keys and included at least two species characteristic of different habitats (i.e., inshore, offshore), morphological types (e.g., spherical, tubular), and microbiomes (high microbial abundance taxa, low microbial abundant taxa). Small individuals (~ 1000 cm3volume) of each sponge species chosen for the study were removed at their base from the substrate by divers, attached to rock tiles with cable ties, and placed back on the bottom for 1-2 mos to heal and attach to the tile. Once healed, sponge transplants were temporarily moved to the laboratory for testing then returned to their original field location.

The mesocosm experiments were conducted at the Newfound Harbor Marine Institute / Seacamp on Big Pine Key, FL where we have established specially designed flow-through mesocosms in which we can test sponge filtration effects. The mesocosms are supplied by a large headtank (2500 liters) into which we draw natural seawater and then precisely adjusted and controlled seawater temperature (heater/chiller recirculation) and DO (computer-controlled nitrogen injection) independently prior to its pumping from the headtank into the 12 experimental mesocosms. The mesocosms (25 cm wide x 50 cm long x 15 tall; ~ 15 liters) were designed so that seawater enters each on one end and flows smoothly through the mesocosm's working area (where the sponges will be placed) and out at the other end in a single pass. By measuring the characteristics of the water entering and leaving a mesocosm and comparing those differences among treatment and control mesocosms, we accurately determined changes in water column constituents due to sponge filtration. Water leaving the mesocosms drained into a treatment tank where it is sterilized with UV light for 24 hrs before discharged onto the ground as a precaution so it does not directly enter the sea.

Prior to each mesocosm trial, sponge transplants of known volume were introduced to each mesocosm (n = 12 mesocosms) and permitted to acclimate with flow-through seawater for 24 hrs to the desired treatment

condition. We ran 12 mesocosms simultaneously, so during each trial we will include 3 replicates of a given sponge species x 3 species plus 3 controls (mesocosms with no sponges) under a given set of environmental (i.e., temperature, DO) conditions. The experimental treatments consisted of three temperature and two DO concentration regimes in an orthogonal design. The temperature treatments will include the typical seasonal range in bottom water temperatures along with two elevated seawater temperature regimes of +2oC and +5oC. Dissolved oxygen levels on the bottom along the Florida Keys reef tract are typically in the range of 6-7 mg/l but can fall episodically ~2 mg/l during heat stress events, so our DO treatment conditions mirrored this.

To begin a trial, seawater from the headtank conditioned to a specific temperature and DO level flowed into each test mesocosm and after 30 mins 1 liter of water was collected in acid-washed polyethylene bottles from the mesocosm outflows. The water samples were processed for water chemistry and bacterioplankton analysis (see below). Ten ml of the seawater samples were preserved with glutaraldehyde and kept frozen at -80oC for processing at FIU's flow cytometry laboratory to discern concentrations of various planktonic components (*Prochlorococcus*, *Synechococcus*, pico/nanoeukaryotes, high nucleic acid (HNA) bacteria, low nucleic acid (LNA) bacteria, and viruses) using a BD FACSCelesta Flow Cytometer and standard methods. The rest of each water sample was placed in a dark cooler filled with ice and then filtered (0.2 µm) at the end of each trial prior to freezing at -80oC and temporary storage until transported to the Water Quality Laboratory at Florida International University, a certified laboratory operating under EPA, FLDEP, and Florida Environmental Laboratory Accreditation Programs. Water quality constituents (NH4+, NOx, PO43-, TDN, TOC, POC, and DOC) will be analyzed at the FIU Water Quality Laboratory using standard methods (not included as part of this dataset).

BCO-DMO Processing Description

* Sheet 1 of submitted file "Fall 2024 Temp. and DO effects on sponge filtration on Mesocosm data FINAL.xlsx" was imported into the BCO-DMO data system for this dataset. Table will appear as Data File: 969125_v1_sponge-temp-and-o2-mesocosms.csv (along with other download format options).

Missing Data Identifiers:
* In the BCO-DMO data system missing data identifiers are displayed according to the format of data you access. For example, in csv files it will be blank (null) values. In Matlab .mat files it will be NaN values. When viewing data online at BCO-DMO, the missing value will be shown as blank (null) values.

* Column names adjusted to conform to BCO-DMO naming conventions designed to support broad re-use by a variety of research tools and scripting languages. [Only numbers, letters, and underscores. Can not start with a number]

* Date and time columns converted to ISO 8601 format

* Supplemental file mesocosm_species_list.csv formatted from an embedded table provided by data submitter in the methodology description.

* Species names corrected to the spelling of the registered name at the World Register of Marine Species (WoRMS) by using the WoRMS taxa match tool used to find misspellings. (taxa match was run 2025-07-17). Taxon identifiers (AphiaID and LSID) added to supplemental file mesocosm_species_list.csv.

* coordinates for experimental site Newfound Harbor Marine Institute obtained from google maps and entered as the geospatial bound for this data 24.6468884,-81.389175 (does not include field origin locations for experimental organisms).

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Related Datasets

IsRelatedTo

Butler, M., Kerigan, J. (2025) **Sponge abundance data from field surveys conducted in May 2023 and June 2024 in the Florida Keys, FL.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-07-21 http://lod.bco-dmo.org/id/dataset/969399 [view at BCO-DMO]
Relationship Description: Data collected as part of the same study.

Butler, M., Kerigan, J. (2025) **Sponge size data from field surveys conducted in May 2023 and June 2024 in the Florida Keys, FL.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-07-21 http://lod.bco-dmo.org/id/dataset/969406 [view at BCO-DMO]
Relationship Description: Data collected as part of the same study.

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Parameters

Parameter	Description	Units
Date	The date the data was collected.	unitless
Day	The day of the trial numbered '1' through '12'	days
Table	The Table on which the particular subject was located; 1, 2, or 3. Each table has six mesocosms on them and data was collected one table at a time.	unitless
Tank	The specific mesocosm number (1-18) that the subject was in.	unitless
Cytom_ID	Short for 'cytometry', this is simply the label assigned to the specific sample for further flow cytometry analysis.	unitless
SampleTime_AMB	The time of day at which the measurement was taken of the ambient temperature and dissolved oxygen conditions. (format hhmm)	unitless
SampleTime_Treat	The time of day at which the measurement was taken of the achieved treatment conditions of temperature and dissolved oxygen.	unitles
TargetTreatment	The target treatment combination for that specific day. For example '5C' means five degrees Celsius above ambient degrees Celsius, '40DO' means 40% less dissolved oxygen saturation than ambient dissolved oxygen, while 'AMB' signifies simply ambient conditions.	unitless
TempTreatment	The target temperature treatment level. '5C' meaning five degrees Celsius above ambient degrees Celsius, '2C' meaning two degrees Celsius above ambient degrees Celsius, and 'AMB' meaning only ambient temperature.	unitless
DOTreatment	The target dissolved oxygen treatment level. '40DO' meaning 40% less dissolved oxygen saturation than ambient, 'AMBDO' meaning only ambient dissolved oxygen.	unitless
BinVolume	The volume of the bin/tub/mesocosm the subject was in. Supply restrictions necessitated the use of two different sizes.	milliliters (mL)

SpongeVolume	The volume of the sponge subject.	milliliters (mL)
SpongeBinRatio	The ratio of the bin volume to the sponge subject volume	unitless
Tag	The specific tag number to denote the specific sponge subject replicate	unitless
Species	The species of the sponge subject or "Control". The first letter of the genus and species of each subject. A. compressa (AC), I. stobilina (IS), N. digitalis (ND), I. felix (IF), S. vesparium (SV), C. alloclada (CA), and N. erecta (NE).. See supplemental file "mesocosm_species_list.csv" for more species information.	unitless
Origin	The origin of the species collected (where its is significantly more dominate). Offshore meaning from the more oligotrophic deeper reefs a few miles south of the Florida Keys archipelago. Inshore meaning the much shallower hardbottom areas close to shore primarily within and amongst the Florida Keys archipelago.	unitless
Morphology	The morphology of the sponge subject species classified as 'Tubular' or 'Spherical'.	unitless
Mic_Ass	Short for microbial association, this is the microbial association of the sponge subject species classified as High Microbial Abundance 'HMA' or Low Microbial Abundance 'LMA'.	unitless
MicMorph	The combination of the sponge subject's species morphology and microbial association.	unitless
AMB_DO_conc	The ambient dissolved oxygen for that day.	milligrams per liter (mg/L)
AMB_DO_sat	The ambient dissolved oxygen for that day measured in percent saturation.	percent (%)
AMB_Temp	The ambient temperature for that day.	degrees Celsius
Treat_DO_conc	The achieved treatment dissolved oxygen conditions.	milligrams per liter (mg/L)
Treat_DO_sat	The achieved treatment dissolved oxygen conditions measured in percent saturation.	percent (%)
Treat_Temp	The achieved treatment temperature conditions measured.	degrees Celsius

DO_conc_difference	The difference between the ambient and achieved dissolved oxygen conditions.	milligrams per liter (mg/L)
DO_sat_difference	The difference between the ambient and achieved dissolved oxygen conditions measured in percent oxygen saturation.	percent (%)
Temp_difference	The difference between the ambient and achieved temperature conditions.	degrees Celsius
Sponge_Health	The sponge health measured on a scale of 1 (meaning almost entirely necrotic) to 10 (perfectly visually healthy). The two observers independently made determinations.	unitless
HNA	The total number of 'events' of as determined by the Flow cytometer and Flowjo software of high nucleic acid bacteria for that sample.	per event
LNA	The total number of 'events' of as determined by the Flow cytometer and Flowjo software of low nucleic acid bacteria for that sample.	per event
TotalBact	Short for 'Total Bacteria' this is the sum of the HNA and LNA events for that sample extracted from the osculum of the subject after exposure to treatment conditions.	per event
Peuks	Short for 'Picoeukaryotes', this the total number of 'events' of Picoeukaryote cells as determined by the Flow cytometer and Flowjo software for that sample extracted from the osculum of the subject after exposure to treatment conditions.	per event
Pro	Short for 'Prochlorococcus' this the total number of 'events' of Prochlorococcus cells as determined by the Flow cytometer and Flowjo software for that sample extracted from the osculum of the subject after exposure to treatment conditions.	per event
Syn	Short for 'Synechococcus' this the total number of 'events' of Synechococcus cells as determined by the Flow cytometer and Flowjo software for that sample extracted from the osculum of the subject after exposure to treatment conditions.	per event
HNA_head	The total number of 'events' of HNA bacteria in the head tank sample prior to exposure to sponge subjects.	per event
LNA_head	The total number of 'events' of LNA bacteria in the head tank sample prior to exposure to sponge subjects.	per event
TotalBact_Head	The total number of 'events' of HNA and LNA bacteria in the head tank sample prior to exposure to sponge subjects.	per event

Peuks_head	The total number of 'events' of Picoeukaryotes in the head tank sample prior to exposure to sponge subjects.	per event
Pro_head	The total number of 'events' of Prochlorococcus in the head tank sample prior to exposure to sponge subjects.	per event
Syn_head	The total number of 'events' of Synechococcus in the head tank sample prior to exposure to sponge subjects.	per event
HNA_difference	The difference between the HNA head and the HNA columns.	per event
LNA_difference	The difference between the LNA head and the LNA columns.	per event
TotalBact_difference	The difference between the Total Bact. head and the Total Bact. columns.	per event
Peuks_difference	The difference between the Pueks head and the Pueks columns.	per event
Pro_difference	The difference between the Pro head and the Pro columns.	per event
Syn_difference	The difference between the Syn head and the Syn columns.	per event
PercentChange_HNA	The percent change in HNA bacteria from the head tank and after exposure to subject.	percent (%)
PercentChange_LNA	The percent change in LNA bacteria from the head tank and after exposure to subject.	percent (%)
PercentChange_TotalBact	The percent change in total bacteria from the head tank and after exposure to subject.	percent (%)
PercentChange_Pueks	The percent change in Picoeukaryotes from the head tank and after exposure to subject.	percent (%)
PercentChange_Pro	The percent change in Prochlorococcus from the head tank and after exposure to subject.	percent (%)
PercentChange_Syn	The percent change in Synechococcus from the head tank and after exposure to subject.	percent (%)

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Instruments

Dataset-specific Instrument Name	BD FACSCelesta Flow Cytometer
Generic Instrument Name	Flow Cytometer
Generic Instrument Description	Flow cytometers (FC or FCM) are automated instruments that quantitate properties of single cells, one cell at a time. They can measure cell size, cell granularity, the amounts of cell components such as total DNA, newly synthesized DNA, gene expression as the amount messenger RNA for a particular gene, amounts of specific surface receptors, amounts of intracellular proteins, or transient signalling events in living cells. (from: http://www.bio.umass.edu/micro/immunology/facs542/facswhat.htm)

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Project Information

RAPID: Consequences of Rapid Environmental Change on Pelagic-to-Benthic Coupling by Sponges on the Continental USAs only Barrier Reef Ecosystem (Temp & DO Effects on Sponges)

Coverage: Florida Keys, Monroe County, Florida, USA

NSF Award Abstract:

It's been hot, record hot in the Western Atlantic. In the shallow seas surrounding the Florida Keys, a region that harbors the world's third longest coral barrier reef and the only one in the continental USA, water temperatures peaked in late July 2023 at 101F. Even at 30ft deep on the coral reef temperatures reached an unprecedented 90F, unleashing a wave of fish kills, corals bleaching, and dying octocorals and sponges. Marine scientists are concerned about the effects of this unprecedented climatic event on coral reefs in the Caribbean and Florida, and there has been a flood of media press as well. Yet, the focus has been almost exclusively on corals. Although corals provide the structural foundation for coral reefs, the functioning of coral reef ecosystems also depends on the health of other reef organisms. Of particular importance are sponges, which are key to capturing and recycling nutrients and carbon from the surrounding seas – a process referred to as "pelagic-to-benthic coupling". This project (a) assesses the damage of the summer 2023 heatwave on shallow water and reef dwelling sponges in the Florida Keys, (b) tests the effects of high seawater temperatures and associated low oxygen levels on sponges, and (c) using those data, develops a model to help predict the effect of future heatwaves on sponges and the ecological services they provide to the ecosystem. The project includes training for undergraduate and graduate students at a minority-serving institution and public outreach and engagement with K-12 students through a partner NGO. Project results inform resource managers with the Florida Keys National Marine Sanctuary.

Seawater temperatures in the Caribbean rapidly rose to unprecedented levels in summer 2023, unleashing a cascade of disturbance to coral reef ecosystems. The event galvanized scientists, resource managers, and the media into action but nearly all of that attention focused on corals. Corals provide the structural foundation for coral reefs, but the functioning of coral reef ecosystems as nutrient sinks and recyclers in otherwise oligotrophic seas is highly dependent on another taxon: sponges. Sponges are key to pelagic-to-benthic coupling and nutrient recycling on coral reefs and coastal backreef habitats, yet almost nothing is known of the effect of extreme environmental stress on sponge survival and function on coral reef ecosystems. The team is (a) using field surveys and leveraging pre-event baseline data to assess changes in sponge community structure across an inshore to offshore gradient in the Florida Keys; (b) using mesocosm experiments to examine the effects of elevated seawater temperatures and low dissolved oxygen on filtering of microbes, consumption of dissolved organic material, and fixation of nitrogen by sponges that differ in phylogeny, morphology, microbiome, or habitat; and (c) integrating these data to model projected changes in coastal and coral reef pelagic-to-benthic coupling. The results of this project advance understanding of the functional role of sponges in coral reef ecosystems in a changing climate.

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.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2347307

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