NOAA DEEP SEA CORAL RESEARCH AND TECHNOLOGY PROGRAM THREE-YEAR FIELD RESEARCH PROGRAM SCIENCE PLAN

Northeast Deep Sea Coral and Sponge Initiative (NECSI)

Version 2.0

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SECTION 1: PROJECT SUMMARY

The Northeast region extends from Maine to North Carolina and eastward out to the boundary of U.S. Exclusive Economic Zone (EEZ) encompassing the continental shelf and slope of Georges Bank, southern New England, and the Mid-Atlantic Bight to Cape Hatteras as well as four New England Seamounts (Bear, Physalia, Mytilus, and Retriever). Of particular interest in the region is the Gulf of Maine, where diverse benthic habitats are found on rocky ledges, soft sediment banks, and within the 21 deep basins (the largest and deepest being Jordan, Wilkinson, and Georges). Georges Bank, another prominent feature in the region, is a shallow elongate extension of the continental shelf bounded by the Gulf of Maine to the north, Great South Channel and Nantucket Shoals to the west and south, and the Northeast Channel/Scotian Shelf to the east and north (U.S. jurisdiction ending at the Hague Line). This region supports a diverse assemblage of deep-sea corals and sponges. A number of important research questions that need to be addressed for effective management of these ecosystems were identified by the New England and Mid-Atlantic Fishery Management Councils, and an August 2011 Deep Coral and Sponge Priorities Workshop. The Northeast Deep Sea Coral and Sponge Initiative (NECSI) will be carried out in FY13-15 and will address the region's objectives by undertaking four major research projects. The NECSI fieldwork will locate and characterize deep coral and sponge ecosystems in the Gulf of Maine, deepwater canyons and seamounts though a systematic field survey developed in part with results of our habitat suitability model. The NECSI will also try to incorporate projects that research the biology and ecology of deep coral and sponge ecosystems by studying species associations and habitat use by economically important fishes and other fauna associated with deep coral and sponge ecosystems. Projects that improve understanding of deep-sea coral and sponge biodiversity and ecology will be included through collection of specimens to resolve taxonomic issues and genetic connectivity between North Atlantic populations. Finally, the potential to set up cost-effective long term monitoring for environmental variables that influence deep coral and sponge communities will be explored. At the conclusion of this project we hope to have advanced knowledge of deep-sea coral and sponge distributions, abundance and ecology in the Northeast region so that management decisions to conserve and protect these habitats will be based on science not inference.

SECTION 2: BACKGROUND

The northeast region extends from Maine to North Carolina and eastward out to the Gulf Stream and ends at the U.S. Exclusive Economic Zone (EEZ). It encompasses the continental shelf and slope of Georges Bank, southern New England, and the Mid-Atlantic Bight to Cape Hatteras as well as four New England Seamounts (Bear, Physalia, Mytilus, Retriever) located off the continental shelf near Georges Bank. In the Gulf of Maine, diverse benthic habitats are found on the rocky ledges, soft sediment banks, and within the 21 deep basins. Georges Bank is a shallow elongate extension of the continental shelf; the central portion is shallow, consisting mostly of larger grain-sized sediments, ranging from sand to gravel to boulders depending on location. Numerous submarine canyons, found near the shelf break along Georges Bank down to Cape Hatteras, cut into the slope and occasionally into the shelf. The Mid-Atlantic Bight includes the shelf and slope from Georges Bank to Cape Hatteras. The shelf topography is relatively smooth and sediments are rather uniform, mostly consisting of sand with some gravel, with finer sediments occurring toward the outer shelf, shelf break, and deeper parts of canyons.

Since the time of Verrill (19th century), deep-sea corals were not only reported from this region but also been recorded as fisheries bycatch. Available information on the four major deep-sea coral orders (alcyonaceans, [soft corals/gorgonians), antipatharians [black corals], scleractinians [stony corals] pennatulaceans [sea pens]) from the continental shelf, slope, and the submarine canyons of the shelf edge/slope has been compiled from historical databases. These data were mainly presence-only or occurrence records or observations. The historical surveys from which these coral records were obtained tend to be of limited spatial extent, and the regional coverage of coral-related investigations is patchy. For example, the majority of survey work in the deepwater canyons off the coast was limited to Heezen, Lydonia, Oceanographer, Hendrickson, Baltimore, and Norfolk canyons, representing only a fraction of the canyons known to exist in the region. Most coral presence records are georeferenced and can be mapped. However, in some cases, documented coral presence or even relative abundance occurs in locations that are poorly georeferenced. Nevertheless, based on these historical surveys, some general patterns in deep-sea coral distribution can be discerned.

For the alcyonaceans, species composition varies with depth. The suite of species that occurs at depths less than 500 m (shelf and upper slope) is different than that which occurs at depths greater than 500 m (lower slope and rise; Watling and Auster, 2005); several species of the former occur (or have occurred in the past) on Georges Bank and in the deep basins of the Gulf of Maine (e.g. Jordan Basin). Many species of alcyonaceans are also found on the New England Seamounts and are dominant members of the epifauna; several have been recently discovered. Most of the scleractinians in this region are small, solitary organisms found on the edge of the shelf as well as in the canyons and on the New England Seamounts. Although major colonial structure-forming scleractinians may also occur on the slope, in the canyons, and on the seamounts. One species of scleractinian can occur in very shallow water on the shelf and inshore as shallow as a few meters. For the pennatulaceans, although the majority of species in this region are found on the continental slope, in the canyons, and on the seamounts, two of the most common and

widespread species are actually found over wide swaths of the continental shelf in soft substrates. *Pennatula aculeata* (common sea pen) is common in the Gulf of Maine and occurs as far south as the Carolinas, while *Stylatula elegans* (white sea pen) is found on the mid-Atlantic outer shelf. Finally, until recently, occurrence of antipatharians was limited to the seamounts. Our recent NEFSC/Woods Hole Oceanographic Institution (WHOI) deep-sea coral submarine canyon survey cruise, however, verified the presence of antipatharians in Gilbert Canyon.

An August 2011 deep-sea coral and sponge ecosystem workshop identified exploration and research priorities for deep-sea coral and sponge ecosystems in the northeast region. The workshop focused on the science needed to inform management about these ecosystems in the region and identified three major research priorities: 1) locate and characterize deep-sea coral and sponge ecosystems; 2) understand the biology, biodiversity and ecology of deep-sea corals and sponges; and 3) understand natural and human impacts on deep-sea coral and sponge ecosystems. Since that time, we have initiated a number of projects and are making progress toward achieving the goals set out in the workshop. Concentrating most heavily on the first priority, we are making progress toward locating deep-sea coral and sponge habitats and moving away from our reliance on historical data sets. Each research project, listed below, builds synergistically upon each other:

- Conduct a gap-analysis on existing information with a geographic focus on canyons and seamounts where a greater concentration of deep-sea corals and sponges likely exists.
- Develop regional habitat suitability predictive models for deep-sea corals/sponges that can assist Fishery Management Councils in drafting management alternatives to designate deep-sea coral zones in this region and guide planned field research.
- Map the bathymetry and backscatter of canyons and seamounts using multibeam sonar.
- Conduct targeted field surveys to identify deep-sea coral and sponge habitats.

For example, the NEFSC has forged partnerships with NOAA's Office of Ocean Exploration and Research (OER) and Office of Coast Survey (OCS). Comprehensive high-resolution multibeam bathymetric surveys of the northeast/mid-Atlantic continental slope and canyons by these two offices in 2012 and 2013 provided us with high quality multibeam images of these areas. The areas mapped had been prioritized with regard to deep-sea corals habitats and input from the NEFMC Habitat Plan Development Team and other external partners. This multibeam data is critical to both the modeling and fieldwork components of our research plan, as well as to the Councils as they draft management alternatives to designate deep-sea coral zones (see below).

Management efforts are currently underway by the New England and Mid-Atlantic Fishery Management Councils (NEFMC, MAFMC) to establish regional deep-sea coral protection zones, and to develop measures to minimize fishing impacts on corals in those zones. There are multiple authorities in the Magnuson Stevens Fishery Conservation and Management Act (MSA), which can be used to justify deep-sea coral protections. One is the Essential Fish Habitat (EFH) authority, where corals are considered a component of EFH, and fishing restrictions are enacted in the context of minimizing, to the extent practicable, the effects of fishing on EFH. In the

Northeast Region, this authority was used in Monkfish Fishery Management Plan Amendment 2 by the NEFMC to protect deep-sea corals and associated habitat features from fishing activity occurring under a monkfish day at sea in Lydonia and Oceanographer canyons.

Any action taken under the EFH authority must occur within areas designated as EFH. However, in the northeast, deep-sea coral distributions extend into deeper waters, beyond the bounds of designated EFH. The discretionary provisions from the 2007 MSA reauthorization provide an additional and more flexible mechanism by which to protect deep-sea corals from the effects of fishing. This authority allows the Councils to designate zones anywhere deep-sea corals have been identified and implement measures to protect corals within those zones, provided that long-term sustainable use of fishery resources has been considered. A range of deep-sea coral protection alternatives relying on this authority are currently under development by the two regional Councils, include "discrete" zones (i.e., area boundaries based on bathymetry, slope, and coral distributions; e.g., the submarine canyons) and "broad" zones (i.e., a large area along the shelf/slope boundary extending to the EEZ, based on a selected depth contour). Current management area options for the submarine canyons were derived from evaluations of coral presence information from the scientific literature and the northeast database and an analysis of habitat suitability. The alternatives will define the boundaries of deep-sea coral protection zones and implement fishing restrictions within them.

However, some of the submarine canyons initially identified as prospective deep-sea coral management discrete zones have few deep-sea coral data associated with them because past survey efforts for deep-sea corals have been patchy. Because of the prohibitive costs and logistical difficulties of surveying for deep-sea corals and their associated habitats, predictive habitat modeling for deep-sea corals has become a cost effective tool to identify potential locations of deep-sea corals and other benthic species. Habitat suitability modeling examines the associations between the presence and/or absence of organisms and their relevant environmental or habitat variables. The resulting habitat suitability maps can be generated by different techniques, but these techniques are limited by the type of data available. Because of limited collections/surveys of deep-sea corals, and the remoteness and inaccessibility of the deep ocean environment, many if not most historical coral records or databases consist mainly of presence data only. This is certainly true for deep-sea coral records and observations in the northeast where much of the information needed to assess the status of deep-sea coral habitats is inadequate or incomplete.

The NEFSC and NOS/NCCOS developed a deep-sea coral predictive habitat model for this region in 2012. A machine-learning technique called Maximum Entropy modeling, or MaxEnt, was used to predict suitability of unexplored habitats based on locations and environmental characteristics of known deep-sea coral presence. The MaxEnt method was selected because it performed well in previous deep-sea coral predictive habitat modeling studies using presence-only data, and out-performed other types of habitat suitability models. The model was run with selected predictor (environmental) variables, high-resolution bathymetry data from NOAA, and presence data for the main taxonomic orders of deep-sea corals in the northeast database. Habitat suitability maps

and model evaluation methods predicted suitable habitat in the vicinity of known deep-sea coral presence locations, as well as in some areas without recorded presences.

Some of the model-predicted "hotspots" of high habitat suitability for deep-sea corals were ground-truthed during a July 2012 NEFSC/DSCRTP funded deep-sea coral research cruise. In collaboration with WHOI, we surveyed known or suspected deep-sea coral habitats associated with submarine canyons in the mid-Atlantic and northeast region. Using high-resolution (25-50 m) continental slope bathymetric maps obtained from the recently completed surveys by OER and OCS and results of the NCCOS/NEFSC predictive habitat model as a guide, we surveyed predicted hotspots with WHOI's underwater towed camera system. Canyon areas surveyed included the Toms Canyon complex (Hendrickson, Toms, Middle Toms, South Toms) in the Mid-Atlantic and Veatch and Gilbert Canyons off New England. The predictive model identified Gilbert Canyon in particular as a deep-sea coral hotspot.

Over 38,600 high-resolution photos were taken in conjunction with environmental data (e.g. depth, temperature, salinity) to characterize benthic and deep-sea coral/sponge habitats. The collection of contemporary, geo-referenced deep-sea coral and sponge data increased our knowledge of deep-sea coral diversity and distribution in the northeast canyons exponentially. Additionally, the deep-sea coral habitat suitability model was qualitatively validated, as supported by the fact that all sites observed to be hotspots of coral abundance and diversity were also predicted hotspots based on the regional model (e.g., Gilbert Canyon was indeed a hotspot of coral abundance and diversity). These findings will used to assist the planning efforts of the 2013-15 northeast field research initiative on deep-sea coral and sponge ecosystems, help the NEFMC and MAFMC draft management alternatives to designate deep-sea coral zones in the region, and, revise/refine future predictive habitat models being developed by NCCOS and NEFSC as part of the upcoming research initiative.

In 2011, the Northeast Regional Office (NERO) and the NEFSC, in collaboration with the two regional Councils, initiated a partnership to develop and implement a strategy for deep-sea coral conservation as part of NOAA's Habitat Blueprint Initiative. The goal is to ensure effective, long-term conservation of deep-sea coral habitats with existing management and scientific resources and provide a template to integrate habitat conservation and science into the Council process. This initiative took advantage of deep-sea coral science and management activities that were already underway in the region. A major component of this initiative is the three-year deep-sea coral/sponge field research initiative. The extensive mapping and photographic survey work done on the outer continental shelf in 2012/2013 and the predictive modeling work have provided a considerable amount of new information that will be used to plan the more targeted survey work during 2013-2015, all of which will inform current and future management decisions being made by the Councils.

SECTION 3: OBJECTIVES AND SCOPE

The objectives of the northeast fieldwork plan are to address the research priorities discussed above. The northeast fieldwork initiative will be carried out in FY13-15. The FY13 fieldwork will involve baseline exploration and reconnaissance to especially satisfy the needs of the Councils, with more focused research and surveys (including specimen collecting) occurring in FY14-15. The fieldwork will occur in select submarine canyons, seamounts, and slope areas, and discrete areas of the Gulf of Maine, based on consultations with and the recommendations of the NEFMC Habitat Plan Development Team and the MAFMC Fishery Management Action Team (Amendment 16 to the Squid, Mackerel, Butterfish FMP).

The following objectives, listed below, will be addressed via several projects outlined in Appendix 2:

1. Characterize the deep-sea coral and sponge ecosystems and determine the distribution, abundance, and diversity of deep-sea corals/sponges in select areas of the continental slope, including the submarine canyons, the seamounts within the EEZ, and select areas of the Gulf of Maine where major structure-forming corals/sponges may or are known to occur. Establish the spatial extent of corals/sponges in these areas, their scales of patchiness, and correlation with substrate features.

2. Establish the species associations/interactions with these deep-sea corals/sponges, especially those of commercially important fish/shellfish species in the Gulf of Maine.

3. Use the deep-sea coral/sponge distribution data to refine the next iterations of the northeast's deep-sea coral habitat suitability model; conversely, the model will assist in choosing survey sites and thus be continuously "field tested."

4. Improve the taxonomy of corals and especially sponges in this region through collections and use of both morphological and genetic analyses. Partnerships with members of the Porifera Tree of Life will support this objective. Recognized taxonomic experts will examine and analyze coral samples.

5. Assist the NEFSC groundfish and shellfish surveys and the observer program in better identifying and quantifying their deep-sea coral and sponge bycatch.

6. Estimate the genetic connectivity between the coral/sponge populations of the New England seamounts and the submarine canyons/slope of nearby Georges Bank. Recognized experts will analyze samples. Collaborating scientists may include Cheryl Morrison (USGS), Scott France (Univ Louisiana Lafayette), Tim Shank (WHOI), or others, dependent on species collected.

7. Determine if the common sea pen (*Pennatula aculeata*) in the Gulf of Maine is being utilized as shelter by fish larvae, perhaps by those of redfish (*Sebastes* spp.) as has been recently found in Canada (Bailon et al. 2012), by collecting of specimens for analyses.

8. Continue to work with other NOAA line offices (OER, OCS) to obtain high-resolution multibeam maps and associated backscatter data of the northeast shelf, slope, and seamounts where corals/sponges are known to or may occur.

9. Foster collaboration between DSCRTP and NEFSC James J. Howard Marine Sciences Laboratory Image Analysis Group (IMAG) to enhance methods for deep-sea coral/sponge image and video analyses.

10. Collect specimens for age and growth studies. Specimens, if collected, would be analyzed by potential partners/collaborators including but not limited to, Brendan Rourk (Texas A&M) and Peter Auster.

Each of these objectives also supports one or more of the DSCRTP objectives, as well as aligns with the objectives in the Strategic Plan for Deep-Sea Coral and Sponge Ecosystems. The projects outlined below will locate and characterize many unknown deep-sea coral and sponge habitats in the northeast and mid-Atlantic, and determine if any of them are in areas that may be in potential conflict with fishing gears. They will also advance our understanding of deep-sea coral and sponge taxonomy, biology, ecology, biodiversity, and species interactions. These projects are designed with the participation of the regional Councils, and their needs and goals are always kept at the forefront; in addition, the projects provide information and contribute to management decisions by other regional NOAA partners (e.g., Mid-Atlantic Regional Council on the Ocean, The Nature Conservancy). The Northeast's three-year fieldwork initiative will satisfy resource management needs while significantly increasing our understanding of the region's deep-sea coral and sponge ecosystems.

SECTION 4: METHODS

The NECSI will conduct at least three major field projects each year to address objectives outlined above. These projects will utilize a variety of methodologies, including modeling, field surveys, collections and laboratory analysis. More specific details are provided below (Appendix 2) in each project description.

The major challenges that the NECSI faces are lack of basic knowledge on many fronts that make long term planning and implementation difficult. For example, more time and resources are needed to answer basic questions (i.e., where are deep-sea corals and sponges located?) before other more quantitative and broad-reaching research questions can be addressed. Lack of assets and infrastructure dedicated to the study of deep corals presents logistical challenges. Deep-sea corals in this region occur in a wide range of habitats including soft muddy sediments, deep canyons, and seamounts, with the majority of significant structure-forming corals and sponges occurring in remote deep waters offshore. Thus, most work will require longer expeditions on larger vessels with industrial-class technology to collect necessary data. Deep-sea corals have just recently come to the forefront in the Northeast; therefore, we need to overcome this deficit in support. Additionally, we serve two management councils with different management styles and

timelines. Perseverance, a coordinated field plan, and successful partnering will be critical to the overall success of this program.

To fulfill the information needs identified for the region, many of the projects funded during the 3-year NECSI are high cost-high value. Major field campaigns, to a variety of habitats and locations, are critical to this program. Two to three expeditions will be conducted each year. Mapping of all canyons located within the Mid-Atlantic and Northeast regions will be completed by the end of FY13 or early FY14. These expeditions, conducted primarily by the *Okeanos Explorer*, through our ACUMEN partnership, will produce multibeam bathymetry and backscatter layers for the entire area. This mapping provides the basis for the majority of our deepwater sampling efforts over the course of the NECSI. *Okeanos Explorer* will attempt shallower water mapping (depths < 500 m) where appropriate but we will explore additional vessels of opportunity (e.g., NOAA ships *Ferdinand R. Hassler*, *Thomas Jefferson*, *Henry Bigelow*) to conduct mapping in the more shallow priority areas in the region. All fieldwork in FY13 is dedicated to reconnaissance, laying the foundation for future expeditions while filling in fundamental data gaps in coral occurrence and distribution. We continue to foster partnerships (e.g., OER, NOS) where additional resources can be leveraged as well as explore options to piggyback on other projects.

In FY13, there will be three major research cruises to the deepwater canyons off the coast of the Northeast Region. Photo and video imagery will be collected in and around several major canyons. Additionally transects will be run along bathymetric isobaths in intercanyon areas to assess the suitability of habitat in these slope areas. The ultimate goal in all these studies is to map the presence/absence, abundance and diversity of deep corals and sponges. Any evidence of fishing impacts will be noted and recorded. Video and bottom imagery will be use to correlate bottom features highlighted in recently collected multibeam data with the habitat type observed in those locations. Additionally, results of a habitat suitability model for the region will be ground-truthed on at least one cruise (Field project 1). Since the majority of data available for much of the Northeast is historical, historical presence data will also be ground-truthed. Data collected during major field projects will be used to refine our model as well as provide high quality, contemporary information of coral and sponge presence/absence, abundance, and density in a variety of habitats. Thus, results of the field sampling will modify and improve the habitat suitability model, and help guide decisions of the NEFMC and MAFMC to manage and conserve deep-sea coral and sponge habitat and diversity. To this end, we will allocate funds to support use of a towed camera system on the FSV *Henry Bigelow* (Field Project 1) and provide partial support for a 19-day ROV/telepresence expedition on the NOAA ship *Okeanos Explorer* (Field Project 3).

A third major field component in 2013 (Field Project 2) will conduct camera tows in Jordan Basin, a 200-250 m deep basin located in the eastern Gulf of Maine and an area southwest of Mount Desert Rock. These sites are proposed as Deep Coral Zones by the NEFMC but this decision is based on a very limited set of observations and inference. The extent of coral distribution in relation to habitat and landscape features associated with these sites remains unknown and is difficult to predict with a high degree of confidence. This area is within current fishing zones, therefore, corals are more likely to be damaged and destroyed. Based on previous work by P.

Auster (2005), Jordan Basin is considered a hotspot for corals and an area of particular concern. An experimental fishery for redfish is being conducted in Wilkinson Basin. Further work in Wilkinson Basin will be based on results obtain from this experimental fishery. Any corals collected during this survey will be sent to M. Nizinski for identification. Thus, the NE Planning team will be aware of any coral bycatch. Similar to other major FY13 field campaigns, bottom imagery and video will be collected in the Gulf of Maine survey. Using a towed video and digital still imaging system, we will conduct visual surveys at depths from 100 - 250 m, to delineate the spatial extent of deep-sea coral species in this region of the northern Gulf of Maine. Imagery collected from a series of transects will be used to determine extent of coral patches, abundances and distribution as well as document occurrence of fishing gear debris or evidence of damage to corals and sponges that might be attributable to fishing. Additionally these data provide information necessary to aid in the determination of boundaries for coral closure areas as well as habitat use by managed fish species and other associated fauna.

Another significant project of the NECSI is habitat suitability modeling. We will continue to support this program throughout the 3-yr initiative. NOS NCCOS will lead the development and application of predictive habitat modeling, validation and ground-truthing of model predictions, and development of model-derived map products. This effort will be tightly integrated with field survey efforts and will result in iterative updating of model products.

Finally, in FY13 we will set up an image analysis work station, develop protocols and train staff to help streamline and standardize data collection and analysis over all projects.

We will continue to pursue leads and partnerships for data mining and long-term monitoring of oceanographic conditions that influence coral and sponge communities. Lines of communication have been opened between planning team members and researchers at Rutgers University and the Virginia Institute of Marine Science regarding the potential of gliders to collect a variety of physical data at various depths. Discussions have begun with the ECOMON program (NEFSC) to share data sets and potentially expand operations further offshore. ECOMON surveys have produced long time series of temperature, salinity, fluorescence, surface productivity, and plankton biomass data. Once coral hotspots are located, these locations can be overlain on known stations for oceanographic monitoring. The ultimate goal will be to compare these data both temporally and spatially to coral and sponge distributions and to determine important relationships between environmental correlates and coral and sponge hotspots. Additionally, these types of data will provide information that will be useful in evaluating the potential impact of various physical parameters (e.g., temperature, DO) and possibly ocean acidification on these coral/sponge communities. Either dedicated long-term sampling or utilizing gliders, for either shore- or ship-based deployments, are being discussed. Determining next steps in FY14-15 will depend upon developments and finding in FY13. [Note: after further discussion and deliberations, the committee decided that long term monitoring was a lower priority given that dedicated funding for deep-sea coral work in the region after completion of the regional effort in FY15 was unlikely.]

In FY14, potentially three major field projects will build on first year's efforts to examine the distribution and abundance of coral and sponge ecosystems, but with emphasis on collections. Field sampling will be carried out primarily with a remotely operated vehicle (ROV) that is capable of collecting specimens *in situ* as well as collect images for verification of species identification, habitat use and association, and abundance and distribution estimates from video transects. Of particular significance will be continued work in the Gulf in the Maine. The main field project will be cross-border collaboration with Canadian deep-sea coral colleagues to examine coral communities in the Northern Gulf of Maine on both sides of the border, as well as some of the northern canyons. This expedition is highest priority and highly significant since animal distributions do not stop at the border. Data collected will be critical to the management and conservation of corals, sponges, and federally managed species that utilize these habitats. Additional fieldwork includes follow-up work in Jordan Basin with associated collecting and mapping. Work will likely continue in the canyons (dependent on shiptime allocations) with an additional TowCam expedition.

Collection of specimens (primarily using ROV, but other methods will be discussed) will take priority in FY14. Collections for taxonomic studies, including DNA barcoding, are critical to this initiative and to DSCRTP. Only examination of physical specimens can ensure that species identifications are correct. These taxonomic collections will serve as museum vouchers. Thus, specific specimens can be tied to an image. Potential for new discoveries is high (i.e., species new to science, changes in the geographic and bathymetric ranges of known species, revised taxonomic classifications). In addition to dedicated sampling initiatives, corals and sponges will be collected opportunistically during existing field projects or surveys. Collections would also provide the material needed to (1) assess genetic connectivity between populations of numerically dominant corals throughout the Northeast/Mid-Atlantic regions and the northern Atlantic; (2) investigate coral reproduction; and (3) estimate age and growth. Partnerships will be critical to success of these initiatives, but these studies are dependent on sample collection. Potential collaborators include Cheryl Morrison (scleractinians, *Primnoa*), Scott France and Andrea Quattrini (*Paramuricea*), Santigao Herrera (*Paragoria*) for genetic analyses; Rhian Waller studying coral reproduction; and Brendan Rourk and Peter Auster investigating coral aging.

Work in FY14-15 will also include pursuing low-cost high-value options to study sea pens in the region. Sea pens are the numerically dominant coral taxon in the region, yet we do not fully understand the extent, abundance and distribution of sea pens in the region, or the role sea pens may play in structuring the benthic habitat. A recent study in Canadian waters revealed a close association between sea pens and redfish larvae. More work is needed to assess the potential of sea pens as essential fish habitat. [Note: Given high the costs associated with FY14 cruises, sea pen work will be conducted in FY15.]

Modeling and image analysis will continue throughout the duration of the project. We will work with and monitor the observer program and groundfish survey to aid in identification of coral collections and quantifying coral bycatch. Collaboration with OER will continue into FY14-15. Through this partnership, there is a strong potential for a ROV expedition to canyons and the

New England seamounts is being discussed for FY14. Unfortunately, at this time, ROV Deep Discoverer has no capacity to collect or process samples. Additional fieldwork and collecting opportunities are being considered and pursued. Data mining and collection efforts should yield contemporary high quality physical and chemical data to feed into the habitat suitability modeling project (Project 4). The 3-year field effort will progressively build up a database of far more precise, higher-resolution, and higher-quality coral, sponge and environmental data, which will be used to develop and progressively improve a high-resolution DSC predictive habitat suitability model for application throughout the Northeast region. We continue networking and exploring leads for other data sources of additional coral and sponge records available for mining (Alvin dives, Kevin Stokesbury's SMAST video surveys of Georges Bank and Mid-Atlantic, OER expeditions).

Successes and failures in FY13-14 will determine the field components for FY15. A final field season to continue work in the canyons and the Gulf of Maine is likely, as dedicated funding to these projects will cease at the end of NECSI. Particularly if ship time or sampling gear is provided/leveraged at no cost to the program, these potential opportunities will be incorporated into the FY15 plan. We will attempt to fill any remaining gaps in multibeam coverage and finalize priority ground-truthing of model results. The Northeast Regional Habitat Suitability Model will be finalizing, with all data collected during the 3-yr initiative included and analyzed. Completion of video and image analyses, including identifications of corals and sponges, estimates of biomass, habitat associations, will be a top priority. We will likely fund experts for consultation either through travel support to IMAG lab in Sandy Hook to view images or to the Smithsonian Institution to examine material. Dependent on samples collected in FY14, FY15 funds will be used to support genetic, reproduction, and age/growth analysis. Specimens will be collected during scheduled fieldwork and then shipped to collaborating laboratories for analysis. Costs associated with participation in fieldwork or laboratory analyses will be supported by the program. Cost for analyses depend upon the number of species and number of samples collected as well as costs for supplies and labor. Funding for these projects will be determined when analyses are scheduled to begin so current costs and overhead can be assessed.

The NECSI project team will ensure timely delivery of data and metadata from individual projects, followed by distribution of these data products to the DSCRTP. Meetings with the DSCRTP data management team were held prior to the beginning of each field season to help streamline data collection and dissemination. Highlights from each field project will be submitted to the DSCRTP within two weeks of the completion of the cruise. Data products will be generated as soon as possible after the field component in which they originated, reviewed, then, made available to the DSCRTP for archiving and incorporating into existing databases. Every effort will be made to meet council deadlines. However, data processing, analysis, and quality control is quite time consuming. Other data products resulting from the NECSI will not be available in the short term, but submitted for archiving as soon after completion as possible. Metadata and data generated for the individual projects will be provided to the project team as they become available. The project team will review these products then make them available to the DSCRTP for archiving and

incorporating into existing databases. Some data generated through this program will also be incorporated in databases at the NEFSC and NOS. Other data, such as the multibeam maps and predicted distribution maps for coral and sponge, will be incorporated into spatial databases housed at NEFSC as well as well archived at NCDCC, shared with the councils and posted on portals such as MARCO.

Communication within and between the project team and collaborators will be key to successful completion of the NECSI. An annual meeting of key participants and team members will be held at a convenient location to discuss results, issues and any changes in the planning of the project. Phone conferences will be held as necessary to make sure that projects are on track and being carried out efficiently. At least one representative of the DSCRTP will be included in all planning meetings and phone conferences to maintain communication with headquarters. Annual reports of progress and results will be produced and submitted to the DSCRTP in October. Data, results and important findings will be communicated to the public through the councils and NEFSC websites. The New England and Mid-Atlantic Fishery Management Councils will be informed of results and progress through direct communication via updates to council staff. This line of communication is already open; both councils were consulted before cruise plans were initiated. Formal meetings will be held with each council at the beginning and end of each field season. Other outlets for public outreach include the NEFSC website, Ocean Exploration website, NOAA Teacher at Sea blogs, and the Smithsonian Institution, Department of Invertebrate Zoology blog (NoBones) and Twitter feed.

SECTION 5: RISK MANAGEMENT PLAN

We anticipate four types of challenges to successful completion of this three year project; availability of ships, technical challenges, logistical challenges and budgetary challenges.

Ship time and availability of ships possessing the capabilities necessary to conduct the proposed fieldwork is the biggest challenge for the NECSI. In several instances, ship time requests were made and in place for over a year with every expectation that time would be granted. Knowledge that requests are denied often comes at the beginning of the fiscal year. Securing other assets late in the scheduling process can be extremely difficult. We try to be as flexible as possible by having several options for field exercises (both in scope and location of project) available that meet the objectives and priorities of the NECSI and the DSCRTP. When ship time is secured, we can match a field plan and location to the capabilities of the ship.

The NECSI will utilize a variety of technology and equipment to accomplish project objectives. Technical challenges always have to be met when working with advanced, automated systems in remote locations. In each case, we will attempt to have an operational back-up system available in case a technical issue cannot be resolved. For example, a towed camera system is the primary sampling gear for several major field campaigns. During this fieldwork, complete sets of spare parts will be onboard for the duration of the fieldwork in case of a breakdown so repairs can be made quickly and lost days at sea minimized. When practical and reasonable, we will have other

types of sampling gear on board so some data collection can continue while the camera is nonoperational.

Careful planning and communication among the investigators will help to minimize logistical challenges. Coordination with other NOAA activities such as multibeam surveys and OER ROV expeditions on the *Okeanos Explorer* will also be necessary. We will open and maintain clear communication channels between the NE planning team and NEFSC and other coral and sponge research in the region to monitor coral and sponge issues and research accomplishments throughout the duration of this 3-year project. We will also strive to have sufficient lead time on all of our field related activities so work can be conducted in a timely manner and progress is not hindered.

The final challenge we will face is budgetary. Uncertainty of budget cuts, availability of funds, and operating under continuing resolution all add to the challenge of matching field programs and availability of funds. Sequestration and other government-wide deficient-reduction cuts hindered planning efforts for fieldwork because most are reluctant to commit assets if funding is not secure. We anticipate this will pose an ongoing and high-impact challenge. We will work with the DSCRTP as well as third party recipients of funding to maximize budgetary flexibility and minimize impact. Some contracts may need to be paid up-front, while other work will be postponed until funds become available. Alternatively, where timing of field operations and analyses are tight, institutions and/or investigators may be reimbursed for time and supplies "donated" to the initiative while budget issues were being resolved.

SECTION 6: PROJECT TEAM

NMFS-Northeast Fisheries Science Center Representative.
Team Lead: Rich Langton

- Along with Chief Scientist, responsible for the overall planning, execution, and coordination of the three-year field effort including coordinating individual projects, ship requests, and field activities.
    - Keeps headquarters informed of schedules for research cruises, issues encountered, and opportunities for leveraging additional expertise or resources.
    - Oversees the preparation of expedition cruise data management plans or agreements that identify data sets to be acquired and meet draft national program criteria; submits these to headquarters before the cruise.
    - Mobilizes regional outreach staff to conduct media and public outreach activities associated with the fieldwork, if any.
- Coordinates preparation and ensures submission of the three-year science plan and field research deliverables to headquarters.
    - Ensures fieldwork data are accessible and appropriately archived within NOAA.
    - Ensures that the identified core data deliverables are submitted to the headquarters data management point of contact.
- Provides regular updates to headquarters on project status at six month intervals and upon completion of cruise activities components.

NMFS-Northeast Fisheries Science Center Representative
Chief Scientist: Martha Nizinski

- Along with Team Lead, responsible for the overall planning, execution, and coordination of the three-year field effort including coordinating individual projects, ship requests, and field activities.
- Ensures the research method and results are scientifically sound.
- Identifies NMFS deep-sea coral information needs and NMFS science assets.
- Builds synergy with collaborators and the larger regional scientific community to advance deep-sea coral program priorities.
- Oversees interim and final results in reports, publications and presentations; contributes to media and public outreach activities if any.
- Identifies scientific and advanced undersea technologies that can contribute to the three-year field effort.

NMFS-Northeast Fisheries Science Center Representative
Dave Packer

- Contributes to, and supports, Team Lead and Chief Scientist decision making and planning efforts.
- Supports and assists Team Lead and Chief Scientist and implements their directives.
- Leads or supports individual projects as necessary.

NMFS-Northeast Regional Office Representative
David Stevenson

- Responsible for ensuring coordination with the NEFMC/MAFMC and NMFS regional management responsibilities (e.g., Essential Fish Habitat information needs).

OAR-Office of Ocean Exploration and Research Representatives
John Tomczuk

- Serves as a headquarters liaison to the Deep-sea Coral Team.
- Builds synergy between the program-funded fieldwork and OAR's deep-sea coral science activities.

NOS-National Centers for Coastal Ocean Science Representative
Brian Kinlan

- Builds linkages with NOS science assets and expertise.
- Oversees and coordinates GIS, habitat suitability modeling efforts and supports groundtruthing efforts.

NOS-Marine Sanctuaries Representative
Paul Ticco

- Assesses planned science activities for effectiveness in coordinating with management needs and actions.

SECTION 7: THREE-YEAR WORKPLAN

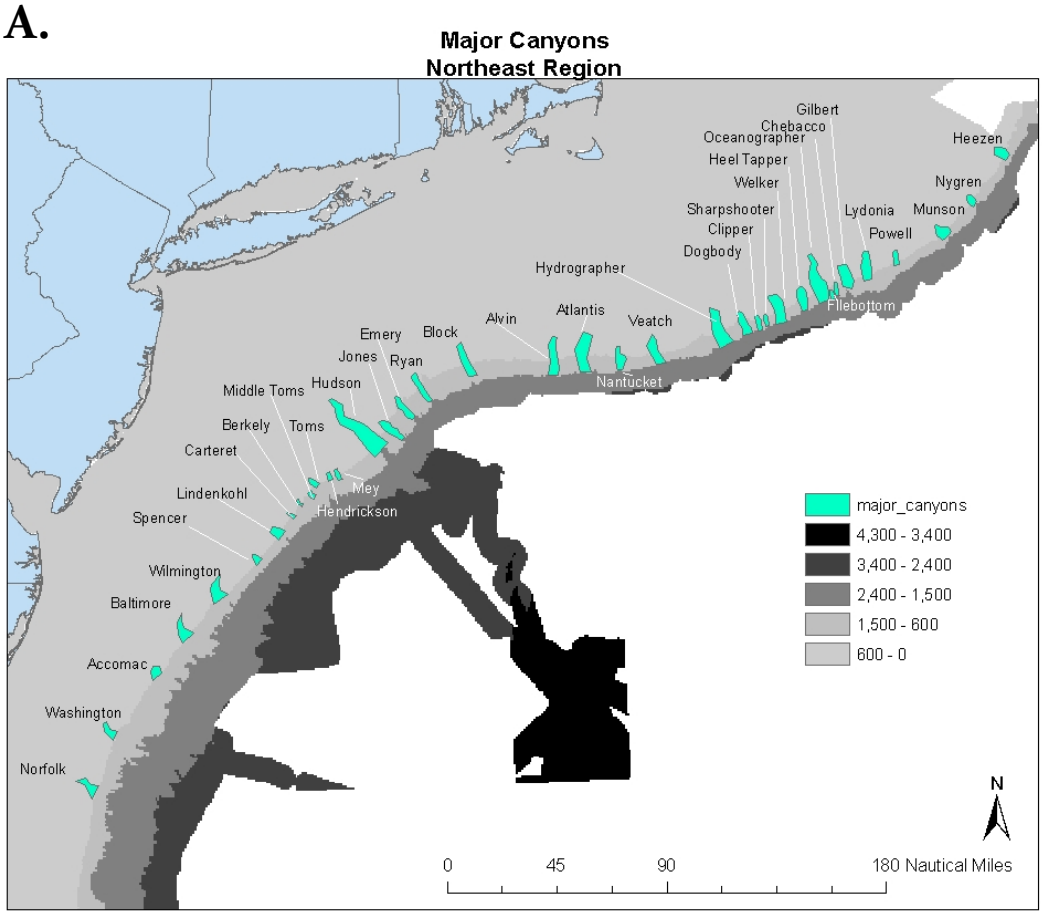
The major activities planned for the NECSI implementation are listed in the table below (with cost estimate to the DSCRTP and target date for milestones). Table will be amended once negotiations are completed for FY14-15 work. The map below shows where each activity will occur in Northeast.

Major Activity	Activity Costs/Labor	Milestones	Target Date
Canyons cruise using *TowCam* (FY13 Field Project 1)	$98,700	Multibeam mapping of bathymetry and backscatter for priority canyons continues	Q1 2013
		Maps processed by OER and delivered to NEFSC	Q3 2013
		Bottom imagery collected on 36 transects	Q3 2013
		Images processed for presence/absence, abundance and diversity of corals, sponges and fishes	Q4 2013-Q4 2014
		Image data processed and delivered to DSCRTP	Q1 2015
Gulf of Maine Jordan Basin cruise (FY13 Field Project 2)	$288,000	Video and bottom imagery collected on 24 transects	Q4 2013
		Video and images processed for presence/absence, abundance and diversity of corals, sponges and fishes	Q4 2013-Q2 2014
		Image data processed and delivered to DSCRTP	Q1 2015
Okeanos Explorer ROV cruise 1 (FY13)	$0	Video collected	Q4 2013
		Video processed for presence/absence, abundance and diversity of corals, sponges and fishes	Q1-4 2014
		Image data processed and delivered to DSCRTP	Q4 2014
Okeanos Explorer ROV cruise 2 (FY13 Field Project 3)	$300,000	Video collected	Q4 2013
		Video processed for presence/absence, abundance and diversity of corals, sponges and fishes	Q4 2014
		Image data processed and delivered to DSCRTP	Q2 2015
US/Canada cross-border collaboration (Gulf of Maine) (FY14 Field Project 2)	$250,000 (fieldwork only)	Video collected on 14 ROV dives	Q4 2014
		Samples collected for taxonomy, genetics, reproduction, aging	Q4 2014
		Video processed for presence/absence, abundance and diversity of corals, sponges and fishes	Q4 2015
		Video data processed and delivered to DSCRTP	Q4 2015
		Sample processing	Q4 2015
Canyons cruise using *TowCam* (FY14 Field Project 1)	$97,700	Bottom imagery collected on 24 transects	Q4 2014
		Images processed for presence/absence, abundance and	Q4 2015

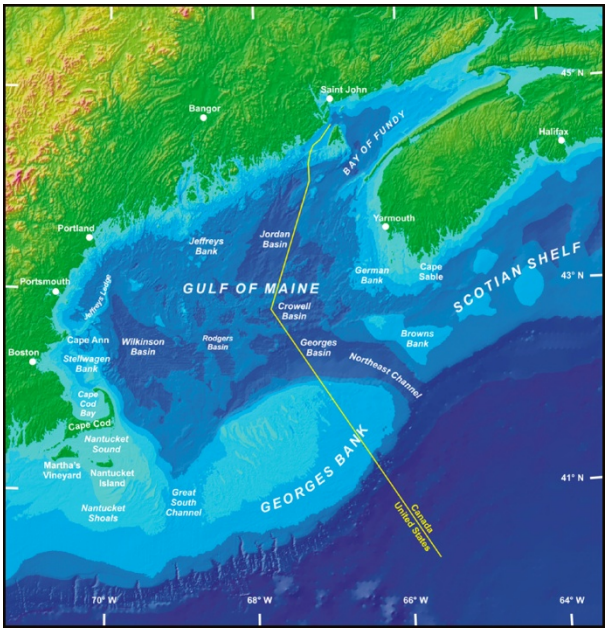
		diversity of corals, sponges and fishes Image data processed and delivered to DSCRTP	Q4 2015
Gulf of Maine Jordan Basin cruise (FY14 Field Project 3)	$376,000	Video and bottom imagery collected on 14 ROV dives Samples collected for taxonomy, genetics, reproduction, aging Video and images processed for presence/absence, abundance and diversity of corals, sponges and fishes Video data processed and delivered to DSCRTP Sample processing	Q4 2014 Q4 2014 Q4 2015 Q4 2015 Q4 2015
Okeanos Explorer ROV cruise (FY14)	$0	Video collected Video processed for presence/absence, abundance and diversity of corals, sponges and fishes Image data processed and delivered to DSCRTP	Q4 2014 Q4 2015 Q4 2015
Sea pens – Gulf of Maine	$0 (FY14 $TDB	Pilot study Cruise, sample collection Sample processing	Q3 2014 Q3 2015 Q4 2015
Sample analysis	$TBD (cost dependent on sample number)	Taxonomy, sample curation Genetics (barcoding, connectivity, taxonomy) Reproduction Aging	Q4 2015 Q4 2015 Q4 2015 Q4 2015
Video analysis	$TDB (cost dependent quantity of work and abilities of processor)	Video and images processed for presence/absence, abundance and diversity of corals, sponges and fishes (all remaining unanalyzed video from all previous cruises)	Q4 2015

Figure 1. Location of major study areas in Northeast. A. Deepwater canyons. B. Gulf of Maine.

A.



B.



APPENDIX 1: FY13 IMPLEMENTATION PLAN AND BUDGET

Introduction

The Northeast region extends from Maine to North Carolina and eastward out to the boundary of U.S. Exclusive Economic Zone (EEZ) encompassing the continental shelf and slope of Georges Bank, southern New England, and the Mid-Atlantic Bight to Cape Hatteras as well as four New England Seamounts (Bear, Physalia, Mytilus, and Retriever). Of particular interest in the region is the Gulf of Maine, where diverse benthic habitats are found on rocky ledges, soft sediment banks, and within the 21 deep basins (the largest and deepest being Jordan, Wilkinson, and Georges). Georges Bank, another prominent feature in the region, is a shallow elongate extension of the continental shelf bounded by the Gulf of Maine to the north, Great South Channel and Nantucket Shoals to the west and south, and the Northeast Channel/Scotian Shelf to the east and north (U.S. jurisdiction ending at the Hague Line). This region supports a diverse assemblage of deep-sea corals and sponges.

A number of important research questions that need to be addressed for effective management of these ecosystems were identified by the New England and Mid-Atlantic Fishery Management Councils, and an August 2011 Deep Coral and Sponge Priorities Workshop. The Northeast Deep Sea Coral and Sponge Initiative (NECSI) will be carried out in FY13-15 and will address the region's objectives by undertaking four major research projects. The NECSI fieldwork will locate and characterize deep coral and sponge ecosystems in the Gulf of Maine, deepwater canyons and seamounts though a systematic field survey developed in part with results of our habitat suitability model. The NECSI will also try to incorporate projects that research the biology and ecology of deep coral and sponge ecosystems by studying species associations and habitat use by economically important fishes and other fauna associated with deep coral and sponge ecosystems. Projects that improve understanding of deep-sea coral and sponge biodiversity and ecology will be included through collection of specimens to resolve taxonomic issues and genetic connectivity between North Atlantic populations. Finally, the potential to set up cost-effective long term monitoring for environmental variables that influence deep coral and sponge communities will be explored. At the conclusion of this project we hope to have advanced knowledge of deep-sea coral and sponge distributions, abundance and ecology in the Northeast region so that management decisions to conserve and protect these habitats will be based on science not inference.

Project Strategy

The general approach for the first year (FY13) of the NECSI will be reconnaissance of areas where deep-sea coral and sponges may or are known to occur. These under-explored or unknown study areas are of particular interest to the Councils. The main priority for Northeast region is gaining a better understanding of distribution of corals. The region has relied heavily on historical data; the need for contemporary ground-truthed data is essential and mission critical to the Northeast program. These field initiatives will lay the groundwork for sampling in the following years. Modeling work will continue as contemporary deep-sea coral/sponge distribution data are used to refine the next iterations of the northeast's deep-sea coral habitat suitability model. Analysis of

images collected during major field campaigns will begin. Additionally, we will explore the potential for and practicality of long-term monitoring projects.

In FY14, the focus will shift to sample collection. The highest priority field project for this year will be collaborative cross-border work between the US and Canada, using the Canadian ROV ROPOS. This work will be conducted in the northern Gulf of Maine, moving back and forth across the border and will include work in northern canyons and the Canadian Discovery Corridor. We will also revisit coral hotspots in areas of interest within Jordan Basin (Gulf of Maine) and priority deepwater canyons in US waters to continue work on coral and sponge distribution, abundance, and diversity, but with the added benefit of physical samples. Once samples are collected, projects addressing taxonomy, connectivity, reproduction, and age and growth will be explored. Modeling work and image analysis continue. Long-term monitoring will likely begin in FY14.

It is unlikely that any major new field initiative will be undertaken in FY15. Fieldwork will focus on closing data gaps. Data analysis and sample processing will take priority.

The anticipated data products from FY13 will include

- Multibeam maps generated from mapping activities at the Northeast and Mid-Atlantic canyons and New England Seamounts
- Video and image data collected from priority canyons and priority areas in the Gulf of Maine to aid in describing the distribution of coral and sponge ecosystems in that region
- Coral and sponge presence/absence data added to the habitat suitability model
- Geo-referenced coral locations added to national database

Additional Resources

In the first year of the NECSI we will partner with OER Office of Ocean Exploration to map deepwater canyons off the coast of the Northeast Region. Bathymetry and backscatter data for deeper portions (> 500 m) of all canyons from Virginia to the Canadian border will collected, processed and archived all at no cost to NECSI. Our partnership with OE will expand in scope and data collection in FY13. Two ROV/telepresence exploration cruises to priority canyon and intercanyon areas are planned. OE will fund the first cruise in total ($500,000), whereas costs for the second cruise will be shared between OE ($200,000) and NECSI ($300,000).

Our partnership with NOS continues and grows stronger as we continue work on the habitat suitability modeling initiative. NOS will provide in-kind matching of resources (e.g., computer software, printing), logistical support and contract labor ($61,500).

Field Project 1 (canyons cruise using TowCam) is heavily subsidized by the NEFSC. The center is supporting this research effort by supplying 15 DAS on the FSV Bigelow ($180,000), and $18,000 to offset costs of supplies, travel, and overtime.

We also received funding ($30,000) to support a workshop to specifically focus on cameras and delivery systems that address the need to cost effectively and comprehensively characterize offshore macrobenthic communities. This workshop will bring together scientists involved this

type of data collection. The results of this workshop would be a published report, by NOAA, reviewing the state of these technologies and making recommendations on what improvements could be made toward developing the "ideal" system for this kind of work.

Data Management

Cruise highlights will be submitted to DSCRTP at the end of each cruise. We expect there will be some post-processing of the data to final products (i.e. examining images and video to collect presence/absence data and identify corals and sponges to the lowest taxonomic level possible). When completed, we will review the data and data products and transfer these to the DSCRTP in a realistic timeframe, as well as archive data at the NEFSC. Much of these data will also be incorporated into existing databases. This will allow the data to be archived "locally" and utilized by other users.

Most of the projects initiated in FY13 will require additional years of collection, so in many cases full analyses of data will be completed at the end of the project life-time (FY15).

Budget Table for FY13

Description	Totals
Salaries and wages	$0
Fringe benefits	$0
Travel	$13,800
Contractual	$767,500
Supplies and materials	$11,250
Equipment	$3000
Others	$4450
Indirect cost	$0
Direct cost	$800,000
Matching or leveraged cost	$989,500
Total cost	$1,789,500

Budget Justification

Most of the funds in FY13 will be used to support contracts for vessels and technology for data collection. There will be no costs to support direct salary or benefits. Other significant expenditures include travel and purchase of supplies. A detailed breakdown of costs are given by category below.

Travel:

- $4800 will be used to support travel for team members to an annual planning meeting
- Travel to the field for scientists ($5,000)
- Invitational travel for expert consultations on coral/sponge identifications ($4000)

Contracts:

- Contract for *TowCam* ($98,700, Project 1)
- Contract for a charter vessel and towed camera system for 14 days to investigate understudied or unknown coral areas in the Jordan Basin ($288,000, Project 2)
- Contract for partial support of 19 day ROV/telepresense mission to deepwater canyons on NOAA ship *Okeanos Explorer* ($300,000, Project 3)
- Contract for labor in support of modeling ($68,000, Project 4)
- Contract for image processing ($12,800, general support)

Supplies and materials:

- Supplies and materials include field supplies, data storage, and laboratory and office supplies ($11,250)

Equipment:

- Imaging processing station ($3,000)

Other:

- Cost from the "Other" category include overtime for scientists while in the field ($4200) and printing/publications costs ($250)

APPENDIX 2: Individual FY13 Project Descriptions

Field Project 1. Photographic surveys and exploration of deep-sea corals and sponge habitats in submarine canyons and slope areas off the Northeast and Mid-Atlantic using a towed camera system

Lead Investigators: Martha Nizinski - NEFSC/National Systematics Lab (Martha.Nizinski@noaa.gov); Timothy Shank - Woods Hole Oceanographic Institution (tshank@whoi.edu).

Collaborators: Dave Packer - NEFSC/James J. Howard Marine Sciences Laboratory (dave.packer@noaa.gov); Brian Kinlan - NOS/NCCOS (brian.kinlan@noaa.gov); Elizabeth Shea - Delaware Museum of Natural History (eshea@delmnh.org); Michelle Bachman - NEFMC (mbachman@nefmc.org); Kiley Dancy - MAFMC (kdancy@mafmc.org); David Stevenson - NERO (david.stevenson@noaa.gov).

Project Duration: Year 1: June 2013, WHOI *TowCam*.

Funds Requested: Year 1 = $98,700.

Background and Justification: The 2012 Atlantic Canyons Undersea Mapping Expeditions (ACUMEN) field efforts finished with a cruise in July aboard the NEFSC's FSV *Henry B. Bigelow* (M. Nizinski, chief scientist) to survey and ground-truth known or suspected deep-sea coral habitats associated with deepwater canyons off the coast of the northeastern U.S . Funded primarily by NEFSC with additional support through a DSCRTP small grant, overall goals of the mission were to (1) characterize benthic habitats and identify areas where deep-sea corals and sponges are present; (2) ground-truth areas predicted to be coral "hotspots" based on data provided from our deep-sea coral habitat suitability model; (3) ground-truth newly collected multibeam data from the ACUMEN cruises; and (4) ground-truth historical deep-sea coral records. Using WHOI's underwater towed camera system (*TowCam*), we targeted three main canyon areas: Toms Canyon complex in the mid-Atlantic (Toms, Middle Toms, and Henderickson Canyons) and Veatch and Gilbert Canyons off New England. Gilbert Canyon in particular was identified as a deep-sea coral "hotspot" by our habitat suitability model; all three canyon areas were either under-explored or unknown with regards to deep-sea coral and sponge occurrences, and thus were of particular interest to the Councils.

Several data sources guided sampling effort. High-resolution 25-50 m multibeam bathymetric data collected during recent ACUMEN expeditions helped identify significant bottom features that appeared likely coral/sponge habitat. Results of our current deep-sea coral habitat suitability model, which used various physical and biological data to predict coral presence based on conditions found in the locations where corals were previously reported, predicted potential deep-sea coral hotspots. Historical presence records were plotted and used as a general guide.

Over 38,600 high resolution photos were taken along with concurrent sampling of environmental data (e.g. depth, temperature, salinity) to characterize benthic and deep-sea coral/sponge habitats. Each bottom image was visually screened for hard and soft corals, sponges, and fish fauna. Presence/absence information was logged for each image using I-view Media Pro through which data catalogues indicating faunal occurrences were constructed. The collection of

contemporary, geo-referenced deep-sea coral and sponge data increased our knowledge of deep-sea coral diversity and distribution in the Northeast canyons exponentially. Analysis of the images will allow us to create deep-sea coral/sponge habitat maps (Fig. 1) as well as provide data necessary for further our understanding of deep-sea coral and sponge distribution and abundance. Additionally, we will use the results from the survey to revise/refine future predictive habitat models to be developed by NOS/NCCOS and the NEFSC.

From the management perspective, these results prompted the NEFMC and MAFMC to revisit their list of the deep sea coral protections zones. Now that these canyon areas have been directly assessed and deep-sea corals observed in all of them, we can confidently classify them as "assessed" and as "suitable" deep-sea coral habitat and therefore recommend them for protection. In addition, we have higher confidence in using our deep-sea coral habitat suitability model to inform current and future management decisions of the Councils. Both the NEFMC and MAFMC will use information gathered to draft management alternatives to designate deep-sea coral zones in the northeast and mid-Atlantic and implement fishing restrictions necessary to protect the deep-sea corals within those zones. This project also supports the northeast's Habitat Blueprint initiative, a partnership between NERO, NEFSC, NEFMC, and MAFMC, whose goal is to develop and implement a deep-sea coral conservation strategy for this region.

Statement of Work: Following the success of last year's cruise, we will continue our *TowCam* explorations of the unstudied areas of the continental slope and canyons of the northeast and mid-Atlantic during a 15 day cruise aboard FSV *Henry Bigelow* (10-24 June 2013; M. Nizinski, chief scientist). Following the same sampling approach and methodologies as last year, we will visit four additional canyons (Block, Ryan, Powell and Munson; Fig. 2) and two intercanyon slope areas that are unknown and have not been assessed or explored for deep-sea corals/sponges. Deep-sea corals, sponges, and other benthic organisms will be identified from the photos to the lowest possible taxon by WHOI personnel, and density estimates will be obtained where possible. Substrate and topographical information will also be noted, and habitats classified using pre-existing definitions from the literature. To the extent possible, we will try to link these classifications with those of the Coastal and Marine Ecological Classification Standard (CMECS). Coral/sponge location data and associated habitat data (e.g, CTD water property data) will be geo-referenced and mapped with the assistance of IMAG, WHOI, and OER, and will be made available for immediate use by the Councils.

Data collected will be combined with the information collected on the 2012 cruise, and other 2012-2013 cruises, to quantitatively validate and assess the accuracy of the regional predictive habitat model, and to generate a new set of high-resolution predictive habitat models for a variety of deep-sea coral taxa of interest. The new high-resolution predictive models generated with the 2012-2013 FSV *Bigelow* data will fill a critical need for higher-resolution spatial planning tools (for example, to precisely delineate potential coral protection zones), and will also support planning and operations for subsequent 2014 field survey efforts.

The goals of this cruise will be closely coordinated with and tied to our upcoming R/V *Okeanos Explorer*/ROV research cruise to the northeastern submarine canyons and seamounts later in the summer. Data collected will significantly improve our knowledge of the spatial extent of corals in these areas, scales of patchiness, correlation with substratum features, and faunal associations.

Budget Narrative:

1. 36 camera tows using *TowCam*, first pass image processing ($93,600)

2. Travel for mobilization/demobilization ($4600)

3. Supplies, communication ($500)

Over-the-side insurance, required for use of this system in the deep-sea in case of loss, is provided from other sources. NEFSC is providing ship time, and covering additional costs for travel, supplies and overtime for Nizinski and Packer.

Field Project 1 Budget Table

TOWCAM BUDGET	**COSTS**	**SUBTOTAL**	**TOTALS**
A. Travel			
1. Mobe FSV Bigelow Woods Hole, MA to Newport RI			
a. Ground General 2 @ $786	$1,572		
b. Lodging Hotel 2 Rooms 1 Nights @ $250	$500		
c. Per Diem U.S. Cont. 2 People 2 Days @ $57	$228		
		$2,300	
2. Demobe FSV Bigelow Newport, RI to Woods Hole, MA			
a. Ground General 2 @ $786	$1,572		
b. Lodging Hotel 2 Rooms 1 Nights @ $250	$500		
c. Per Diem U.S. Cont. 2 People 2 Days @ $57	$228		
		$2,300	
Total Travel			$4,600
B. Other Direct Costs			
1. Materials and Supplies			
a. Supplies			
1. External hard drives for data, 2 @ $100	$200		
		$200	
2. Other			
a. Communications			
1. Cruise Coordination	$100		
b. Duplicating			
1. Report Creation	$200		
c. MISO Use w/Engineer 36 @ $2,600	$93,600		
		$93,900	
Total Other Direct Costs			94,100
TOTAL COSTS			**$98,700**

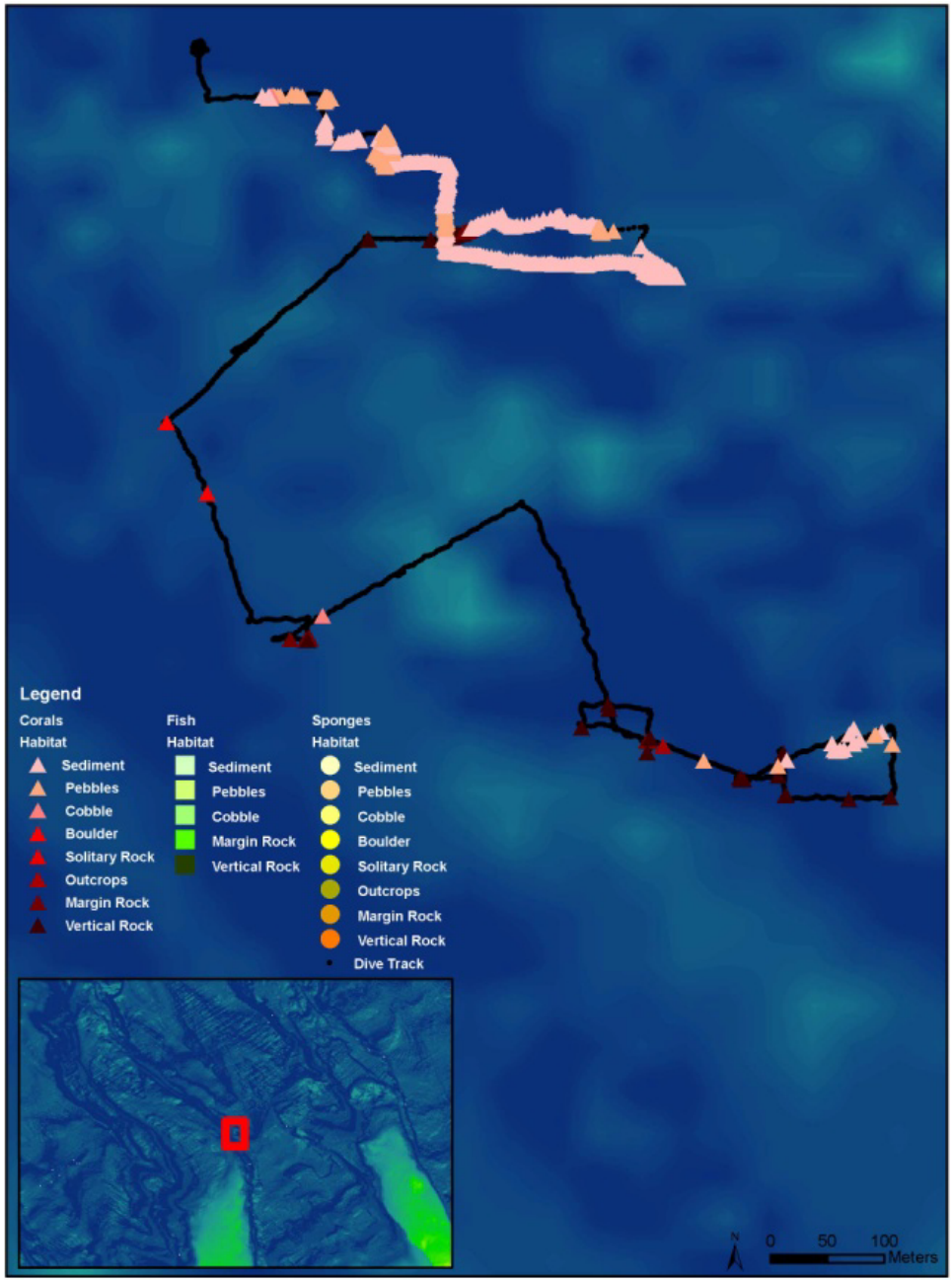


Figure 2. Example of coral habitat mapping. The distribution of corals (triangles) and their associated habitat types (including sediment, pebbles, cobbles, boulders, outcrops, vertical margins, and vertical canyon rock represented by color gradation) documented in 2012 during a single 6.5 hour *TowCam* lowering in Toms Canyon (Dive 2, ~1703 m depth). 27% of the 2067 bottom images contained corals.

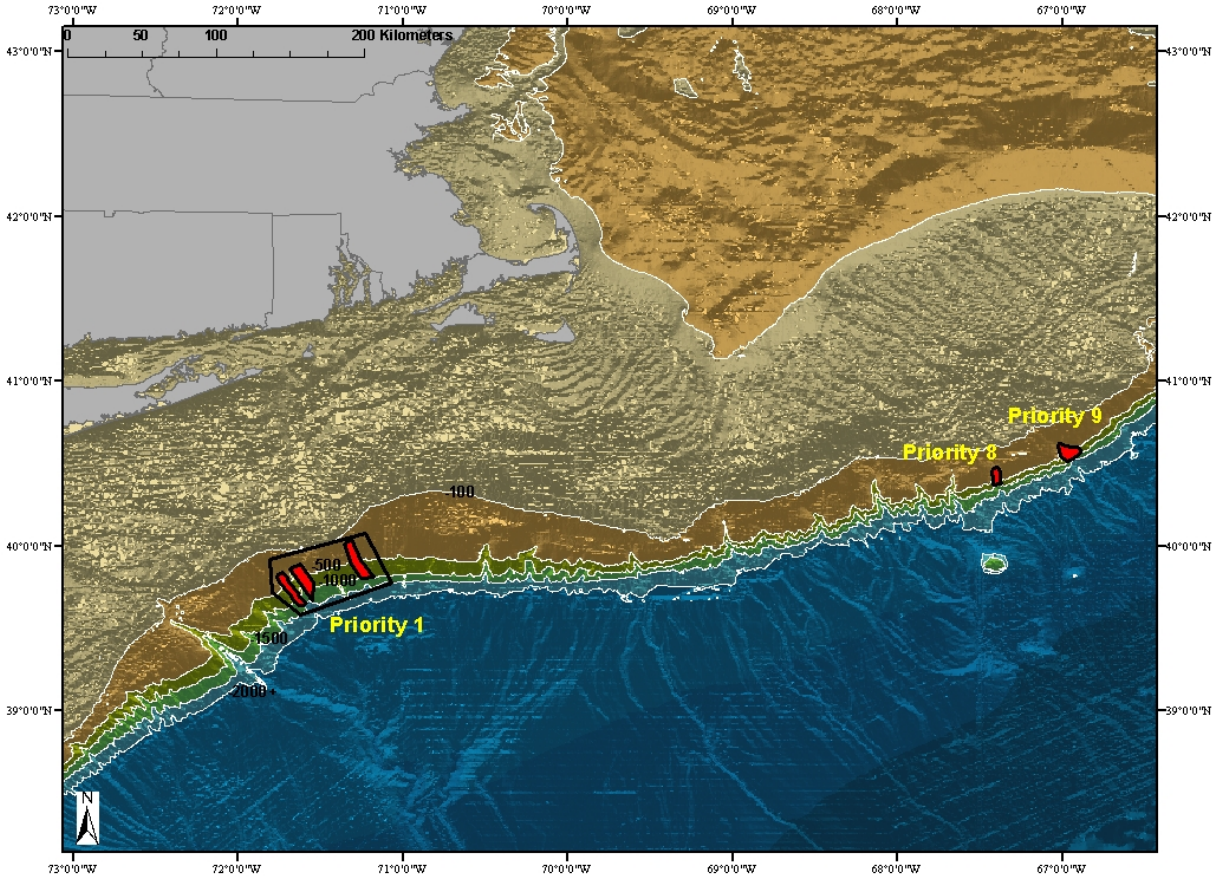


Figure 3. General planned area of operations for the NOAA Ship *Henry B. Bigelow*, Cruise HB 13-02, Deep-Sea Corals and Benthic Habitat: Ground-truthing and exploration in deepwater canyons off the Northeast, 10-24 June 2013.

Field Project 2. Surveys of Northern Gulf of Maine/Jordan Basin Habitat Areas for Deep-sea Corals and Sponges

Lead Investigators: Peter Auster, Department of Marine Sciences and Northeast Undersea Research Technology & Education Center, Univ. of Connecticut at Avery Point (peter.auster@uconn.edu); Dave Packer, NEFSC/James J. Howard Marine Sciences Laboratory (dave.packer@noaa.gov); Martha Nizinski, NEFSC/National Systematics Laboratory (Martha.Nizinski@noaa.gov).

Collaborators: Michelle Bachman, NEFMC (mbachman@nefmc.org); David Stevenson, NERO (dave.stevenson@noaa.gov); Les Watling, Department of Biology, University of Hawaii, Manoa (watling@hawaii.edu)

Project Duration: Year 1: 11-24 July 2013, ISIS 2 Video-camera sled.

Funds Requested: Year 1 = $288,000.

Background and Justification: Section 303(b) discretionary provisions from the 2007 Magnuson Stevens Fishery Conservation and Management Act (MSA) reauthorization provide a flexible mechanism by which to protect deep-sea corals from the effects of fishing. This authority allows Councils to designate protection zones anywhere corals have been identified and implement measures to protect corals within those zones, provided that long term sustainable use of fishery resources has been considered. A range of coral protection alternatives relying on this authority are currently under development by the New England Fisheries Management Council (NEFMC) and the Mid-Atlantic Fishery Management Council (MAFMC). The alternatives will define the boundaries of coral protection zones and implement fishing restrictions within them. The two areas proposed as coral protection zones are located in the Gulf of Maine.

1. Western Jordan Basin

Jordan Basin is 200-250 m deep basin located in the eastern Gulf of Maine. The suggested Western Jordan Basin Deep-Sea Coral Zone is approximately 1300 km^2. This site (Fig. 1A) is proposed based on ROV video observations and sample collections at four stations during research cruises in 2002 and 2003, as well as samples cataloged in the CoWCoG coral database that come from Watling & Auster (2005).

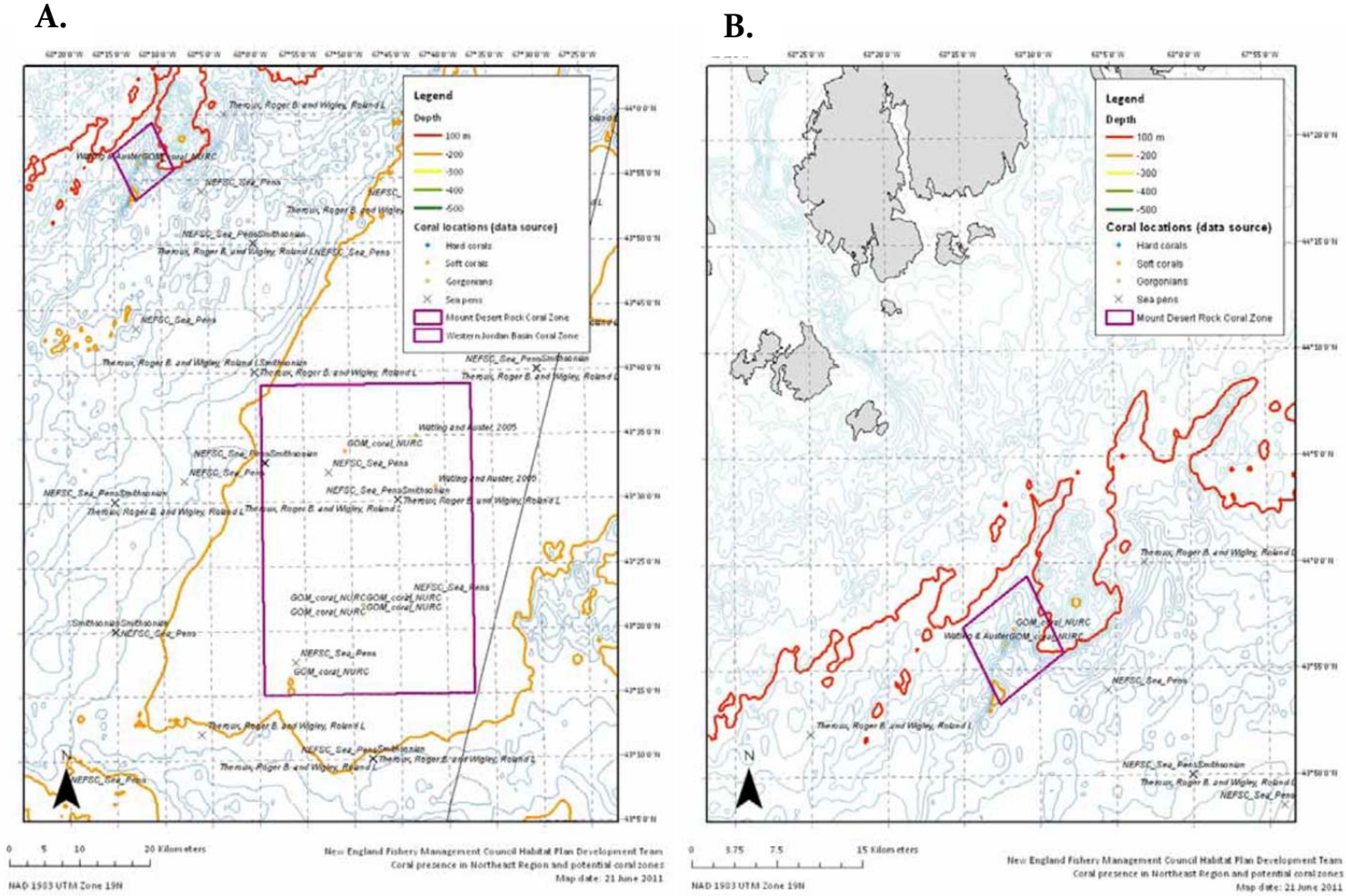
2. Southwest of Mt. Desert Rock

Mount Desert Rock is located approximately 30 km offshore of Mt Desert Island, Maine. The waters immediately surrounding the rock itself are 30-40 meters deep. The suggested coral zone area to the southwest of Mount Desert Rock (approximately 52 km^2) has water depths ranging from approximately 100 m to 200 m (Fig. 1B). The coral zone is proposed based on ROV video observations and sample collections at two stations around Mount Desert Rock made during a research cruise in 2002.

The current boundaries for these sites are based on a very limited set of observations and inference to decide if corals are continuously distributed between stations or are discrete patches. The extent of coral distribution in relation to habitat and landscape features associated with these sites remains unknown and is difficult to predict with a high degree of confidence. We plan to conduct visual surveys at depths from 100 - 250 m, using a towed video and digital still imaging

system, to delineate the spatial extent of deep-sea coral species in this region of the northern Gulf of Maine.

Figure 4. Map depicting A. western Gulf of Maine NEFMC proposed deep-sea coral protection zones; and B. Mount Desert Rock NEFMC proposed deep-sea coral protection zones.



Statement of Work: We will collect seafloor imagery (i.e., continuous video and digital still) extending from the deep-sea coral locations used to delineate the existing coral conservation zones. During this 14-day cruise, we will dedicate 3 survey days to the Jordan Basin area (1 day effort in each of 3 areas; approximately 5 track miles of imagery at each site) and 7 days to working northeast to the Canadian border and southwest from Mount Desert Rock (approximately 1 nm transect at each station; approximately 4 stations per day; 28 stations total, Fig. 2). Survey patterns will vary based on area. In Jordan Basin parallel linear transects will expand from central points determined from previous ROV dives in 2002-2003. Multibeam data will guide transect design. In the Mount Desert Rock area we plan to conduct a set of triplicate

parallel transects at sites previously observed to contain corals in order to assess within site variability in distribution and abundance. Single transects at widely spaced stations will be used to assess broad scale distribution. This effort will significantly improve knowledge of the spatial extent of corals in these areas, scales of patchiness, correlation with substratum features, and associations with mobile fauna.

Figure 5. Bathymetric chart of Mount Desert Rock region (Fisheries and Oceans Canada LC 4011). Red rectangles are draft transect stations (n=28) in areas of steep topography and within the depth ranges where corals were observed previously. Each station is approximately 1 nm in length along the long axis.

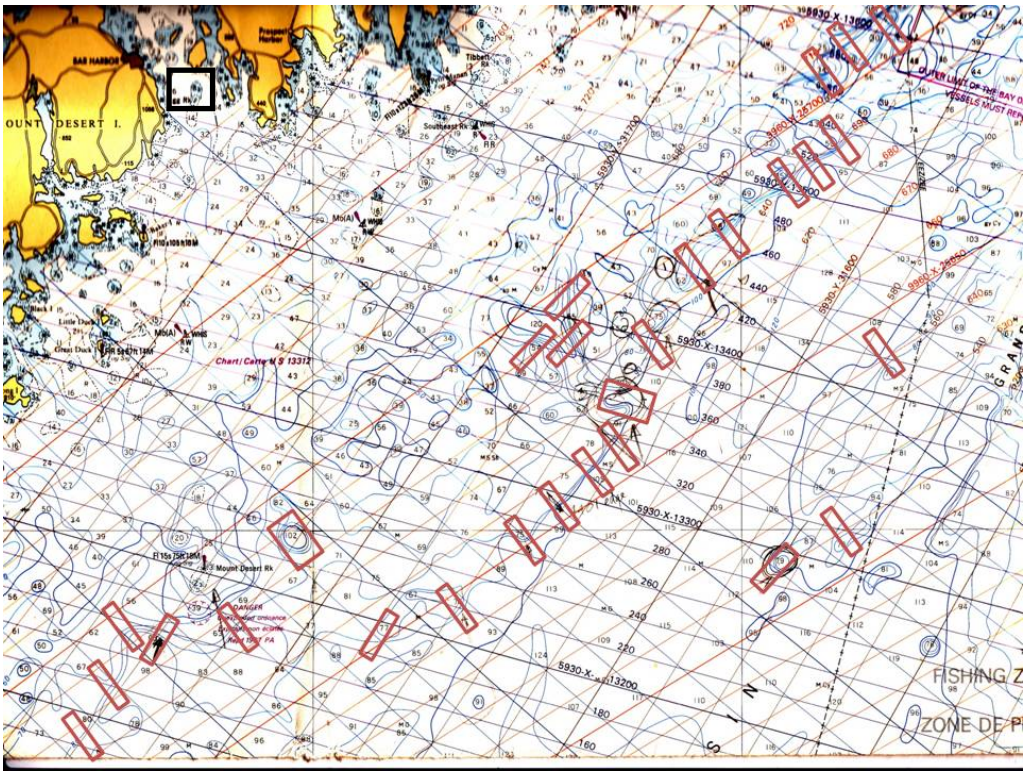


Photo and video images will be analyzed and the deep-sea corals, sponges, and other benthic organisms will be identified to the lowest possible taxon by the Sandy Hook Lab image analysis team (IMAG). Coral locations along transects and patch boundaries will be determined and geo-referenced and used to produce map products and general habitat descriptions that can be of immediate use by the NEFMC in development of the Omnibus Deep-Sea Coral Amendment. Coral location data and metadata will be submitted for inclusion in the DSCRTP's Deep-Sea Coral Geodatabase. Coral distribution data will be used to refine the next iteration of the northeast's deep-sea coral habitat suitability model (Kinlan et al. 2012). Data collected will provide the foundation for several peer-reviewed publications.

Budget Narrative:

The budget includes the following:

1. Fourteen day cruise on RV *Connecticut* with the ISIS2 tethered underwater camera system ($173,685)

2. System configuration ($51,335)

3. Mobilization/demobilization ($24,980)

4. Two mo. salary for P. Auster, who will serve as chief scientist on the cruise and science advisor for image analysis on this project ($38,000)

Field Project 2 Budget Table

Gulf of Maine DSC ISIS Cost Estimates	1000 meter ISIS $5406/day	RV *Connecticut* $7000/day	Total
1. ISIS w 4 Operators for 24 hr operations, 14 DAS System configured with downlooking HD video, hi-res (10 MP) digital stills, lights, parallel lasers, forward looking video and digital stills (3 MP), lights, parallel lasers and Go-Pro HD video, day rate includes insurance and digital storage (HDDs)	$75,685		$75,685
2. RV *Connecticut* for 14 DAS 5 crew for 24 hour ops, 7 Science/Technician berths, Dynamic Positioning		$98,000	$98,000
3. System Configuration	$51,335		$51,335
4. Mobilization Costs per Trip	$8,890	$4,800	$13,690
5. Demobilization Costs per Trip	$8,890	$2,400	$11,290
6. Peter Auster - Scientist	$38,000		$38,000
Total			**$288,000**

Field Project 3. Northeast US Canyons Expedition

Lead Investigators: Kelley Elliott, Craig Russell – OER (Kelley.Elliott@noaa.gov; Craig.Russell@noaa.gov), Martha Nizinski – NEFSC/NSL (Martha.Nizinski@noaa.gov); Jeremy Potter – OAR (jeremy.potter@noaa.gov)

Collaborators: Timothy Shank - Woods Hole Oceanographic Institution (tshank@whoi.edu); Peter Auster - Department of Marine Sciences and Northeast Undersea Research Technology & Education Center, Univ. of Connecticut at Avery Point (peter.auster@uconn.edu); Dave Packer - NEFSC/James J. Howard Marine Sciences Laboratory (dave.packer@noaa.gov)

Project Duration: 3 years: 2013 (multi-beam, ROV operations), 2014 & 2015 (ROV operations)

Funds Requested: $300,000 – Year 1; (Year 2-3 – to be determined)

Background and Justification: In 2012, the Northeast Fisheries Science Center and OER began conversations to coordinate research and exploration activities in and around deepwater canyons in the Northeast region. From these conversations, the ACUMEN initiative was developed. This program leveraged assets from multiple NOAA line-offices to meet the needs of NEFSC, OER, and external partners with interest in the region. Input was sought from MARCO, SeaGrant, New England and Mid-Atlantic Fishery Management councils, NGOs, and academic institutions. Through this program, multibeam bathymetric data and digital still images were collected. Data collected through this collaboration provided information necessary for all partners to gain a better understanding of canyon habitats in general and, more specifically, where deep-sea corals are likely to occur. Additionally, this information was critical to the regional fishery management councils as both are working on management alternatives to protect coral habitats and the ecosystem services they provide. Using newly collected multibeam data, results from the NE region habitat suitability model and historical coral location records, we identified several canyons that may provide appropriate habitat for deep-sea corals and sponges. Towed camera operations in three priority canyons (July 2012) confirmed the presence of deep-sea corals in these areas.

Statement of Work: This project will build on the partnerships forged between Ocean Exploration and Research, Northeast Fisheries Science Center, and Office of Habitat Conservation and data collected during the ACUMEN fieldwork to leverage a major follow-on field campaign in 2013. Field operations would focus on deepwater canyons off the northeastern U.S. and the New England seamounts. High-level objectives include 1) enhance criteria and methods to identify critical habitats in the canyon region, 2) extend mapping coverage and 3) use a telepresence-enabled remotely-operated vehicle (ROV) to explore and characterize priority targets.

We will use a deep-diving ROV to verify the location of deep-sea corals and sponges occurring in canyons designated as priorities by the councils in the western North Atlantic. We have identified at least 8 canyons, occurring on the outer continental shelf/upper slope between New Jersey and the Canadian border, for exploration and in-depth surveys. At each designated canyon, we will run a series of seafloor transects to explore canyon morphology, topography, verify coral presence/absence, areal extent of the coral features and estimate the abundance of corals and sponges. In Year 1 high-resolution multibeam maps will be produced for deeper portions (> 500 m) of all deepwater canyons (major and minor) from Virginia to the Canadian border; data will be made publically available. These maps will facilitate ROV operations and provide important habitat data for potential use in ongoing modeling efforts. The ROV will collect high definition

video and still photos. Several months prior to the cruise, NOAA Office of Ocean Exploration will reach out to interested individuals working in federal and state government, non-government and academic institutions to solicit input to cruise planning. Since DSCRTP will help fund this cruise, priorities set by the NE regional planning team will take priority. This cruise will coordinate with two other cruises to the canyons with the overall goal to explore and run reconnaissance to determine the location of coral habitat as well as the provide information on diversity, distribution and abundance of corals and sponges. Video images will be analyzed and deep-sea corals, sponges, fishes, and other benthic organisms will be identified to the lowest possible taxon. Coral locations will be geo-referenced and used to produce map products and general habitat descriptions for immediate use by the NEFMC and MAFMC. Coral location data and metadata will be submitted for inclusion in the DSCRTP's Deep-Sea Coral Geodatabase.

Budget Narrative:

This field initiative represents a continuation of the successful ACUMEN project with major input of assets by OER. Multibeam mapping missions and one ROV mission to the NE canyons conducted in FY13 by OER to support this collaboration at no cost to the DSCRTP or the NEFSC.

1) *Okeanos Explorer* multibeam mapping missions – no cost to DSCRTP (Year 1)

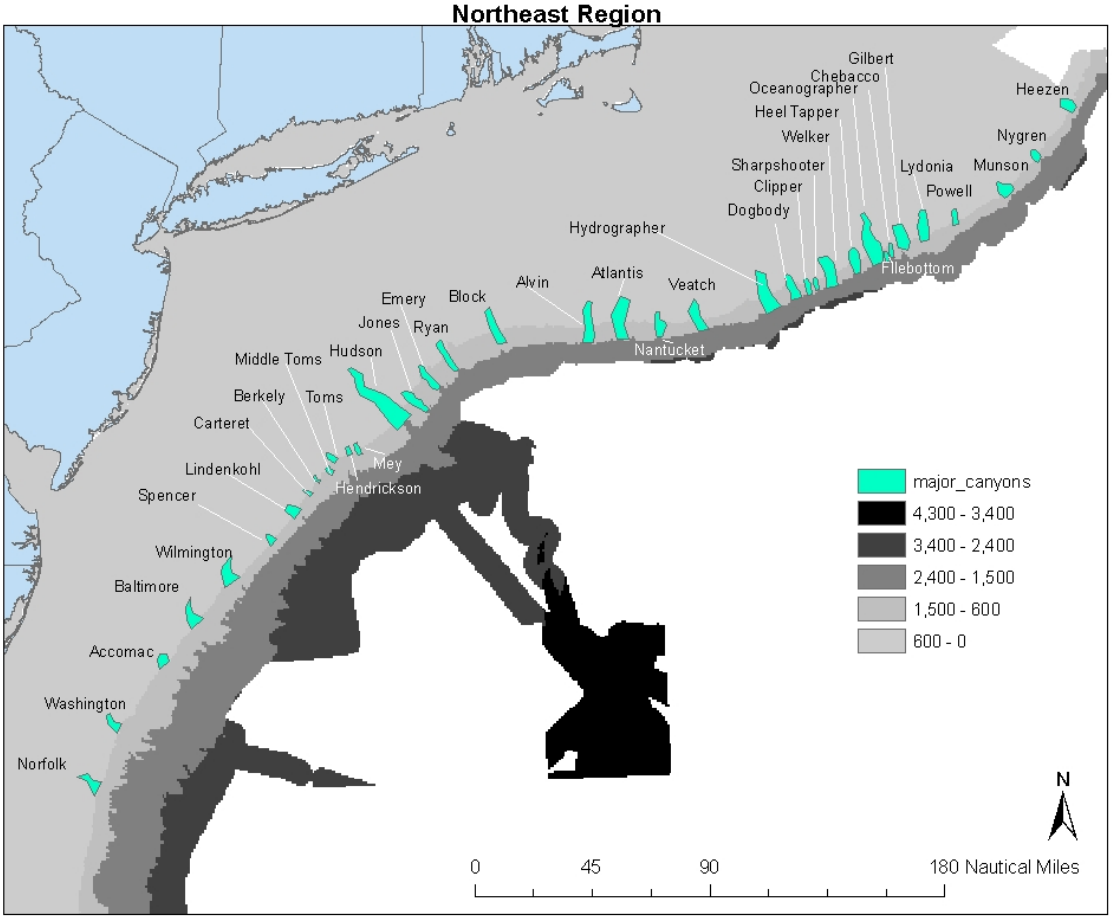
2) OER-funded 18-day ROV expedition to high priority canyons (July 8-25) using NOAA Ship *Okeanos Explorer*. No cost to DSCRTP (Year 1)

2) Second ROV/*Okeanos Explorer* cruise to NE canyons - $300,000 in partial support of ROV crew and tele-presence costs for 19-day mission (Year 1; 31 July-17 August).

Project 3 Budget Table

	Description	Amount FY13
1100	Direct Labor:	
1150	Overtime and Hazard Pay	
1200	Benefits:	
2100	Travel	
2200	Transportation	
2300	Rents et al.	
2400	Printing	
2500	Contracts:	
	ROV/telepresence	$300,000
2600	Supplies and Materials:	
3100	Equipment:	
4100	Grants	
	Total	$300,000

Major Canyons
Northeast Region



FY13 Project 4. Habitat Suitability Modeling

Lead Investigator: Brian Kinlan – (brian.kinlan@noaa.gov), NOS/NCCOS

Collaborators: members of the NCCOS Biogeography Branch; NEFSC (Drohan, Packer, Nizinski)

Project Duration: 3 years: 2013-14 (modeling, cruise support); 2015 (data analysis, final products, cruise support)

Funds Requested: $74,250 – Year 1; $75,500 – Year 2; $151,000 – Year 3

Background/Justification: Over the past 5 years, the DSCRTP supported development of a geospatial database of known coral presence locations in the Northeast/Mid-Atlantic region based on historical records. In 2012, using this geodatabase and a suite of regional-scale environmental predictors, NCCOS and NEFSC scientists produced and ground-truthed the first medium spatial resolution (370 meter) models for deep-sea coral taxonomic groups in this region. Models were fitted using Maxent software, constructed using presence-only data and a suite of environmental variables including bathymetry/terrain, substrate (mean grain size and percent sand/mud/gravel of benthic sediments), and physical, biological, and chemical oceanographic variables. Three major taxonomic groups were modeled: true soft corals/gorgonians (orders Alcyonacea and Gorgonacea combined), sea pens (order Pennatulacea), and stony corals (order Scleractinia). For each major taxonomic group, two subgroups were also considered based on suborder or family-level taxonomy. Models predicted extensive areas of potential habitat on the continental slope, concentrated in submarine canyon areas at 300-2000m depth, for all major taxonomic groups and subgroups modeled. Results identified several unexplored, potential hotspots of suitable deep coral habitat in the northern Mid-Atlantic and New England canyons. A subsequent ground-truthing cruise aboard the NOAA Ship FSV *Henry B. Bigelow* in July 2012 confirmed the existence of these hotspots.

This initial effort highlighted the usefulness of regional habitat modeling for guiding field survey efforts. However, it also underscored the limitations of models based on medium-resolution regional seafloor data and historical presence-only data. Medium-scale bathymetry cannot resolve features on the seafloor known to be important to coral distribution. Moreover, historical coral records do not have the same precision as modern GPS systems allow. Thus, it is difficult to associate fine-scale features of the seafloor to coral precise locations. Additionally, historical records are often limited in taxonomic accuracy and resolution and habitat information associated with many coral collections is often lacking. Effective conservation, management, and field survey planning require higher resolution, higher quality predictions.

Data collected throughout the DSCRTP 3-year field efforts will be used to progressively build a database of far more precise, higher-resolution, and higher-quality coral, sponge and environmental data. This database will be used to develop and progressively improve a high-resolution DSC predictive habitat suitability model for application throughout the Northeast region. The bathymetry and other seafloor geomorphology information already being collected and processed in partnership with OER is more than 50 to 200 times finer resolution than the bathymetry used in the 2012 regional DSC model (<25-50m vs. 370m). State-of-the-art GPS navigation technologies will enable precise geo-referencing of each still photo and video frame collected during towed camera and ROV operations. The Shank lab (WHOI), in collaboration with the NEFSC/NSL at the Smithsonian and the image processing lab at NEFSC/Sandy Hook, will

produce presence, absence, and relative abundance data of coral and sponge taxa identified to the lowest possible taxonomic level. NOS/NCCOS will use these new high-quality, high-resolution data streams to generate improved predictive models of habitat and relative abundance for a greater variety of DSC taxa in the Northeast region. These models will be iteratively ground-truthed and re-fitted as field surveys progress. Model outputs will be used to help plan future surveys, and to guide conservation and management actions in the region. At the end of the 3-year effort, additional analysis and processing time is allocated for preparation of reports, data products, and synthetic analyses. As part of this final synthesis effort, model output maps will be finalized and prepared for wide distribution (including via relevant data portals), and map products tailored to meet management and conservation planning needs.

Scope of Work: Over the course of the 3-year field effort, NCCOS will lead the development and application of predictive habitat modeling, validation and ground-truthing of model predictions, and development of model-derived map products. This effort will be tightly integrated with field survey efforts and will result in iterative updating of model products over the course of the 3-year project, culminating in a final set of high-resolution models with a comprehensive accuracy assessment and map products suitable for use in management and conservation planning.

A senior statistical ecologist (contractor) will lead development of modeling, participate in model ground-truthing and validation, supervise development of reports and products, and lead scientific publications. A marine spatial analyst (contractor) will help develop and conduct modeling under supervision of the senior statistical ecologist. The analyst will assist with mapping, GIS analysis, survey planning, cruise operations, and report and product development. Funds are also budgeted to support publications/communications costs, development of reports and map products (including metadata and section 508 compliance for final products), equipment/supply costs, required computational and hardware and software resources, and federal and contractor travel costs, including travel to/from cruise departure locations and project-related meetings and workshops.

Major tasks to be conducted by NCCOS are:

Year 1 (FY13)

- Acquire and process new high-resolution bathymetry from ACUMEN and other sources to generate high-resolution information on seafloor features (e.g. slope, slope-of-slope, plan and profile curvature, BPI, rugosity)
- Apply regional predictive habitat model results in conjunction with high-resolution bathymetric and seafloor feature information to help plan 2013 research cruises
- Provide map products and GIS support related to predictive habitat modeling for 2013 research cruises
- Generate and distribute research products to NEFSC & DSCRTP scientists
- Participate in June 9-24 cruise aboard NOAA Ship *Bigelow*
- Attend and participate in planning workshops, phone calls, and meetings

Budget narrative FY13:

1. Contract labor: Marine spatial analyst (3 mo.; $36,000)
   Senior statistical ecologist (2 mo.; $29,000)
   Publications/communications specialist (0.25 mo.; $3000)
2. Equipment/supplies ($3000 – computing costs)
3. Travel ($3000)
4. Publication/reporting costs ($250)

	Description	Amount FY13	Amount FY14	Amount FY15
1100	Direct Labor:			
1150	Overtime and Hazard Pay			
1200	Benefits:			
2100	Travel	$3,000		
2200	Transportation			
2300	Rents et al.			
2400	Printing	$250		
2500	Contracts:			
	Labor	$68,000		
2600	Supplies and Materials:	$3,000		
3100	Equipment:			
4100	Grants			
	Total	$74,250		

FY13 Project support. General Overall support

Budget narrative:

1. Contract labor image analysis (2 mo; $12,800)

2. Image processing workstation ($3000)

3. Data storage and computing ($5000)

4 Field supplies and overtime ($7450)

5. Travel (including fieldwork, planning team meetings, and invitational travel for consultation by experts; $10,800)

General Overall FY13 Project Support

	Description	Amount FY13	Amount FY14	Amount FY15
1100	Direct Labor:			
1150	Overtime and Hazard Pay	$4200		
1200	Benefits:			
2100	Travel	$10,800		
2200	Transportation			
2300	Rents et al.			
2400	Printing			
2500	Contracts:			
	Labor	$12,800		
2600	Supplies and Materials:			
	Data storage; computing	$5000		
	Office; collecting	$3250		
3100	Equipment:	$3000		
4100	Grants			
	Total	$39,050		

APPENDIX 2.1: FY13 Individual Project Summaries

Members of the Northeast Regional Planning team designed and conducted a highly successful field season for the NESCI. Three cruises, funded in part by the DSCRTP, collected data on coral and sponge diversity, abundance, and distribution in a variety of under-explored priority areas. These field initiatives included a towed camera survey in Northeast and Mid-Atlantic canyons (Field Project 1), a towed camera survey in Jordan Basin and Schoodic Ridges, Gulf of Maine (Field Project 2), and a ROV survey to the Northeast Canyons (Field Project 3). Overall, 10 canyons, four intercanyon areas, one seamount, and two Gulf of Maine priority areas were explored and surveyed. Collaborations with NOAA partners yielded multiple cruises dedicated to collection of multibeam data and a 19-day ROV cruise to the NE canyons at no cost to the program. Analysis of data collected in FY12 and FY13 cruises is ongoing. Summaries of major field expeditions are provided below.

Field Project 1. Photographic surveys and exploration of deep-sea corals and sponge habitats in submarine canyons and slope areas off the Northeast and Mid-Atlantic using a towed camera system.

During a 15-day (10-24 June 2013) cruise to the Northeast and Mid-Atlantic canyons, we surveyed three major canyons (Ryan, Powell and Munson), one minor canyon between Powell and Munson and two intercanyon slope areas using the WHOI towed camera system *TowCam*. These canyon areas were among those identified as primary, priority targets that previously had not been adequately assessed for presence of deep-sea corals and sponges. Selection of these particular canyons and other survey areas was based on model outputs, data gaps in existing information and input from NEFMC and MAFMC. Primary objectives were to (1) survey canyon and intercanyon slope habitats with concurrent sampling of environmental factors (i.e. depth, hydrography) to characterize benthic habitats and identify areas of coral presence and (2) ground-truth areas predicted to be coral hotspots based on data provided from a habitat suitability model. Over 52,000 high definition images were taken over 22 camera tows; 37,500 of these images were of the bottom, while 12,000 images were of corals. Sampling depths ranged from 489 to 2087 m. Corals were observed in all canyons. However, Ryan Canyon had fewer corals overall, with most corals observed as depths approaching 2000 m. In contrast, Powell and Munson canyons had a much higher frequency of coral observations with the majority of corals observations occurring in mid-depth range between 1200 and 1600 m. Coral diversity was moderate with approximately 10-15 species recognized in images. Surveys of intercanyon areas along the 500 m depth contour yielded few coral observations. This is not surprising given the overall lack of suitable habitat for deep-sea corals (i.e., hard substrata). Metadata on camera tow locations and nominal presence-absence of corals were submitted to the MAFMC. These data were incorporated into planning documents and used by council and FMAT members in discussions concerning corals conservation areas. Images are being QA/QC and analyzed further to produce habitat maps and habitat characterization descriptions. This work is a collaborative effort between NEFSC, NOS, WHOI, the Delaware Museum of Natural History, and fishery management councils. Additional partners include OER's *Okeanos Explorer*, who collected seafloor bathymetry and produced multibeam maps of our primary survey areas.

Field Project 2. Surveys of Northern Gulf of Maine/Jordan Basin Habitat Areas for Deep-sea Corals and Sponges.

During a 14-day (11-24 July 2013) cruise in the northern Gulf of Maine aboard the R/V *Connecticut*, a seafloor imaging survey was conducted utilizing UConn's ISIS-2 (Integrated Seafloor Imaging System version 2) towed camera platform. The primary objective of this cruise was to collect data necessary to assist the NEFMC in selecting deep-sea coral protection zones. Known and suspected deep-sea coral/sponge hotspots were surveyed in five areas (western Jordan Basin, Mount Desert Rock-Outer Schoodic Ridges, Blue Hill Bay, Sommes Sound, near Monhegan Island). Forty camera tows were completed. Deep-sea corals were present at 15 stations, sea pens at 20 stations and sponge fauna at 29 stations. Impressive octocoral communities were discovered in Jordan Basin and the Schoodic Ridge areas of the Gulf of Maine at depths just beyond 200 m. Areas with steep and vertical rock faces had higher densities of octocorals (primarily *Paramuricea placomus* with lower abundances of *Primnoa resedaeformis* and *Acanthogorgia* cf. *armata*) compared to nearby areas with less vertical relief. Some *P. placomus* colonies were over 1 m in height from the base and both yellow and purple color morphs were observed. Preliminary analyses of coral colony densities in digital still images, based on area estimates determined by 20 cm spaced parallel laser dots, revealed densities of approximately 15.7–38.6 colonies m–2 in areas of highest coral abundance. Other areas supported single colonies or small aggregations of coral on exposed gravel patches. These communities are spatially rare in the Gulf and support commercially important species (e.g., Atlantic cod, haddock, Acadian redfish, ocean pout, cusk, white hake, silver hake, pollock, and lobster). Acadian redfish used coral for cover and Atlantic cod, cusk, pollock, and silver hake were observed searching and catching prey (i.e. pandalid shrimp and krill) amidst corals and other attached-emergent seafloor fauna (e.g. *Cerianthus borealis*, *Polymastia* sp.). The common sea pen *Pennatula aculeata* was found in muddy areas surrounding the topographic highs. Pandalid shrimp were common associates of coral colonies. Witch flounder, herring, hagfish, and sculpin were also seen in adjacent habitats.

Metadata on camera tow locations and nominal presence-absence of target fauna have been submitted to the DSCRTP. A post-cruise review of selected still imagery produced the initial set of coral taxa identifications for use in analysis of video imagery. A protocol for throughput of video imagery, selecting and labeling frame-grabs, image enhancement, data types (e.g., taxonomic resolution, habitat classification), data handling (data set structure and storage), and linking to navigation and bathymetric data is being developed by the NMFS James J. Howard Marine Sciences Laboratory image analysis team (IMAG). Detailed extraction of data from video imagery is ongoing. A subset of transects has been selected for initial analyses in order to identify limitations based on image and taxonomic resolution. A note, published in the journal *Biodiversity*, reported the occurrence of coral gardens in the Gulf of Maine. This work is a collaborative effort between NEFSC, University of Connecticut (Dr. Peter Auster) and University of Maine (Dr. Rhian Waller). Additional partners include the Ecosystem Monitoring group of NEFSC and OER's *Okeanos Explorer*, who provided assistance and expertise to produce multibeam maps of seafloor bathymetry at two of our primary survey areas.

Field Project 3. Northeast US Canyons Expedition

From 8 July to 16 August 2013, NOAA Office of Ocean Exploration and Research conducted an extensive survey of the northeast canyons. Leg 2 (July 31 to August 16) of this telepresence-enabled expedition aboard NOAA ship *Okeanos Explorer* was supported in part by the DSCRTP. During this leg of the mission, ROV *Deep Discoverer* (D2) surveyed the area extending between Alvin and Block canyons in the west and Heezen Canyon (eastern limit of the EEZ) to the east. Fifteen dives, ranging in depth from 490 to 3300 m were completed at five named canyons (Nygren, Heezen, Oceanographer, Lydonia, and Welker), one minor canyon (unnamed near Shallop Canyon), two intercanyon sites, two USGS geohazards targets, and Mytilus Seamount.

Preliminary observations indicate that this region supports a high diversity of fauna and habitat types. Initial estimates of species include at least 40 species of corals. Of particular note, were the stand of large-sized *Paragorgia* ("the coral forest") observed in Heezen Canyon, high abundances and large-sized colonies of several octocoral species including, but not limited to, *Paramuricea*, *Primnoa*, *Acanthogorgia*, *Anthothelea*, *Acanella* and other bamboo corals, and anthipatherians *Bathypathes*-related and *Parantipathes*. Scleractinians were not diverse, restricted to medium- to small-sized colonies of *Solenosmilia*, clumps of *Desmophyllum*, and a few individuals of other solitary coral species. *Lophelia pertusa* was likely not observed. Additionally, at least 40 species of fishes as well as numerous species of sponges, crustaceans, cephalopods, echinoderms, and other invertebrates (e.g., salps, siphonophores, bivalves (or brachiopods?)), were observed throughout the dives. Overall, exploration of this region advanced our understanding of species distributions and occurrences, including expanded ranges for certain species. Many questions remain. For example, little is known about connectivity of species found among the canyons examined.

During this expedition, two dives were dedicated to the exploration of Mytilus Seamount, the least explored seamount of the New England Seamount chain. Thus, these dives represent the most comprehensive exploration of this seamount to date. While the areas examined on the north and south sides had very different topography, similar faunal assemblages were observed on both sides of the seamount. The large, smooth basalt rock features were colonized by sponges and corals. No scleractinian corals were observed on either dive, but several species of bamboo corals and other octocorals were noted. Overall, few fish were present. These dives enhanced our understanding of the distribution of species on and among seamounts as well as the faunal relationships between seamounts and submarine canyons.

Exploration and data collection during this expedition has greatly enhanced our understanding of the geomorphology, biodiversity and ecology of the Northeast canyons along the northern US Atlantic margin. Overall, we expanded our understanding of the spatial distributions, both geographic and bathymetric, of species along the continental margin and slope, including observations of species not previously known from the region and species once considered rare. Canyons represent dynamic environments, supporting diverse species assemblages, the composition of which are a function of depth, slope stability, and location within the canyon. It is apparent that the underlying foundation and geological structure are important factors influencing the faunal composition within the canyons. However, the relationship between canyon geomorphology, the role of intercanyon areas, and faunal biodiversity and ecology still are not fully understood.

Appendix 3: FY14 IMPLEMENTATION PLAN AND BUDGET

In FY14, the focus will shift from reconnaissance to sample collection, although model ground-truthing and investigation of new or suspected deep-sea coral and sponge habitats will continue as well. The highest priority field project for this year will be collaborative cross-border work between the US and Canada, using the Canadian ROV ROPOS. This work will be conducted in the northern Gulf of Maine, moving back and forth across the border and will include work in northern canyons and the Canadian Northeast Channel Conservation Area. We will also revisit coral hotspots in areas of interest within Jordan Basin (Gulf of Maine) using the ROV Kraken II. Towed camera surveys in priority deepwater canyons in US waters will continue. Thus, we will continue to collect data on coral and sponge distribution, abundance, and diversity, but with the added benefit of physical samples in some locations. Once samples are collected, we will address and prioritize projects concerning taxonomy, connectivity, reproduction, and age and growth. The majority of funding to analyze samples for these projects will come in FY15. Modeling work and image analysis continue.

The anticipated data products from FY14 will include

- Multibeam maps generated from mapping activities at the Northeast and Mid-Atlantic canyons and New England Seamounts
- Video and image data collected from priority canyons and priority areas in the Gulf of Maine to aid in describing the distribution of coral and sponge ecosystems in that region
- Coral and sponge presence/absence data added to the habitat suitability model
- Geo-referenced coral locations added to national database
- Physical samples

Additional Resources

The Northeast planning team has been extremely successful in finding additional support for the NECSI through partnerships and leveraging assets. As a result, we have more than doubled the investment of the DSCRTP, thus providing additional opportunities to collect data needed by the fisheries management councils and the DSCRTP. A significant amount of fieldwork is now possible in FY14.

Our strong partnership with OER Office of Ocean Exploration continues in FY14. Mapping of deepwater canyons and other areas of interest off the coast of the Northeast Region will be completed. Bathymetry and backscatter data will collected, processed and archived at no cost to NECSI. One ROV/telepresence exploration cruises to priority canyons and seamounts is also planned. OE will fully fund this cruise in total ($500,000).

Our partnership with NOS also continues and grows stronger as we continue work on the habitat suitability modeling initiative and increase our field sampling. By providing assets (computer software and processing) and expertise, NOS is instrumental in cruise planning and field support for several of our planned projects. NOS will provide in-kind matching of resources, logistical support and contract labor ($45,000).

Field Project 1 (canyons cruise using TowCam) is heavily subsidized by the NMFS S&T. S&T is supporting this research effort by supplying 12 DAS on the FSV Bigelow ($180,000). NEFSC contributed $7,000 to offset costs of supplies, travel, and overtime.

The Canadian government is heavily invested in Field Project 2 (Gulf of Maine international collaboration with Canada). All costs associated with transport, mobilization/demobilization and use of the ROV ROPOS are covered by NSERC grants from the Canadian government to our Canadian collaborators. Canadian scientists will also cover their own salaries, travel and supplies needed for participation in this cruise (total contribution $400,000). Additional funding for this project is provided by OMAO ($20,000) and NMFS International Science support (grant to Nizinski, $10,500) in support of modifications needed on the Bigelow to support ROV operations.

Data Management

Cruise highlights will be submitted to DSCRTP at the end of each cruise. Post-processing of the data to final products (i.e. examining images and video to collect presence/absence data and identify corals and sponges to the lowest taxonomic level possible) will be accomplished on shore over a period of several months after the end of the cruise. When completed, we will review the data and data products and expect to transfer data to the DSCRTP in a timely fashion, as well as archive these data at the NEFSC. Much of these data will also be incorporated into existing databases. This will allow the data to be archived "locally" and utilized by other users.

Many FY14 projects are follow-on work to projects initiated in FY13, while others are new initiatives. Therefore, in many cases full analyses of data will not be completed until the end of FY15 at the earliest. Every effort will be made to meet the requirements of the DSCRTP data management team.

Budget Table

Description	Totals
Salaries and wages	$0
Fringe benefits	$0
Travel	$8000
Contractual	$576,965
Supplies and materials	$14,267
Equipment	$0
Grants	$198,518
Other	$2250
Indirect cost	$0

Direct cost	$800,000
Matching or leveraged cost	$1,162,500
Total cost	$1,962,500

Budget Justification

Most of FY14 funds will support contracts and grants for vessels and technology for data collection. There will be no costs to support direct salary or benefits. Other significant expenditures include grants for PI support (Project 3), travel and purchase of supplies. A detailed breakdown of costs by category is given below.

Travel:

- Travel to the field for scientists ($8,000)

Contracts:

- Contract for NOAA ship *Henry Bigelow* for 12 days in support of international collaboration ($177,612, Project 2)
- Contract for modifications needed on *Bigelow* (35,000, Project 2)
- Contract for crane need for mob/demob of ROPOS ROV ($20,000, Project 2)
- Contract for a charter vessel and ROV for 14 days to investigate understudied or unknown coral areas in the Jordan Basin ($273,103, Project 3)
- Contract for labor in support of modeling ($69,250, Project 4)
- Contract for GIS work in support of council needs ($2,000, general support)

Grants:

- *TowCam* ($97,700, Project 1)
- PIs salaries, fringe, travel, supplies ($100,818, Project 3)

Supplies and materials:

- Supplies and materials include field supplies, data storage, and laboratory and office supplies ($14,267)

Other:

- Cost from the "Other" category include overtime for scientists while in the field ($2000) and printing/publications costs ($250)

APPENDIX 3.1: FY14 Individual Project Descriptions

Workshop. Undersea Imaging Workshop, Jan 14-15, 2014.

The New Jersey Sea Grant Consortium (NJMSC) and the NOAA Fisheries James J. Howard Marine Science Laboratory on Sandy Hook invited 30 guests to participate in an Undersea Habitat Imaging Workshop, January 14-15, 2014, in Red Bank, NJ. The purpose of this workshop was to evaluate the strengths and limits of camera and camera-delivery systems for benthic photographic work as one aspect of an overall monitoring strategy. The workshop brought together scientists and engineers from across NOAA and academia to discuss cameras and delivery systems that address the need for cost effective and comprehensive characterization of offshore macrobenthic/demersal communities and habitats in the northeast. Three workshop sessions included: 1) presentations describing 10 different camera/delivery systems associated with workshop participants; 2) discussions about what could be done differently, as well as issues related to work flow of imagery once back in the lab as well as handling, viewing, producing data, storage and retrieval and archiving data; and 3) future directions. A report of the workshop proceedings is in preparation and will be posted on the Web, by the NJ Sea Grant Consortium. NMFS Science and Technology Division provided funding for this workshop.

Field Project 1. Photographic surveys and exploration of deep-sea corals and sponge habitats in submarine canyons and slope areas off the Mid-Atlantic using a towed camera system

Lead Investigators: Martha Nizinski - NEFSC/National Systematics Lab (Martha.Nizinski@noaa.gov); Timothy Shank - Woods Hole Oceanographic Institution (tshank@whoi.edu).

Collaborators: Dave Packer - NEFSC/James J. Howard Marine Sciences Laboratory (dave.packer@noaa.gov); Brian Kinlan - NOS/NCCOS (brian.kinlan@noaa.gov); Elizabeth Shea - Delaware Museum of Natural History (eshea@delmnh.org); Michelle Bachman - NEFMC (mbachman@nefmc.org); Kiley Dancy - MAFMC (kdancy@mafmc.org); David Stevenson - GARFO (david.stevenson@noaa.gov).

Project Duration: Year 1: 14 DAS June 2013, Year 2: 12 DAS, Aug 2014, followed by analysis

Funds Requested: Year 1 = $98,700; **Year 2 = $97,700**.

Background and Justification: The 2012 Atlantic Canyons Undersea Mapping Expeditions (ACUMEN) field efforts finished with a cruise in July aboard the NEFSC's FSV *Henry B. Bigelow* (M. Nizinski, chief scientist) to survey and ground-truth known or suspected deep-sea coral habitats associated with deepwater canyons off the coast of the northeastern U.S. Funded primarily by NEFSC with additional support through a DSCRTP small grant, overall goals of the mission were to (1) characterize benthic habitats and identify areas where deep-sea corals and sponges are present; (2) ground-truth areas predicted to be coral "hotspots" based on data provided from our deep-sea coral habitat suitability model; (3) ground-truth newly collected multibeam data from the ACUMEN cruises; and (4) ground-truth historical deep-sea coral records. Using WHOI's underwater towed camera system (*TowCam*), we targeted three main canyon areas: Toms Canyon complex in the mid-Atlantic (Toms, Middle Toms, and Henderickson Canyons) and Veatch and Gilbert Canyons off New England. Gilbert Canyon in particular was identified as a deep-sea coral "hotspot" by our habitat suitability model; all three canyon areas

were either under-explored or unknown with regards to deep-sea coral and sponge occurrences, and thus were of particular interest to the Councils.

In 2013, a second cruise, aboard the NEFSC's FSV *Henry B. Bigelow* (M. Nizinski, chief scientist) was conducted to survey and ground-truth known or suspected deep-sea coral habitats associated with deepwater canyons off the coast of the northeastern U.S. This cruise, a logical follow-on to previous work, had similar goals and objectives and followed the same sampling protocols. Three major canyons were surveyed: Ryan, Powell, and Munson Canyons. A minor canyon and two intercanyon areas were also surveyed.

In total, over 48,000 high-resolution photos were taken along with concurrent sampling of environmental data (e.g. depth, temperature, salinity) to characterize benthic and deep-sea coral/sponge habitats. Each bottom image was visually screened for hard and soft corals, sponges, and fish fauna. Presence/absence information was logged for each image using I-view Media Pro through which data catalogues indicating faunal occurrences were constructed. The collection of contemporary, geo-referenced deep-sea coral and sponge data increased our knowledge of deep-sea coral diversity and distribution in the Northeast canyons exponentially. Analysis of the images will allow us to create deep-sea coral/sponge habitat maps (Fig. 1) as well as provide data necessary for further our understanding of deep-sea coral and sponge distribution and abundance. Additionally, we will use the results from the survey to revise/refine future predictive habitat models to be developed by NOS/NCCOS and the NEFSC.

From the management perspective, these results prompted the NEFMC and MAFMC to revisit their list of the deep sea coral protections zones. Now that these canyon areas have been directly assessed and deep-sea corals observed in all of them, we can confidently classify them as "assessed" and as "suitable" deep-sea coral habitat and therefore recommend them for protection. In addition, we have higher confidence in using our deep-sea coral habitat suitability model to inform current and future management decisions of the Councils. Both the NEFMC and MAFMC will use information gathered to draft management alternatives to designate deep-sea coral zones in the northeast and mid-Atlantic and implement fishing restrictions necessary to protect the deep-sea corals within those zones. This project also supports the northeast's Habitat Blueprint initiative, a partnership between GARFO, NEFSC, NEFMC, and MAFMC, whose goal is to develop and implement a deep-sea coral conservation strategy for this region.

Statement of Work: Following the success of previous cruises, we will continue our *TowCam* explorations of the under-studied areas of the continental slope and canyons of the mid-Atlantic during a 12 day cruise aboard FSV *Henry Bigelow* (5-16 August; M. Nizinski, chief scientist). Following the same sampling approach and methodologies as last year, we will visit five additional canyons (Washington, Wilmington, Lindenkohl, Spencer, Carteret; Fig. 2) and, time permitting, intercanyon slope areas that are unknown and have not been assessed or explored for deep-sea corals/sponges presence. WHOI personnel will identify deep-sea corals, sponges, and other benthic organisms from images to the lowest possible taxon; density estimates will be obtained where possible. Substrate and topographical information will also be noted, and habitats classified using pre-existing definitions from the literature. Coral/sponge location data and associated habitat data (e.g, CTD water property data) will be geo-referenced and mapped with the assistance of IMAG, WHOI, and NOS, and will be made available for use by the Councils.

Data collected will be combined with information collected on 2012-2013 cruises, to quantitatively validate and assess the accuracy of the regional predictive habitat model, and to generate a new

set of high-resolution predictive habitat models for a variety of deep-sea coral taxa of interest. The new high-resolution predictive models generated with the 2012-2013 FSV *Bigelow* data will fill a critical need for higher-resolution spatial planning tools (for example, to precisely delineate potential coral protection zones), and will support planning and operations for subsequent 2014-2015 field survey efforts.

The goals of this cruise will be closely coordinated with the MAFMC, who is moving forward with plans to delineate coral alternative zones. Proposed alternatives will be submitted for public comment in summer 2014. Results will significantly improve our knowledge of the spatial extent of corals in these areas, scales of patchiness, correlation with substratum features, and faunal associations.

Figure 6. General planned area of operations for the NOAA Ship *Henry B. Bigelow*, Deep-Sea Corals: Ground-truthing and exploration in deepwater canyons off the Mid-Atlantic, 5-16 Aug 2014.

Budget Narrative:

1. Grants: 21 camera tows using *TowCam* ($95,760)

2. Travel: mobilization/demobilization ($1940)

Over-the-side insurance, required for use of this system in the deep-sea in case of loss, is provided from other sources. NMFS/S&T is providing ship time; NEFSC is covering additional costs for travel and overtime for Nizinski and Packer.

Field Project 1 Budget Table

TOWCAM BUDGET	**COSTS**	**SUBTOTAL**	**TOTALS**
A. Travel			
Travel, Mobilization, Demobilization	$1,940		
		$1,940	
B. Other Direct Costs			
MISO Use w/Engineer 21 @ $2,600	$54,600		
Additional engineer, technical support for TowCam ops,			
and analysis	$41,160		
		$95,760	
TOTAL COSTS			**$97,700**

Field Project 2. Benthic communities in the Gulf of Maine on US and Canadian continental margin: Research relevant to deep-sea coral and sponge conservation

Lead Investigators: Martha Nizinski - NEFSC/National Systematics Lab (Martha.Nizinski@noaa.gov); Anna Metaxas - Dalhousie University (metaxas@dal.ca)

Collaborators: Timothy Shank - Woods Hole Oceanographic Institution (tshank@whoi.edu); Brian Kinlan - NOS/NCCOS (brian.kinlan@noaa.gov); Peter Lawton – DFO Canada, St. Andrews (Peter.Lawton@dfo-mpo.gc.ca); Paul Snelgrove – Memorial University (psnelgro@mun.ca); Suzanne Dufour – Memorial University (sdufour@mun.ca); Amanda Demopolous – USGS, Gainesville, FL (ademopolous@usgs.gov); Rhian Waller – University of Maine (rhian.waller@maine.edu); Cheryl Morrison – USGS, Leetown, WV (cmorrison@usgs.gov); Scott France – University of Louisiana, Lafayette (email); Peter Auster – University of Connecticut (peter.auster@uconn.edu).

Project Duration: Year 2: 14 DAS, June 2014, followed by data analysis

Funds Requested: Year 2 = $242,612.

Background and Justification: In 2011, NOAA convened a group of federal, state, academic, and non-governmental organization scientists to identify exploration and research priorities to inform management regarding deep-sea coral and sponge ecosystems in the Northeast region. The purpose of this workshop was to develop a list of critical information needs to guide NOAA's three-year field research initiative on Northeast deep-sea coral and sponge ecosystems planned for FY 2013-15. Canadian colleagues also participated in this workshop and provided input based on their experiences and areas of expertise. Two presentations given at the workshop focused on coral-related activities by Canadian academics and the Department of Fisheries and Oceans. Our Canadian colleagues have a multifaceted research program related to deep-sea corals and sponges, which includes habitat mapping, basic biology, i.e. abundance, distribution, reproduction, recruitment and growth studies, as well as assessing species associations and the role of corals in the structure and function of microhabitats. In terms of management the Canadian approach to identification of sponge and coral 'hotspots', or high density clusters of these organisms, has enabled the closure of specific areas while maximizing fishing opportunities. With the US/Canadian border dividing the Gulf of Maine, both presenters suggested international collaborations as a way to move forward. This might include sharing ship/remotely operated vehicle time, samples and databases as well as sharing our approaches and methodologies on identification and characterization of coral habitats and understanding ecological processes that structure and sustain deep-sea corals.

Given that both American and Canadian scientists share many deep-sea coral research interests, a plan for trans-boundary collaboration was discussed. Since that time, Martha Nizinski, representing the NECSI, and Anna Metaxas, representing the Canadian science team, have worked toward procuring money and resources in support of fieldwork to address research priorities in the northern Gulf of Maine. Scientists from both nations have mutual scientific and fisheries management interests. The potential for continued collaborations and information sharing is high as we work toward a better understanding of the Gulf of Maine as a whole. Fisheries and deep-sea corals do not recognize boundaries therefore collaborative research should be conducted in both US and Canadian waters.

Basic knowledge of deep-sea coral habitats is lacking in much of the Northeast region, but this is particularly true for the northern Gulf of Maine. Similarly, data on faunal distribution, abundance, and diversity are still largely lacking for many deep-sea regions of Atlantic Canada. Baseline and long-term data from this area are required to guide future research, protect sensitive habitats and fisheries resources, and provide managers with information necessary to make informed policy decisions. Quality, contemporary data are needed to manage ecosystems. We propose collaborations with Canadian colleagues in order to gain a better understanding of the northern Gulf of Maine, on both sides of the border, and of the Gulf of Maine as a whole. Fisheries and deep-sea corals do not recognize boundaries therefore collaborative research should be conducted in both US and Canadian waters.

This project will open lines of communication between federal agencies to manage and protect marine resources. US scientists will gain valuable experience working with Canadian colleagues since Canada has conducted deep-sea coral research in the region for a longer period, and has proposed and enacted a variety of conservation initiatives to protect deep-sea coral habitat.

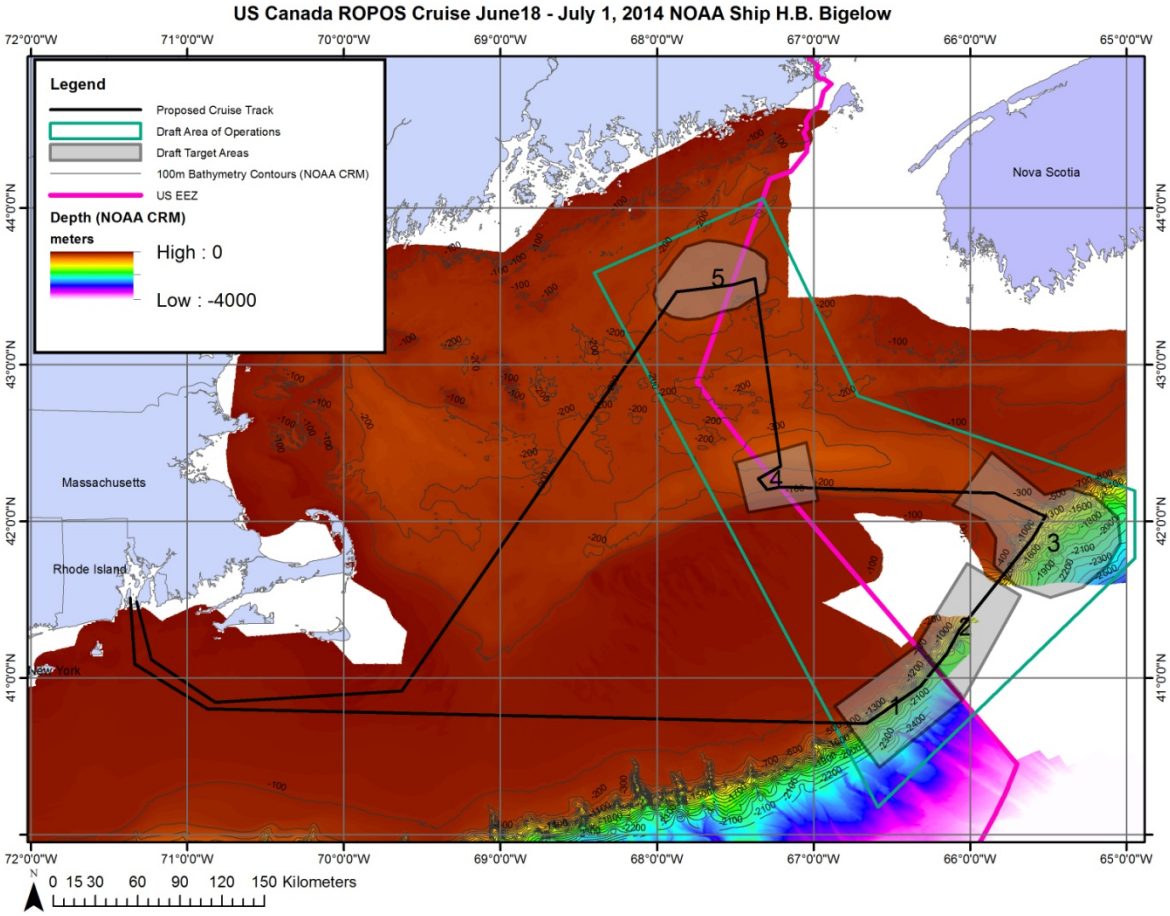
Statement of Work: We propose to explore and survey under-studied areas of the northern Gulf of Maine and continental slope off the northeast region. Working on both sides of the Hague line, we will target four priority areas during a 14-day cruise aboard FSV *Henry Bigelow* (18 June – 1 July 2014; M. Nizinski and A. Metaxas, co-chief scientists). These areas include (1) Jordan Basin; (2) Nygren and Heezen canyons; (3) Corsair Canyon; (4) Northeast Channel Coral Conservation Area (Fig. x). Specifically, we propose to: (1) conduct detailed multibeam mapping of selected areas of known and suspected coral habitat in the Gulf of Maine, on both sides of the US/Canadian border; (2) assess biodiversity; (3) assess deep-sea coral abundance, distribution, size, (4) characterize deep-sea coral habitats using multibeam maps to guide ROV sampling; (5) classify coral and adjacent soft sediment habitats and document faunal affinities; (5) collect deep corals for taxonomic, reproduction, and age analyses; (6) collect deep corals and associated fauna for genetic studies (e.g., phylogenetic, phylogeographic, community genetics, and connectivity); (7) validate habitat suitability models; and (8) refine estimates of coral recruitment.

The principal activities involve measurement of abundance of benthic invertebrates and characterization of spatial patterns in benthic ecosystem structure. ROV ROPOS will be the primary sampling tool. Sampling will include: (1) video transects; (2) digital photographic quadrats; (3) benthic faunal collections (1-2 individuals of species not readily identifiable on video) for morphological or molecular identification; (4) collection of small pebbles and cobbles within metre-square quadrats for measurement of coral recruitment; (5) collection of fragments of coral colonies for taxonomic identification, reproductive analyses, and genetic analyses; (6) collection coral-associated fauna for taxonomic identification and genetic (phylogenetic, connectivity, population genetics) analyses; and (7) sediment coring of small areas.

Deep-sea corals, sponges, and other benthic organisms will be identified from videos and photos to the lowest possible taxon by science personnel on board ship. Density estimates will be obtained where possible. Substrate and topographical information will also be noted, and habitats classified using pre-existing definitions from the literature. Coral/sponge location data and associated habitat data (e.g, CTD water property data) will be geo-referenced and mapped with the assistance of IMAG, WHOI, NOS, and Canadian colleagues, and will be made available for use by the NEFMC. In-depth video and image analyses, QA/QC of coral identifications, habitat characterization will occur on shore at both US and Canadian laboratories. Physical samples

collected for taxonomy, genetics, reproduction, and aging will be dispersed to collaborators, with vouchers deposited in the Smithsonian Institution collections. The majority of sample processing and analysis will occur in FY15.

Figure 7. General planned area of operations for the NOAA Ship *Henry B. Bigelow* for cruise to northern Gulf of Maine on US and Canadian continental margin, 18 Jun – 1 Jul 2014.



Budget Narrative:

Shiptime: 12 days @ $14,801 = $177,612

Ship Modifications: $35,000

Crane rental: $20,000

Travel: $4000

Overtime: $1000

Supplies: $5000

Additional support for ship modifications provided through OMAO and a NOAA Fisheries International Science grant. Two days of ship time are funded by OMAO. Canadian collaborators are covering costs for ROPOS, their travel and supplies through grants from the Canadian government.

	Description	Amount FY14
1100	Direct Labor:	
1150	Overtime and Hazard Pay	$ 1,000
1200	Benefits:	
2100	Travel	$ 4,000
2200	Transportation	
2300	Rents et al.	
2400	Printing	
2500	Contracts:	
	Ship time	$177,612
	Crane	$ 20,000
	Ship Modifications	$ 35,000
2600	Supplies and Materials:	$ 5,000
3100	Equipment:	
4100	Grants	
	Total	$242,612

Field Project 3. ROV Surveys of Northern Gulf of Maine/Jordan Basin Habitat Areas for Deep-sea Corals and Sponges

Lead Investigators: Peter Auster, Department of Marine Sciences and Northeast Undersea Research Technology & Education Center, Univ. of Connecticut at Avery Point (peter.auster@uconn.edu); Rhian Waller, School of Marine Sciences, Darling Marine Center, University of Maine (rhian.waller@maine.edu); Dave Packer, NEFSC/James J. Howard Marine Sciences Laboratory (dave.packer@noaa.gov); Martha Nizinski, NEFSC/National Systematics Laboratory (Martha.Nizinski@noaa.gov).

Collaborators: Michelle Bachman, NEFMC (mbachman@nefmc.org); David Stevenson, GARFO (david.stevenson@noaa.gov); Les Watling, Department of Biology, University of Hawaii, Manoa (watling@hawaii.edu)

Project Duration: Year 1 = 14 DAS; Year 2: 14 DAS, followed by analysis

Funds Requested: Year 1 = $288,000; **Year 2 = $375,921**

Background and Justification: Section 303(b) discretionary provisions from the 2007 Magnuson Stevens Fishery Conservation and Management Act (MSA) reauthorization provide a flexible mechanism by which to protect deep-sea corals from the effects of fishing. This authority allows Councils to designate protection zones anywhere corals have been identified and implement measures to protect corals within those zones, provided that long term sustainable use of fishery resources has been considered. A range of coral protection alternatives relying on this authority are currently under development by the New England Fisheries Management Council (NEFMC) and the Mid-Atlantic Fishery Management Council (MAFMC). The alternatives will define the boundaries of coral protection zones and implement fishing restrictions within them. Two areas proposed as coral protection zones are located in the Gulf of Maine: western Jordan Basin and Schoodic Ridge - Mt. Desert Rock Area. The current boundaries for these sites are based on a very limited set of observations and inference to decide if corals are continuously distributed between stations or are discrete patches. The extent of coral distribution in relation to habitat and landscape features associated with these sites remains poorly known and is difficult to predict with a high degree of confidence.

Towed camera surveys conducted in 2013 (Field Project 2) in these areas revealed impressive remnant coral and sponge gardens (i.e., areas of high deep-sea corals and sponges abundances) in several locations. More information is needed regarding the spatial extent of these habitats, as well as determining species composition, abundance, size, and density of deep-sea corals and sponges.

We plan to conduct ROV surveys at depths ranging from 200 - 250 m at priority tow sites (determined based on the 2013 survey results). Use of an ROV will allow us to delineate, with greater precision, the spatial extent and densities of deep-sea coral and sponge habitats and their associated species in this region as well as make vital collections of corals, sponges and associated fauna. Collections are especially important to confirm identifications and provide material for reproduction, age, and genetic analyses.

Figure 8. Map depicting western Gulf of Maine Jordan Basin priority tows from the 2013 field survey using the ISIS2 towed camera system. Multibeam bathymetry obtained during the *Okeanos Explorer* EX1306 cruise.

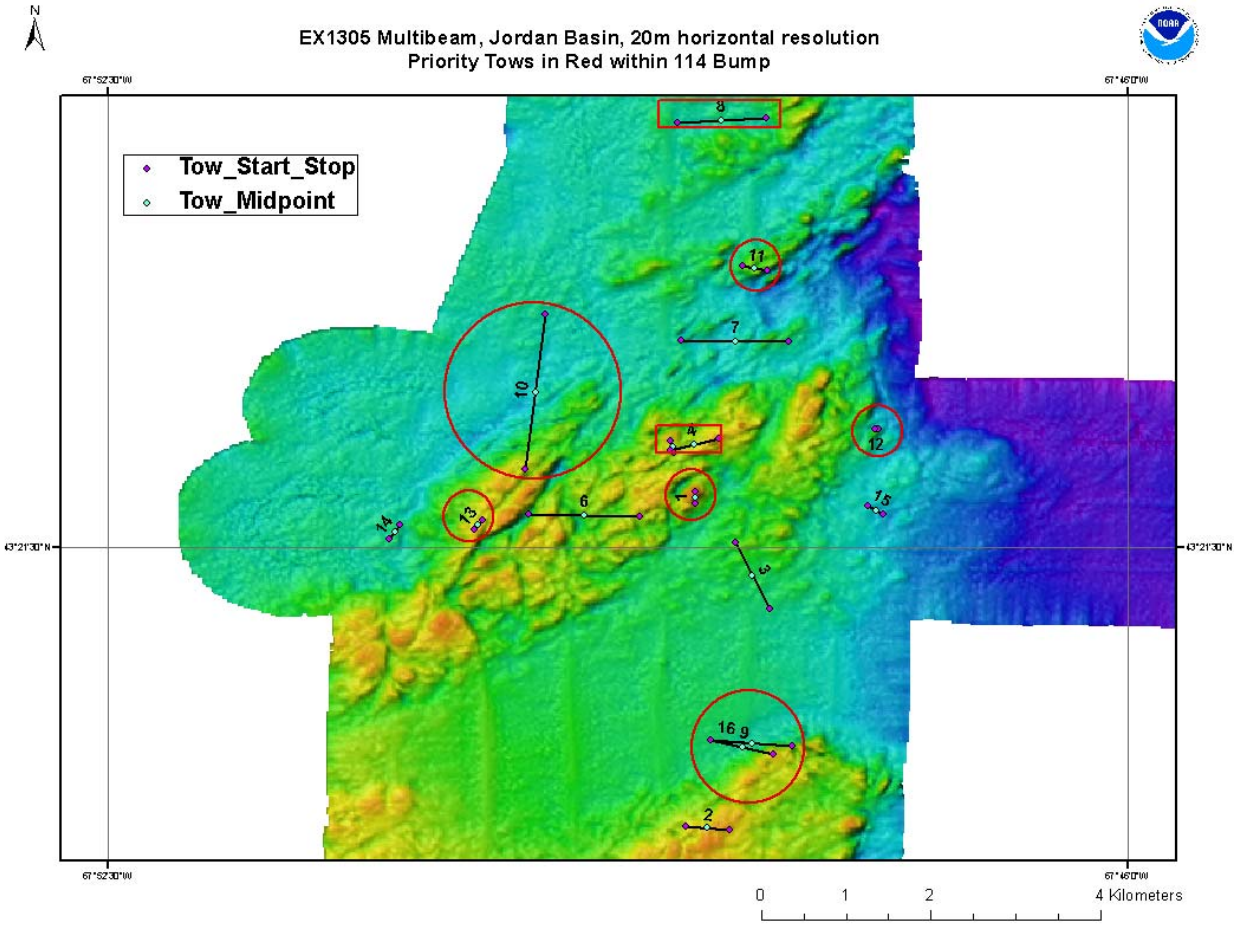
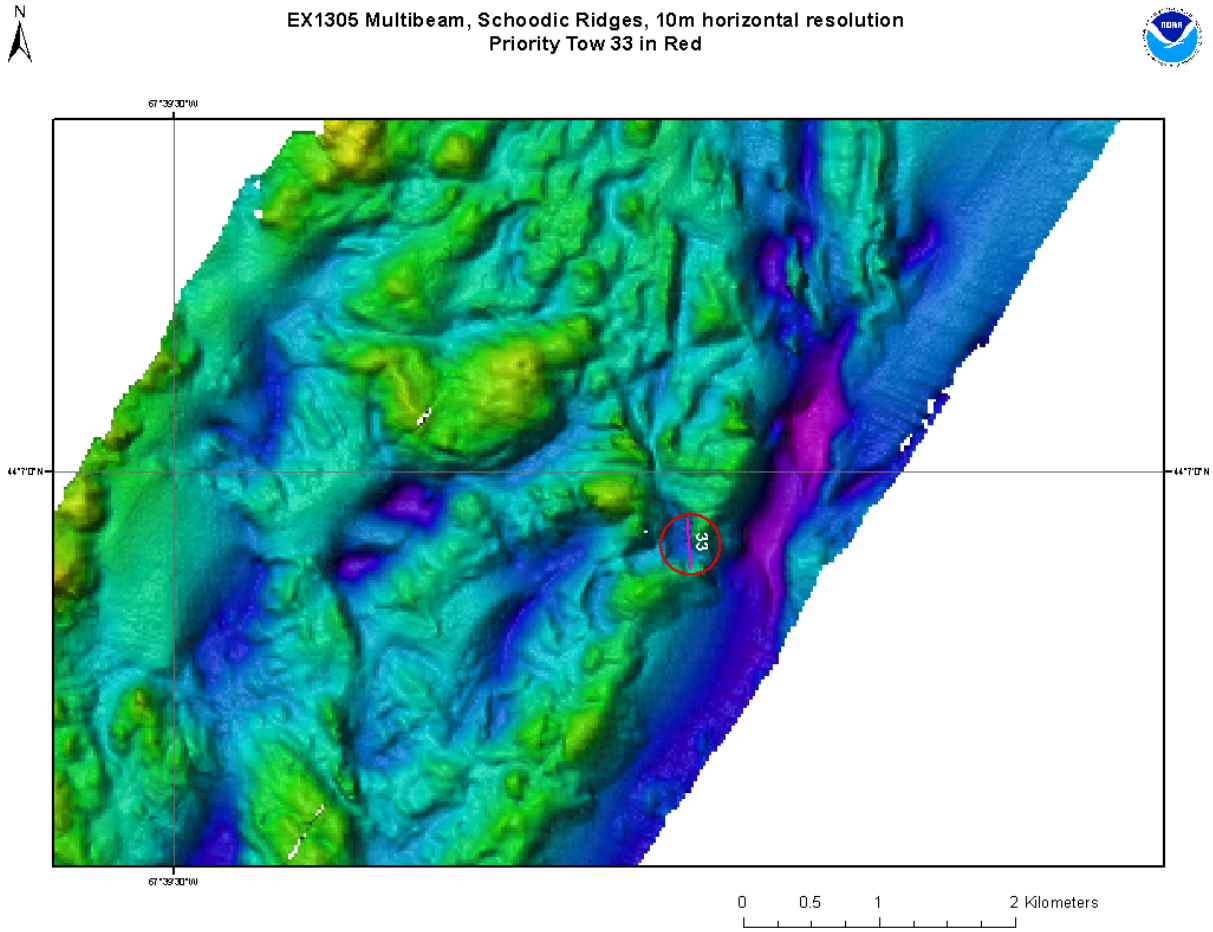


Figure 9. Map depicting Schoodic Ridges priority tow 33 from the 2013 field survey using the ISIS2 towed camera system. Multibeam bathymetry obtained during the *Okeanos Explorer* EX1306 cruise.



Statement of Work: We will collect seafloor imagery (i.e., continuous video and digital still) via transect surveys around the 2013 priority tow sites in Jordan Basin and Schoodic Ridges. During this 14-day cruise, we will dedicate 7 survey days to the Jordan Basin area and 3 days to Schoodic Ridges. Survey patterns will vary based on area and topography. In Jordan Basin parallel linear transects will expand from central points, determined from ISIS 2013 dives. Multibeam data will guide transect design. In the Schoodic Ridge Area, we plan to focus on several biologically diverse coral and sponge walls and escarpments discovered during the previous cruise. This will significantly improve knowledge of the spatial extent of corals in these areas, scales of patchiness, correlation with substratum features, and associations with mobile fauna. Collection of physical samples is a high priority at each dive location. Collections will include several pieces of each coral and sponge species observed during transects as well as opportunistic collections of associated fauna. Physical samples will be photographed, processed, and preserved onboard ship. These samples will be dispersed to various labs/collaborators for taxonomic, reproduction, age, and molecular analyses. Analysis will be conducted in FY15. Vouchers will be deposited at the Smithsonian Institution.

Photo and video images will be analyzed and the deep-sea corals, sponges, and other benthic organisms identified to the lowest possible taxon by the Sandy Hook Lab image analysis team

(IMAG), using protocols worked out for the 2013 survey images. Coral locations along transects and patch boundaries will be determined and geo-referenced and used to produce map products and general habitat descriptions. These products will be shared with NEFMC for immediate use in development of the Omnibus Deep-Sea Coral Amendment. Coral location data and metadata will also be submitted to the DSCRTP for inclusion in the Deep-Sea Coral National Geodatabase. Additionally, coral distribution data will be used to refine the next iteration of the northeast's deep-sea coral habitat suitability model (Kinlan et al. 2014). Data collected will provide the foundation for several peer-reviewed publications.

Budget Narrative:

Vessel/ROV contract for 14 DAS: $273,103

Grants: (support PI time, travel, and supplies): $ 100,818

Supplies (Packer): $2000

Travel (Packer): $1000

Overtime (Packer): $1000

	Description	Amount FY14
1100	Direct Labor:	
1150	Overtime and Hazard Pay	$1000
1200	Benefits:	
2100	Travel	$1000
2200	Transportation	
2300	Rents et al.	
2400	Printing	
2500	Contracts:	
	Ship/ROV	$273,103
2600	Supplies and Materials:	$2000
3100	Equipment:	
4100	Grants	$100,818
	Total	$375,921

FY14 Project 4. Habitat Suitability Modeling

Lead Investigator: Brian Kinlan – (brian.kinlan@noaa.gov), NOS/NCCOS

Collaborators: members of the NCCOS Biogeography Branch; NEFSC (Drohan, Packer, Nizinski)

Project Duration: 3 years: 2013-14 (modeling, cruise support); 2015 (data analysis, final products, cruise support)

Funds Requested: Year 1 = $74,250; **Year 2 = $75,500**; Year 3

Background/Justification: Over the past 5 years, the DSCRTP supported development of a geospatial database of known coral presence locations in the Northeast/Mid-Atlantic region based on historical records. In 2012, using this geodatabase and a suite of regional-scale environmental predictors, NCCOS and NEFSC scientists produced and ground-truthed the first medium spatial resolution (370 meter) models for deep-sea coral taxonomic groups in this region. Models were fitted using Maxent software, constructed using presence-only data and a suite of environmental variables including bathymetry/terrain, substrate (mean grain size and percent sand/mud/gravel of benthic sediments), and physical, biological, and chemical oceanographic variables. Three major taxonomic groups were modeled: true soft corals/gorgonians (orders Alcyonacea and Gorgonacea combined), sea pens (order Pennatulacea), and stony corals (order Scleractinia). For each major taxonomic group, two subgroups were also considered based on suborder or family-level taxonomy. Models predicted extensive areas of potential habitat on the continental slope, concentrated in submarine canyon areas at 300-2000m depth, for all major taxonomic groups and subgroups modeled. Results identified several unexplored, potential hotspots of suitable deep coral habitat in the northern Mid-Atlantic and New England canyons. A subsequent ground-truthing cruise aboard the NOAA Ship FSV *Henry B. Bigelow* in July 2012 confirmed the existence of these hotspots.

This initial effort highlighted the usefulness of regional habitat modeling for guiding field survey efforts. However, it also underscored the limitations of models based on medium-resolution regional seafloor data and historical presence-only data. Medium-scale bathymetry cannot resolve features on the seafloor known to be important to coral distribution. Moreover, historical coral records do not have the same precision as modern GPS systems allow. Thus, it is difficult to associate fine-scale features of the seafloor to coral precise locations. Additionally, historical records are often limited in taxonomic accuracy and resolution and habitat information associated with many coral collections is often lacking. Effective conservation, management, and field survey planning require higher resolution, higher quality predictions.

Data collected throughout the DSCRTP 3-year field efforts will be used to progressively build a database of far more precise, higher-resolution, and higher-quality coral, sponge and environmental data. This database will be used to develop and progressively improve a high-resolution DSC predictive habitat suitability model for application throughout the Northeast region. The bathymetry and other seafloor geomorphology information already being collected and processed in partnership with OER is more than 50 to 200 times finer resolution than the bathymetry used in the 2012 regional DSC model (<25-50m vs. 370m). State-of-the-art GPS navigation technologies will enable precise geo-referencing of each still photo and video frame collected during towed camera and ROV operations. The Shank lab (WHOI), in collaboration with the NEFSC/NSL at the Smithsonian and the image processing lab at NEFSC/Sandy Hook, will

produce presence, absence, and relative abundance data of coral and sponge taxa identified to the lowest possible taxonomic level. NOS/NCCOS will use these new high-quality, high-resolution data streams to generate improved predictive models of habitat and relative abundance for a greater variety of DSC taxa in the Northeast region. These models will be iteratively ground-truthed and re-fitted as field surveys progress. Model outputs will be used to help plan future surveys, and to guide conservation and management actions in the region. At the end of the 3-year effort, additional analysis and processing time is allocated for preparation of reports, data products, and synthetic analyses. As part of this final synthesis effort, model output maps will be finalized and prepared for wide distribution (including via relevant data portals), and map products tailored to meet management and conservation planning needs.

Scope of Work: Over the course of the 3-year field effort, NCCOS will lead the development and application of predictive habitat modeling, validation and ground-truthing of model predictions, and development of model-derived map products. This effort will be tightly integrated with field survey efforts and will result in iterative updating of model products over the course of the 3-year project, culminating in a final set of high-resolution models with a comprehensive accuracy assessment and map products suitable for use in management and conservation planning.

A senior statistical ecologist (contractor) will lead development of modeling, participate in model ground-truthing and validation, supervise development of reports and products, and lead scientific publications. A marine spatial analyst (contractor) will help develop and conduct modeling under supervision of the senior statistical ecologist. The analyst will assist with mapping, GIS analysis, survey planning, cruise operations, and report and product development. Funds are also budgeted to support publications/communications costs, development of reports and map products (including metadata and section 508 compliance for final products), equipment/supply costs, required computational and hardware and software resources, and federal and contractor travel costs, including travel to/from cruise departure locations and project-related meetings and workshops.

Major tasks to be conducted by NCCOS are:

Year 2 (FY14)

- Draft and submit NE Regional modeling manuscript to scientific journal
- Acquire and process new high-resolution bathymetry from OER and other sources to generate high-resolution information on seafloor features (e.g. slope, slope-of-slope, plan and profile curvature, BPI, rugosity)
- Apply regional predictive habitat model results in conjunction with high-resolution bathymetric and seafloor feature information to help plan 2014 research cruises
- Provide map products and GIS support related to predictive habitat modeling for 2014 research cruises
- Generate and distribute research products to NEFSC & DSCRTP scientists
- Provide modeling expertise and map products to MAFMC and NEFMC to aid in designation of coral conservation alternatives
- Participate in two cruises aboard NOAA Ship *Bigelow*
- Attend and participate in planning workshops, phone calls, and meetings

Budget narrative FY14:

1. Contract labor: Marine spatial analyst (3 mo.; $36,750)
   Senior statistical ecologist (2 mo.; $29,500)
   Publications/communications specialist (0.25 mo.; $3000)
2. Equipment/supplies ($3000 – computing costs)
3. Travel ($3000)
4. Publication/reporting costs ($250)

NCCOS in kind "match" $45,000

	Description	Amount FY13	Amount FY14	Amount FY15
1100	Direct Labor:			
1150	Overtime and Hazard Pay			
1200	Benefits:			
2100	Travel	$3,000	$3000	
2200	Transportation			
2300	Rents et al.			
2400	Printing	$250	$250	
2500	Contracts:			
	Labor	$68,000	$69,250	
2600	Supplies and Materials:	$3,000	$3000	
3100	Equipment:			
4100	Grants			
	Total	$74,250	$75,500	

Project 5. Defining and Identifying Essential Fish Habitat for Larval Red Fish

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Project Duration: Year 2 =

Funds Requested: Year 2 = $0; Year 3 = TBD

Background/Justification: The decline in many of our commercial fish species, since we established the Exclusive Economic Zone and adopted single species management is a matter of record. This focus on individual species began to change twenty years later, with the Sustainable Fisheries Act of 1996, which required documenting essential fish habitat for all commercial species. Identifying essential fish habitat for all life stages of fish continues to this day, and recent findings have revealed a previously unknown relationship between sea pens and redfish that could have significant consequences for fisheries management in the Gulf of Maine.

Sea pens are soft corals and are limited to a single species, *Pennatula aculeate*, in the Gulf of Maine where they can be found in silty sediments in water greater than 60 meters deep. They have no commercial value and are relatively unstudied, with most of the available information being limited to their taxonomy, morphology and distribution. In contrast, Acadian redfish are a well-studied, slow growing, long-lived, fish found in the deeper waters of the Gulf of Maine. They are harvested commercially and have seen declining landings almost from the beginning of the fishery in the 1930s.

In a recent paper, Canadian scientists described a relationship between larval redfish and sea pens that potentially has significance in the debate over cold-water corals as essential fish habitat. Previous to this publication, sea pens were acknowledged as part of the cold-water coral assemblage, but because of their wide distribution and abundance there was little concern about protecting sea pens from the impacts of trawl fisheries. Nor were sea pens ever considered essential fish habitat. The Canadian paper notes a decline in the size of sea pens and a decline in the prevalence of sea pen colonies hosting larval fish. Furthermore, they call for fishery managers to reassess the role of cold-water corals, and particularly sea pens, as fish habitat and set aside protection for these resources. Indeed, the Canadian's have taken steps to protect areas of sea pen and sponge habitat off the Flemish Cap, while the US Fishery Management Councils in the northeast are considering deep- sea coral protection zones, albeit at a slower pace. Nevertheless, the question remains as to how important sea pen beds may be as essential habitat for US-based fisheries and to what extent do they need to be protected.

Project outline: This project represents an opportunity for one to two students to investigate the relationship between sea pens and redfish specifically, and cold-water corals and fish in general,

from both a policy and biological perspective. It will include developing an understanding of the laws behind essential fish habitat as well as an in depth review of the current efforts being considered to protect deep sea coral and sponge resources, and a consideration of how these efforts may be modified in light of the finding of the proposed field sampling and data analysis. It will also include a review of the results of resource assessment cruises in the Gulf of Maine, both Federal and State, which form the basis of fish stock assessments, and participation on day trips to sample sea pen/red fish "hotspots" in the area.

The following steps outline a potential approach to this project.

1) Review the existing literature on sea pens and redfish to better understand what information exists that could tie the occurrence of larval redfish to sea pen beds in the Gulf of Maine.

2) Review available information on the distribution and abundance of redfish, and redfish larvae, in National Marine Fisheries Service trawl survey and plankton survey datasets.

3) Review available data from inshore trawl surveys conducted by the Maine Department of Marine Resources, to identify redfish "hotspots" and determine if sea pens have been captured as bycatch, and if so where.

4) Review available benthic photographic data to evaluate sea pen occurrence and abundance throughout the Gulf of Maine. (This could involve identifying datasets and contacting the owners to request permission to review their information.)

5) Participate in day trip inshore trawl surveys, using the University of Maine research vessel "Ira C", to potentially collect sea pens in the near shore, but deep, areas of the Gulf of Maine. The details of this sampling will depend on development of a sampling strategy based on steps 1-3. The numbers of days fishing has yet to be determined, but it would start in April/May.

6) In the laboratory, examine the collections of sea pens and potentially other sessile invertebrates, for the presence of larval fish. Identifying both the invertebrate and the larval fish species.

7) Depending on the outcome of this preliminary sampling, funding will be sought for a more extensive, offshore, sampling effort that will extend over the entire Gulf of Maine, with a focus on identifying sea pen beds and redfish concentrations, as well as the collection of animals for laboratory examination.

Statement of work: A pilot project is proposed for FY14. The NMFS Orono Lab has one, paid, internship available summer. Activities in support of this project will be part of the responsibilities of this summer intern. The University of Maine is also interested in supporting

this work. Negotiations for time on UM 42' research vessel (up to five day trips to fish for sea pens valued at $800 per day for a total of $4000) are currently underway. The primary project objective is to locate redfish "hotspots", based on available trawl, depth and sediment type data. Depending on the success of securing boat time, additional fishing will take place over the summer as redfish are reported to extrude live larvae, which would potentially associate with sea pens, from April through August.

FY14 Project support. **General Overall support**

Budget Narrative:
1. Contract labor GIS support ($2,000)

2. Data storage and computing ($4000)

General Overall FY13-14 Project Support

	Description	Amount FY13	Amount FY14	Amount FY15
1100	Direct Labor:			
1150	Overtime and Hazard Pay	$4200		
1200	Benefits:			
2100	Travel	$10,800		
2200	Transportation			
2300	Rents et al.			
2400	Printing			
2500	Contracts:			
	Labor	$12,800	$2000	
2600	Supplies and Materials:			
	Data storage; computing	$5000	$4000	
	Office	$3250		
	Collecting			
3100	Equipment:	$3000		
4100	Grants			
	Total	$39,050	$6000	