Plan Overview

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Title: Collaborative Research: Quantifying the ecological role of Gulf of Maine deep sea coral gardens at multiple spatial scales.

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Project abstract:

Overview: Deep-sea and cold-water corals are known to be ecosystem engineers, creating foundation structures and habitat for a myriad of associated species. As autogenic engineers, these structure-forming species increase the complexity of the environments in which they grow and associated organisms rely on the physical growth of these corals to change the environment by providing shelter and altering resources. These corals often have a large branching morphology, which creates space for other organisms to seek refuge (for safety from predators, feeding, procreation and protection of young) and thus results in increased abundance, biodiversity and faunal densities around these important ecosystem engineers. In 2013 extensive coral ecosystems were discovered in the Gulf of Maine, an area traditionally thought not to have large coral aggregations, because of prolonged disturbance from fisheries. Two species of octocoral were found to be particularly abundant - Primnoa resedaeformis and Paramuricea placomus and were discovered to form “garden” habitats, which are communities formed by dense aggregations (i.e. > 0.1 colonies per m2) of one or more species. Within this region, 97 epifaunal species and various megafauna including Acadian redfish, cusk, silver hake, Atlantic cod, and pandalid shrimp have been observed to associate with these two coral species, making them important to the wider Gulf of Maine ecosystem. The Gulf of Maine is one of the fastest warming bodies of water in the world, and one of these species, P. resedaeformis, is already living towards its recorded upper thermal limit. A previous investigation by the PI’s of this proposal examined population and individual level variation in reproductive potential of different coral ecosystems around the region. This study found that not all populations were equal when it came to reproductive output, and thus relative importance to other coral ecosystems (through larval transport dynamics) in the region is skewed. Coral populations, within the Gulf of Maine have been subjected to a synergy of multiple stressors, amplifying the vulnerability of these coral habitats on individual, population, and evolutionary timescales. Intellectual Merit: Through this proposal we seek to examine the ecological role of these vulnerable

coral populations in the Gulf of Maine at multiple spatial scales using 3D photogrammetry techniques on two major areas (Outer Schoodic Ridge and Western Jordan Basin). First we wish to expand on our previous reproductive study to examine fine scale reproductive processes (fertilization and larval ecology) and examine discrete areas where all colonies are sampled for reproductive material and placed in context with the 3D mapping and population genetic techniques. This will allow us to examine how much reproductive material is available and where fertilization is occurring in a population using models. We will then use a combination of longer transects and discrete area 3D photo mosaics to examine larger scale processes. We will examine the interactions between coral colonies and coral colony sizes within these two populations, and compare areas with dense and sparse coral cover for associated species. We will then examine mobile fauna, looking at how fishes utilize these two coral habitats in a 3D space. These data will allow us to understand the ecological role of coral communities within the Gulf of Maine, how they contribute not just to other coral communities in the region, but also how individual populations function. We already have a NOAA funded research cruise to the Gulf of Maine in August 2020, this proposal seeks funding for the ROV, 3D system, student support, analysis of data and broader impacts. Broader Impacts: The broader impacts of this proposal are twofold: Student Training and Educational Outreach. We will use this proposal to enhance student training from undergraduates to postdoctoral students. This project will utilize a Postdoctoral investigator (fish mapping) and a Ph.D. student (reproductive ecology and 3D photogrammetry) for the major parts of this study, and 8 undergraduate interns split between the three institutions over the two years proposed (targeting first generation college students). The postdoc, Ph.D. student and two undergrads will be present on the research cruise and will learn all aspects of the project through inter-institution collaboration. We will also employ a significant education and outreach component for this proposal, specifically targeting audiences that are tied to the Gulf of Maine environment. We will use Virtual Reality systems to visualize the 3D data, and bring the general public into the coral environments found in their backyards. We will use displays already present at Mystic Aquarium (CT) on Gulf of Maine cold-water corals to show the 3D data to daily visitors. We will also use data within our collective teaching and outreach programs to undergraduates and high school students at our respective institutions.

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The project investigators will comply with the data management and dissemination policies described in the NSF Award and Administration Guide (AAG, Chapter VI.D.4) and the NSF Division of Ocean Sciences Sample and Data Policy. We will work with staff at BCO-DMO to incorporate all data streams and following the BCO-DMO best practices guide.

Pre-cruise planning will be done via teleconferencing and a planning workshop held in collaboration with NOAA (who are providing ship time to Dr. Martha Nizinski). A science implementation plan for the cruise will be drawn up, detailing station locations, ROV deployment objectives, split beam and multibeam strategies and other sampling needs. An ROV log will be kept both on paper (scanned into PDF documents) by the watch leader, and in an event recorder software provided by the ROV contractor. Sample logs will be kept on paper in an excel spreadsheet. The principle investigators will prepare a cruise report at the end of the cruise.

The project will produce several observational and experimental datasets, described in the list below. In addition to the datasets described below, educational resources produced by the project, including data and images, will be made available for public use on the COSEE.net website. Observational data will be collected on a Gulf of Maine research cruise planned to take place August 2020.

Observational Datasets:

1. **CTD:** CTD data collected using a SeaBird SBE CTD package mounted on the ROV system; processing to be done using SeaBird's SeaSave software; data will include standard environmental measurements (such as pressure, temperature, salinity, fluorescence). File types: Raw (.con, .hdr, .hex, .bl) and processed and .cnv, .asc, .btl) ASCII files. Repository: BCO-DMO
2. **Event log:** Cruise scientific sampling event log; will include event numbers, start/end dates, times & locations of instrument deployments. File types: Excel file converted to .csv; scanned PDFs. Repository: BCO-DMO and Rolling Deck to Repository (R2R).
3. **Cruise underway data:** Routine underway data collected along the ship's track (including meteorological data, sea surface temperature, salinity, fluorescence, ADCP). Will be collected by the shipboard instrumentation. File types: .csv ASCII files. Repository: BCO-DMO and R2R.
4. **Split Beam Sonar Data:**
5. **Deep sea coral samples:** Corals will be sampled using the ROV during the cruise. Species identified, dive numbers, locations, depths, dates, and times will be recorded by hand on log sheets. Information from log will be transferred into an Excel spreadsheet. Images of each coral collected will be taken both in-situ by the ROV, and on the ship using a digital camera. File types: PDF files of scanned log sheets; Excel files of sampling logs; images (.jpg files). Repository: BCO-DMO.
6. **ROV Images:** Still and video images will be taken during this cruise from the ROV, including 3D models generated from stero-pair data. File types: images (.jpg files), video (.mov files). Repository: BCO-DMO.

Experimental Datasets:

1. **Coral Reproductive Data and Images:** Snips of animals taken by ROV will be used for histological and larval ecology purposes. Samples with either be processed to slides, creating images and data, or be used for live experiments where larvae are created and recorded via SEM and TEM imagery. All samples will be processed at the Waller Laboratory, UMaine. File types: Excel file(s), images (.jpg files). Repository: BCO-DMO.
2. **Genetic sequencing:** microsatellite and RADSeq sequences from corals collected at sea. Sequencing will be

performed at USGS and the Smithsonian Institution (see letters of collaboration) following the research cruise. File types: Short-read archive (.sra) and .fasta files. Repository: NCBI; accession numbers to be provided to BCO-DMO.

Field observation data will be stored in flat ASCII files, which can be read easily by different software packages. Field data will include date, time, latitude, longitude, cast number, and depth, as appropriate. Metadata will be prepared in accordance with BCO-DMO conventions (i.e. using the BCO-DMO metadata forms) and will include detailed descriptions of collection and analysis procedures.

The investigators will store all project data on laboratory computers that are backed up daily using Apple Time Machine to an onsite external hard drive, and weekly to an offsite hard drive. Data will be shared between PI's and students via Google Drive.

Immediately after completion of the research cruise, underway data and metadata will be submitted to the Rolling Deck to Repository (R2R) project. DNA sequences will be deposited in the National Center for Biotechnology Information (NCBI) database GenBank upon submission of manuscripts. GenBank accession numbers will be provided to the Biological and Chemical Oceanography Data Management Office (BCO-DMO) in an Excel spreadsheet or .CSV file and metadata will be provided using the BCO-DMO Dataset Metadata submission form. Data sets produced by the science party will be made available through the BCO-DMO data system within two-years from the date of collection. The project investigators will work with BCO-DMO data managers to make project data available online in compliance with the NSF OCE Sample and Data Policy. Data, samples, and other information collected under this project can be made publically available without restriction once submitted to the public repositories. We will adhere to and promote the standards, policies, and provisions for data and metadata submission, access, re-use, distribution, and ownership as prescribed by the BCO-DMO Terms of Use (http://www.bco-dmo.org/terms-use).

R2R will ensure that the original underway measurements are archived permanently at NCEI and/or NGDC as appropriate. BCO-DMO will also ensure that project data are submitted to the appropriate national data archive. The PI will work with R2R and BCO-DMO to ensure data are archived appropriately and that proper and complete documentation are archived along with the data. Samples of deep-sea corals that are not destroyed in analysis wil be archived at the Smithsonian Institution for use by future investigators.

Each PI will be responsible for sharing his/her subset of data among the project participants in a timely fashion. The Lead PI, R. Waller, will coordinate the overall data management and sharing process and will submit the project data, including GenBank accession numbers, and metadata to the Biological and Chemical Oceanography Data Management Office (BCO-DMO) who will be responsible for forwarding these data and metadata to the appropriate national archive.