Appendix A: Council Member Applicant and Proposal Information Summary Sheet

Council Member: Department of the Interior	Point of Contact: Amanda Demopoulos Phone: 352-264-3490 Email: ademopoulos@usgs.gov

Project Identification

Project Title: Recovery and Restoration of Deep-water Coral Habitats in the Gulf of Mexico

State(s): TX, LA, MS, AL, FL | County/City/Region:

General Location: *Projects must be located within the Gulf Coast Region as defined in RESTORE Act. (attach map or photos, if applicable)*
Gulf of Mexico continental slope, broad region southeast of Louisiana Mississippi delta in vicinity of *Deepwater Horizon* spill.

Project Description

RESTORE Goals: *Identify all RESTORE Act goals this project supports. Place a **P** for Priority Goal, and **S** for Secondary Goals.*

_P_ Restore and Conserve Habitat
___ Restore Water Quality
___ Restore and Revitalize the Gulf Economy
_S_ Replenish and Protect Living Coastal and Marine Resources
___ Enhance Community Resilience

RESTORE Objectives: *Identify all RESTORE Act objectives this project supports. Place a **P** for Priority Objective, and **S** for secondary objectives.*

_P_ Restore, Enhance, and Protect Habitats
___ Restore, Improve, and Protect Water Resources
_S_ Protect and Restore Living Coastal and Marine Resources
___ Restore and Enhance Natural Processes and Shorelines
___ Promote Community Resilience
_S_ Promote Natural Resource Stewardship and Environmental Education
_S_ Improve Science-Based Decision-Making Processes

RESTORE Priorities: *Identify all RESTORE Act priorities that this project supports. [full text provided in Guidelines: Section A(3)]*
_x_ Priority 1: Projects that are projected to make the greatest contribution …
_x_ Priority 2: Large-scale projects and programs that are projected to substantially contribute to restoring…
___ Priority 3: Projects contained in existing Gulf Coast State comprehensive plans for the restoration ….
___ Priority 4: Projects that restore long-term resiliency of the natural resources, ecosystems, fisheries …

RESTORE Commitments: *Identify all RESTORE Comprehensive Plan commitments that this project supports.*
_x_ Commitment to Science-based Decision Making
_x_ Commitment to Regional Ecosystem-based Approach to Restoration
_x_ Commitment to Engagement, Inclusion, and Transparency
_x_ Commitment to Leverage Resources and Partnerships
_x_ Commitment to Delivering Results and Measuring Impacts

RESTORE Proposal Type and Phases: *Please identify which type and phase best suits this proposal.*

_x_ Project ___ Planning ___ Technical Assistance **_x_** Implementation
___ Program

Project Cost and Duration

Project Cost Estimate:		**Project Timing Estimate**:	
Total :	**$__11,234,739_____**	Date Anticipated to Start:	___10___/_2015__
		Time to Completion:	__3__ months / **years**
		Anticipated Project Lifespan:	_>10___ years

Executive summary

Title: Recovery and Restoration of Deep-water Coral Habitats in the Gulf of Mexico

Co-Principal Investigators: **Amanda Demopoulos**, USGS, Gainesville, FL, **Greg Boland**, BOEM, Herndon, VA, **Christina Kellogg**, USGS, St. Petersburg, FL, **William Shedd**, BOEM, New Orleans, LA, **Charles Fisher**, Penn St. Univ., St. College, PA, **Erik Cordes**, Temple Univ., Philadelphia, PA, **Nancy Prouty**, USGS, Santa Cruz, CA, **Holly Bik**, University of Birmingham, UK, **Kurt Rosenberger**, USGS, Santa Cruz, CA, and **Cheryl Morrison**, USGS Leetown, WV.

Deep-sea corals provide a number of ecosystem services; however, the degree to which these ecosystems can recover from and/or are resilient to contamination is not understood. The proposed research will use the best-available science and cutting edge methods to help reveal the potential recovery of deep-sea coral habitats, provide baseline information to gauge future impacts, and initiate the first-ever application of direct restoration of deep-sea corals. **Goals and Objectives:** The principal goal of the proposed research is to support restoration and conservation of deep-sea coral habitats. Implicit in the proposed approach is elucidating the health, recovery, and resilience of deep-sea corals and adjacent habitats exposed to different stressors and protecting living marine resources associated with them. Understanding long-term recovery and preparing for potential future impacts are fundamental to the basic concept of habitat restoration and protection of ecosystem services. Specific objectives include:

1. Document temporal change in deep-sea coral communities in order to track long-term responses to natural and anthropogenic disturbance.
2. Understand the environmental baseline conditions necessary for the long term resilience of deep-sea coral sites, including mapping, ocean circulation, surface production, organic flux to seafloor, larval supply, and microbial communities.
    a. Explore and map newly identified hard bottom features in order to locate additional *Paramuricea* communities for future restoration activities.
    b. Quantify and measure temporal changes in the hydrological conditions around the impacted and reference coral habitats through the use of instrumented moorings.
    c. Utilize biomarkers to track changes in nutrient dynamics (e.g., changes in quality, quantity, and source, whether surface-derived or from seeps).
    d. Track changes in the microbial and metazoan communities using eDNA to better understand community structure and larval supply.
    e. Examine realized genetic connectivity among *P. biscaya* populations to determine the appropriate source populations for transplant studies.
3. Develop advanced rapid response technologies to detect both lethal and sub-lethal impacts to deep-sea communities, including species-specific environmental sensitivity, quantification of health, and estimates of resilience. These cutting edge techniques will help track impacts from pulsed catastrophic events to longer-term changes and include utilization of advanced next generation sequencing facilities at USGS, Leetown, West Virginia.
    a. Develop assays of coral health, including characterization of functional genes (transcriptomes and qPCR)
    b. Estimate coral ages and growth rates (e.g., radiocarbon dating, direct measures) to expand beyond initial NRDA funded results.
    c. Develop rapid assessment techniques of benthic communities using environmental sequencing methods to evaluate sediment community changes at impacted coral sites.
4. Develop and test methods for direct restoration of deep-sea corals as foundational efforts

leading to expanded restoration plans.

a. Test fragment collection methods and monitor effects on corals
b. Collect fragments from *P. biscaya* colonies and return to native sites
c. Monitor growth and mortality of redeployed coral fragments

Study sites: Specific deep-sea coral study sites will include locations within lease blocks: MC294, MC297, MC344, MC507, MC203, and VK826. Sites were selected to examine a broad range of coral species, depths, and coral habitats in order to develop tools that could be used in the event of future incidents. At least two additional reference areas containing the most common species of coral impacted in the spill, *P. biscaya*, will be selected following initial visual surveys of areas identified through analysis of the 3D seismic data available from BOEM. **Broader Impacts**: There is a fundamental need to identify the best methods for monitoring and restoration of deep-sea coral habitats. This study represents the primary restoration phase involving data collection to understand changes and possible recovery to the impacted deep-sea coral communities, locating sources of populations of impacted coral, developing advanced techniques to understand the coral and associated community response, and to develop transplantation techniques for deep-sea corals. This research will initiate the development of a deep-sea component to a GoM-wide observing system that extends from shallow to deep waters (>1500 m). This work will track the success of direct restoration techniques while continuously monitoring the environmental conditions and natural resources over broad temporal and spatial scales. After successful restoration and continued protection from future damage, these coral habitats will provide ecosystem services for decades to come. The proposed work also has broad applications to understanding the GoM-wide ecosystem, making trophic connections from the Gulf-state watersheds to deep-sea environments. **NOAA Damage Assessment, Remediation, and Restoration Program:** The PIs of this proposal wrote and lead several deep-water study plans as part of the NRDA process, and as this process is shifting to developing options for the Restoration work, Demopoulos, Cordes, and Fisher are involved as consultants in the scoping and writing of these restoration options. We remain in contact with the Deep-water Coral Restoration working group, and they support this proposed study as complementary, yet not duplicative with NRDA efforts, and a necessary precursor to some restoration options under consideration. **Outreach and Education:** This project will emphasize public awareness and educational opportunities during the field sampling programs as well as broad-based outreach material development resulting from research analysis and results, by following the model established by several award-winning deep-water studies involving the same agencies and co-principal investigators. Educational outreach will involve providing employment of young Gulf-state scientists, training of graduate and undergraduate students, the development of interactive cruise expedition web sites and project related lesson plans, and utilize other social media avenues. **Funding request**: 3 year study: $11,234,379. Shiptime (Global Class Vessel, ROV, AUV): $5,330,000, travel, analyses, salary (assistants, post-docs., students, and operating expenses): $4,807,058, indirect costs: $1,097,321. Cost match: $877K from salaries, OE, and equipment from USGS and >$2.5M from proposed complementary GoMRI ECOGIG project. **Implementation information**: Start: 10/2015, End: 9/2018. This research represents an initial 3-year study with cruises each year. Cruises: Yr 1, one 10d cruise with *Ron H. Brown (RHB)*/AUV *Sentry*, and one 18d cruise with *RHB*/*Jason* ROV. Yr 2: one 25d cruise, *RHB*/*Jason,* Yr 3: one 15d cruise, *RHB*/*Jason*. **Uncertainties and risks:** In addition to inherent risks for all offshore deepwater research, direct restoration of deep-sea corals has never been conducted to date. However, this work will lay the foundation for future directed restoration activities.

Proposal Narrative

Title: Recovery and Restoration of Deep-water Coral Habitats in the Gulf of Mexico

Background and Rationale: Although most of the deep seafloor of the Gulf of Mexico (GoM) is composed of soft sediments (mixtures of sand, silt, and clay), numerous areas with patchy hard-bottom features have been identified. Despite increased research on these areas in recent years, their associated biological communities are poorly understood and most of these features remain unexplored. The majority of hard substrate in the areas of active oil and gas leasing in the northern GoM was created through precipitation of carbonate associated with the activity of free-living archaea and bacteria. These authigenic carbonate deposits can become exposed and subsequently colonized by diverse assemblages of megafauna in the deep sea, including communities dominated by symbiont-containing vestimentiferan tubeworms, vesicomyid clams, and/or bathymodiolin mussels in areas of active seepage, and eventually deep-sea corals in some areas (Cordes et al. 2009). The ecosystem services provided by these deep-sea biogenic habitats are numerous, including provision of food for higher trophic levels and habitat for commercially important fishery species (Thurber et al., 2014). The sediment fauna found adjacent to corals are also influenced by their presence (Demopoulos et al. 2014). Thus, the influence of deep-sea corals on the ecology and biodiversity of the surrounding habitats is extensive.

The primary goal of the proposed work is to support restoration and conservation of deep-sea coral habitats and adjacent ecosystems. This includes understanding the health, biodiversity, recovery, and resilience of deep-sea corals and adjacent habitats exposed to anthropogenic and natural stressors and to restore and protect living marine resources associated with deep-sea coral habitats. The Deepwater Horizon (*DWH*) spill event was responsible for changes in multiple ecosystems within the GoM, including deep-sea coral habitats, leading to shifting baselines within coastal and deep-sea ecosystems. However, estimates of baseline ecological conditions in the deep sea are scant despite being a critical component of effective restoration and long-term monitoring. The impact of the spill on deep-sea environments has been well documented, including soft sediments (Montagna et al. 2013) and corals (Fig. 1-see "Other" section, White et al. 2012, Hsing et al. 2013, Fisher et al. 2014a, b). However, the quantification of long-term dynamics, recovery of populations, communities, and ecosystems exposed to natural and anthropogenic disturbance, as well as establishing the baseline health and life history parameters of deep-sea corals remains incomplete, and the appropriate tools used to quantify many of these factors continue to be developed. Deep-sea coral monitoring programs will yield important insights into the patterns and trajectory of change within these unique ecosystems by identifying their sensitivity and resiliency to disturbance. This knowledge will allow for the separation of impacts due to oil and gas activities from other forms of disturbance. The proposed work will help elucidate the recovery of deep-sea coral habitats impacted by oil contamination and provide the foundation necessary to gauge future impacts.

The current policy pertaining to routine offshore oil and gas activities, including discharge of drill cuttings, requires surface activities and infrastructure to be 610 m (2000 ft) from areas likely to harbor sensitive communities such as corals or chemosynthetic communities (NTL 2009-G40). Seafloor placements, including anchor chains, have an avoidance distance of 150 m (500 ft), although a petition for a 75 m (250 ft) setback can be made and is usually successful due to the precision of modern GPS-guided operations. However, regulatory policies defining avoidance or "buffer" distances from sensitive resources are not feasible to prevent impacts from

catastrophic events that can affect very large areas, including a blowout. Specific knowledge needed to help facilitate successful restoration, including understanding the local and regional hydrography and its influence on the supply and transport of propagules (potential new recruits), the resulting genetic connectivity (location of source and sink populations), the associated population dynamics, and the realized ranges and bathymetric distributions of impacted species are lacking. A significant aspect of prior work (Hsing et al. 2013; Doughty et al. 2014) and the results from this project (if funded) will provide the science necessary to address the questions about the long-term impacts from catastrophic events including oil-spill contamination.

Deep-sea coral ecosystems provide habitat and reproductive grounds for commercially important fisheries species and other ecologically important organisms. However, basic information regarding where deep-sea coral communities thrive remains scarce. Organic input from surface waters (food supply), specific hydrodynamic characteristics (e.g., current regime), and other abiotic and biotic factors are believed to limit distribution of these high-density, high-diversity communities (Mienis et al. 2012, Georgian et al. 2014). Specifically, near-bed currents can inhibit sediment deposition on corals and provide the food that corals need for survival. Changes in phytoplankton production in the upper water column may influence deep-sea coral communities, including survival, growth, and reproduction. Understanding how deep-sea organisms respond to disturbance and restoration efforts in the short and long term is necessary to successfully develop restoration efforts that will assist in the holistic ecological and economic recovery of the Gulf.

Ecological restoration is the process of assisting the recovery of an ecosystem that has been damaged, destroyed, or degraded (Van Dover et al. 2014) and seeks to reset the ecological processes that were interrupted by human activities. The ultimate goal is to facilitate the recovery of the biodiversity, ecosystem function, health, and integrity of damaged ecosystems. However, the implementation of ecosystem restoration in the deep sea is highly complex and, to our knowledge, has yet to be attempted. Deep-sea corals are remote, difficult to sample, and require specialized gear to manipulate. In addition, deep-sea corals have been documented to be very slow growing and long lived (Roark et al. 2009; Prouty et al. 2011). Colonies of *Paramuricea* species, including some individuals from sites impacted by the spill, are estimated to be over 500 years old (Prouty et al. in press). This longevity makes deep-sea corals highly vulnerable to disturbance, and sets the trajectory for recovery to very long temporal scales, making human intervention through restoration efforts even more significant for these species. In the long term, deep-sea restoration activities will require monitoring and adaptive management.

There is a basic need to determine the best methods and apply the best available science for future monitoring and assessing change, including the collection of essential baseline information in order to make appropriate comparisons before and after impacts from disturbance. This proposal will expand beyond recent studies from both before and after the *DWH* spill that used similar techniques to those proposed here to discover new deep-sea coral habitats, including *Lophelia pertusa* cold-water coral reefs and the *Paramuricea biscaya*-dominated impact sites. Methods used to understand the recovery of these ecosystems require advanced technologies and the development of new tools to track response and change. In addition, as we move towards developing viable restoration strategies for deep-sea coral ecosystems it is essential that we better understand these systems, that we document the recovery time after minimally-invasive coral fragment collection, and that we develop and test methods for fragment deployment that result in growth and survival of "transplanted" corals. The proven techniques we have developed for repetitive imaging and subsequent image digitization and analysis for deep water octocorals

(Hsing et al. 2013) can be used to quantitatively accomplish these goals. Research proposed here will provide the best available science to help establish informed restoration benchmarks for deep-sea ecosystems.

This research and monitoring study represents the **initial phase** of a multi-phased effort involving data collection to understand changes and possible recovery to the impacted deep-sea coral communities, locating additional populations of the species of impacted coral, augmenting our capacity to respond to future spills, and carrying out the first deep-sea transplantation experiment for deep-sea corals. This foundational work will contribute significantly to the development of a deep-sea component to a GoM-wide observing system that extends from shallow to deep waters (>1500 m) using advanced technologies and the best available science in order to monitor environmental conditions and natural resources over broad temporal and spatial scales. Our restoration efforts will enhance the ability for these corals and associated habitats to provide ecosystem services for decades to come (Baillon et al. 2012). Furthermore, because the entire GoM habitats from the upper watersheds to offshore surface waters to deep-sea environments are intrinsically linked, the proposed work presented here will significantly advance our understanding of the GoM-wide ecosystem and economy.

In order to quantify changes in both deep-sea corals and adjacent sediments,, select study sites include locations within lease blocks MC294, MC297, MC344, MC507, MC203, VK826, and two new reference sites. Specific deep-sea coral sites impacted by the *DWH* event include MC294, MC297, and MC344 (Fisher et al. 2014ab). Valentine et al. (2014) also documented that these three sites are within the contaminated region impacted by the DWH spill. Additional sites that may have been impacted by the spill and had fishing line entanglement on the corals included MC507 and MC203 (Fisher et al. 2014b). VK826 is selected to include a range of depths, coral species, and coral habitats to develop techniques that could be used in the event of future incidents at any deepwater sites. At least two additional reference areas containing the most common species of coral impacted during the spill, *P. biscaya*, will be selected following initial AUV and ROV surveys of potential targets identified through analysis of the 3D seismic data available from BOEM.

Goals and Objectives:

1. Document temporal change in deep-sea coral community structure and function in order to track long-term responses to natural and anthropogenic disturbance (Fisher, Demopoulos, Kellogg).
2. Establish observation and monitoring of resources at a variety of deep-sea coral sites, including mapping, ocean circulation, surface production, organic flux to seafloor, larval supply, and microbial communities (Prouty, Rosenberger, Morrison, Kellogg, Cordes, Demopoulos, Fisher).
    a. Explore and map newly identified hard bottom features in order to locate additional *P. biscaya* communities for collection of baseline data and for future restoration activities.
    b. Quantify and measure temporal changes in the hydrological conditions around the impacted and reference coral habitats through the use of instrumented moorings.
    c. Utilize biomarkers to track changes in nutrient dynamics, including variations in quality, quantity, and source (e.g., whether surface-derived or from seeps).
    d. Track changes in the microbial and metazoan communities using eDNA, in order to better understand the community structure and potential larval supply.
    e. Examine realized genetic connectivity among *P. biscaya* populations to determine the

appropriate source populations for recolonization of impact sites.

3. Develop rapid response techniques and advanced technologies through integrative lab and field studies and synthesis of new and existing data. (Cordes, Morrison, Demopoulos, Bik, Prouty, Fisher).
   a. Develop assays of coral health, including characterization of functional genes in corals (transcriptomics and qPCR).
   b. Estimate coral ages and growth rates (e.g., radiocarbon dating, direct measures).
   c. Develop rapid assessment techniques of benthic metazoan communities using environmental sequencing methods to evaluate sediment community changes
4. Develop and test methods for direct restoration of deep-sea corals (Cordes, Fisher).
   a. Test fragment collection methods and monitor effects on corals.
   b. Collect *P. biscaya* colonies, fragment, and return to native sites.
   c. Monitor growth and mortality of redeployed coral fragments.

Implementation methodology: We are proposing to conduct 4 major oceanographic research expeditions and require the use of a Global Class Vessel (e.g., NOAA ship *Ron Brown*), ROV *Jason* and AUV Sentry, or similarly capable platforms. The ROV must be equipped with closed loop navigation capabilities and sufficient basket space and the ability to cut small branches of corals, place them into individual containers and seal them on the seafloor, suction and slurp animals into sealed chambers, and collect undisturbed push cores, while also carrying a dedicated digital still camera for close up imagery. The ship will need sufficient deck space and infrastructure for mooring preparation and deployment. Ideally, the first cruise would occur either late 2015 or early 2016. See details regarding AUV surveys in Obj. 2.

Objective 1. Document temporal change in deep-sea coral community structure and function in order to track long-term responses to natural and anthropogenic disturbance (Fisher, Demopoulos, Kellogg).

Rationale and approach:

Deep-sea coral monitoring: In late 2010 we discovered a deep-water coral community that had been adversely impacted by the *DWH* spill (White et al. 2012). Since that time we have been supported by NRDA and GoMRI to continue monitoring this community (Hsing et al. 2013) and conduct exploration and survey work that resulted in the discovery of two additional sites in the area that were impacted by the spill (Fisher et al. 2014a). While conducting these studies we developed the exploration, survey, and coral monitoring techniques we will employ in this proposal, and have also collected baseline datasets for establishing this proposed study. By conducting the same image-based individual monitoring of coral colonies at the additional sites included in this proposal, some of which we will discover during this study, we can establish robust measures of natural growth and branch mortality rates and coral associate fidelity, as well as collect quantitative data on the associated soft sediment community composition over time. Critically, we can sample fragments from these corals for the proposed genetic analyses and quantitatively document any adverse effects and recovery from fragment sampling. Finally, we can test potential transplant techniques by replacing a subset of the fragments on the sea floor and monitoring their growth and survival when revisiting the sites for similar analyses of the undisturbed and sampled colonies (see Obj. 4).

Two sites (MC507 and MC203) were discovered close to the spill site during our NRDA-funded studies, but are not being monitored as part of our GoMRI-supported work due to

limitations in available ROV time. Both of these sites are relatively small (12 and 20 coral colonies respectively), and both harbor colonies that have been impacted by fishing line (Fig. 2, in "Other"). Revisiting these sites will allow imaging for growth calculations and assessment of damage from the fishing line, as well as an opportunity for limited fragment sampling for genetic (see Obj. 2) and recovery analysis.

For the in situ image based analyses (present-day growth rates, damage monitoring and assessment, fragment removal effects, fragment growth and survival), we will use the same basic protocol as described in Fisher et al. (2014a). The location of each individual coral colony will be recorded and identified using a combination of ultra short baseline (USBL) navigation, physical markers placed on the sea floor, and down-looking photomosaics for high density portions of the sites. With this technique for example, we were able to relocate and reimage over 98% of our target corals during our 2014 cruise with the EV *Nautilus* and the ROV *Hercules*. The colony is imaged using a high definition still camera (currently our BFC6000, which is an AquaSLR underwater camera consisting of an 18 megapixel Cannon T5i in a custom 6000 m titanium housing with optical dome and dedicated lights that can be held in an ROV manipulator for close up work and optimal lighting), from the same heading every time, and during the imaging the scientists and ROV pilots use the picture taken the previous year to frame and appropriately fine tune the camera heading to duplicate the image (Fig. 3, "Other" section). All images are digitized using Inkscape 0.48.2 (Fig. 4, "Other" section) in order to compare the condition of all portions of all visible branches and quantify changes between years, such as change in epizoic hydroid covering, health of branches, loss of portions, and most recently growth. See Fisher et al. (2014a) for additional details on the application of these techniques.

Coral sediment community assessment: Sediment macro- and meiofauna represent important indicators of natural and anthropogenic disturbance primarily due to their sedentary lifestyle and their rapid response to change; thus, examining these communities has proven useful in impact assessments of coastal and deep-sea communities. For example, in the wake of the *DWH* oil spill, immediate impacts were detected in benthic communities including sediments adjacent to deep-sea corals (Fisher et al. 2014b). We have continued collecting sediment adjacent to the impacted corals to assess temporal changes in these communities (2010-2014). While long-term impacts to these habitats are unknown, recovery rates are predicted to be slow with *DWH*-derived contaminants remaining in biologically active sediments for many years (Montagna et al. 2013). Coral-associated sediments contain benthic communities that differ from other soft-sediments in the GoM (Demopoulos et al. 2014), and thus recovery trajectories at these locations may differ as well, making regional generalizations inaccurate. Without the knowledge of the natural trajectory for recovery of communities, we will be unable to apply remediation tactics to restore these habitats.

This objective will characterize infaunal community structure at several deep-sea coral sites. Sediment cores will be collected adjacent to corals to assess infaunal abundance, diversity, evenness, and composition in ecosystems affected by different stressors. This work will provide traditional taxonomic data that is comparable to existing datasets available at impacted (Fisher et al. 2014b) and non-impacted (Demopoulos et al. 2014) coral sites, and regionally for northern GoM soft-sediments (Rowe and Kennicutt 2009; Wei et al. 2010), and natural hydrocarbon seeps (Demopoulos et al. 2014) including the environmental parameters for these habitats. These comparisons will quantify community changes since the spill, estimate resilience, and determine whether these systems have recovered to comparable community structures near healthy

reference areas. Assessing the community composition and biodiversity at selected deep-sea coral sites will provide baseline data for community response to contaminant exposure and critical data for future restoration projects. Benthic fauna provide essential ecosystem services, including nutrient cycling, biomass production, and sediment bioturbation (Snelgrove et al. 1997), and a loss of benthic biodiversity has been correlated to an exponential decline in ecosystem services (Danovaro et al. 2008).

Sediment will be collected adjacent to deep-sea corals using ROV-deployed push cores to quantify macro- (> 300 μm) and meiofaunal (> 45 μm) densities, diversity, and biomass. Sediment also will be processed for total organic carbon and nitrogen, hydrocarbon and metal concentrations, particle size analyses and redox conditions. Faunal diversity will be estimated using PRIMER Statistical Software. Similarities and differences in benthic communities will be examined using non-metric multidimensional scaling; pairwise comparisons will be made between sites using Analysis of Similarity, and similarity percentages (SIMPER) will estimate the percent dissimilarity/similarity and the taxa responsible for differences among coral sites (e.g., Demopoulos and Smith 2010, Levin et al. 2010; Demopoulos et al. 2014). RELATE and DISTLM multivariate statistics will be used to analyze and model the relationship between the meio and macrofaunal assemblage data and the environmental variables (e.g., organic carbon, total hydrocarbons, metal concentrations, particle size) (Anderson et al. 2008).

In coordination with the studies of sediment infauna, parallel assessments will be conducted on the sediment microorganisms. These microbes serve as food for infauna and may be affecting the patterns observed in meio- and macroinfaunal communities via microbial community changes, alteration of food availability, and/or degradation of hydrocarbons. A dramatic response was detected in the sediment microbial communities in oiled sediments near the Macondo well soon after the spill event (Mason et al. 2014). Paired sediment cores will be collected for metazoans and microbes at both the impacted and reference sites. Sub-samples of these sediment cores will be removed utilizing sterile techniques and used to enumerate total prokaryotes and viruses (by staining and microscopy) and assayed by DNA sequencing to identify and characterize the prokaryotic components of the sediment community in order to extend our understanding of benthic ecology impacts and resilience to the microscopic level.

This work will compare the microbial communities at selected deep-sea coral sites to data obtained from other deep-sea sediment environments (Kellogg, unpublished), including previous GoM work (Kellogg 2010). As has been done in beach environments (Engel and Gupta 2014), the goal is to assess the sediment microbial communities and determine if the system is moving towards its previous 'natural' state or at least a new steady state, and how these changes correlate with infaunal community patterns. Following coral transplantation (Obj. 4), the surrounding sediment microbial community will be monitored to track the completeness of recovery.

Objective 2. Establish observation and monitoring of resources at a variety of deep-sea coral sites, including mapping, ocean circulation, surface production, organic flux to seafloor, larval supply, and microbial communities (Prouty, Rosenberger, Morrison, Kellogg, Cordes, Demopoulos, Fisher)

Rationale and approach:

Explore & Map Deep-Sea Coral Communities: To better understand these ecosystems we need to discover and study at least one, and preferably two, pristine site(s) similar to the sites we have been studying with respect to origin, environmental chemistry, and composition. At present, we do not know of a Gulf slope site within 100 nautical miles of our ongoing study sites with the

same species of corals (*P. biscaya*) in moderate abundance. The nearby sites we discovered are either impacted, at the wrong depth (and therefore host different species) or host fewer than 10 coral colonies (i.e., insufficient to provide fragments needed for the proposed work or restoration activities).

This objective will focus on sites in the depth range of the impacted corals: 1200 - 1900 m depth. This effort will begin with a review of the 3D seismic data housed at the BOEM facilities. The presence of positive amplitude anomalies in this data set indicates the presence of hard substrata within the top 8 m of the seafloor. These data have been used in the past to locate the vast majority of the known coral locations in the northern GoM. These data will be supplemented with recently collected multibeam data and additional surveys conducted as part of this program. In the new data, and when available from previous surveys, the backscatter of the multibeam will be processed. This approach will enable us to identify locations of exposed hard substrata and can be used to greatly refine the site selection from the regional to the local scale. Together, these efforts will help to improve the predictive capacity for deep-sea coral habitat.

Once potential areas of deep-sea coral habitat are identified, an AUV survey will be conducted to search these high-probability sites for coral presence. AUV surveys will begin with high-resolution multibeam mapping along with backscatter data to examine for hard substrata on the seafloor. Following this portion of the survey, the AUV will drop down to 5 m altitude and conduct photographic transects to attempt to locate coral colonies. This technique was successfully employed in the discovery of the sites described in Fisher et al (2014a) and also listed in this proposal.

Monitoring for environmental and community change: Once the coral communities are mapped, monitoring stations will be established in these communities. If there are less than 200 corals present in the communities, all will be imaged and monitored using a combination of precise location information from USBL navigation, downlooking habitat mosaics, and physical markers (see Fig. 2, in "other") to identify and relocate individual colonies (Hsing et al. 2013; Fisher et al. 2014b). If larger communities are discovered, a subset of at least 100 haphazardly chosen colonies will be imaged and monitored for condition, mortality and growth in addition to monitoring all sampled corals for collection effects as described above (Obj. 1).

Instrumented moorings (Fig. 5, in "Other") will be deployed at the impacted and reference sites, adjacent to deep-sea coral habitats, in each of the three study years. Each mooring will be equipped with a rotating sediment trap to collect and preserve particulate material, including coral larvae, at monthly intervals, an Acoustic Doppler Current Profiler (ADCP) to measure in high accuracy the speed and direction of ocean currents, and CTD with dissolved oxygen optode and chlorophyll (CDOM) fluorescence probe providing continuous records of physical properties (e.g., temperature, salinity, DO) at one year intervals for each deployment over a 3-year period. These long-term measurements will lead to characterization of the hydrodynamic variability around the deep-sea coral sites. The deployment and recovery of the moorings will follow protocols developed by the PIs for deep-sea studies in the GoM, Mid-Atlantic Canyons, and the Caribbean. Sediment trap samples will be processed for zooplankton, ^{210}Pb, bulk density, grain-size, % organic carbon, nitrogen, pigments, organic biomarkers, and stable isotopes (Mienis et al. 2012) in order to measure the quality and quantity of organic matter fluxing to the deep sea. This will provide information on the source of food for the corals, as well as identifying the trophic and energetic links form the watersheds to the deep sea.

Sediment trap material will also be analyzed for environmental DNA (eDNA). All organisms

shed genetic material into their environment through feces, mucus, urine and epidermal cells. DNA obtained directly from environmental water samples (eDNA) enables the characterization of both microbial and macrofaunal components of ecosystems, and is revolutionizing species inventories in both freshwater (Goldberg et al. 2011) and marine systems (Thomsen et al., 2012). In this study, sediment trap material will be screened for select GoM taxa (fishes, zooplankton, coral larvae, and microbes) using taxon-selective amplicon libraries and next-generation sequencing, following methods of Thomsen et al. (2012). This will also provide a new type of evidence for the high degree of connectivity between coastal ecosystems and deep coral habitats.

Data from the ADCP, CTD, and sensors will provide monthly measurements of the oceanographic environment (Davies et al. 2010). Sediment trap and instrument data will enable a better understanding of the transport, fate, seasonality, and sources of nutrients to deep-sea corals and associated deep-water circulation that can influence the larval supply to the hardbottom environments. Following this baseline profiling, rapid assessment of changes in nutrient delivery and food sources to the deep sea following human-triggered events will be possible.

Genetic connectivity: Small samples of the corals will be identified genetically and morphologically. Sclerite preps will be conducted and examined using scanning electron microscopy (SEM). This classical taxonomic work will be complimented with genetic identification using a combination of a standard, octocoral-specific molecular barcode (mt *COI+igr+MutS* + nuclear *28S* rDNA) according to the methodology in Doughty et al. (2014). In addition, microsatellite markers will be developed from existing next-generation genomic data housed in the Cordes lab. The use of these markers on existing and newly collected samples will allow for an examination of intra-specific population differentiation among the *P. biscaya* populations at the sampled sites. This will indicate where there is genetic structure, barriers to dispersal, and inferred isolation in the Gulf. With sufficient sampling effort at each site, the relative contribution of each site as a source of larvae for other communities can be inferred. Together, these data will provide critical insights into the genetic connection among sites and whether the impacted populations serve as a source of larvae that have historically led to the colonization of other isolated habitat islands. In the context of restoration, this work will also provide the information necessary to select appropriate source populations for the transplant experiments so that the source site contains members of the same population(s) as the restoration site. This will ensure the highest possible survival rate for the transplanted fragments (Obj. 4).

Objective 3: Develop rapid response techniques and advanced technologies through integrative lab/field studies and synthesis of new and existing data. (Cordes, Morrison, Demopoulos, Prouty, Fisher)

Rationale and approach:

Coral Transcriptomics: An early organismal response to environmental stressors includes the alteration of gene expression and the synthesis of proteins that drive homeostatic physiology. Sub-lethal, chronic effects may include shifts away from normal homeostasis at the molecular and cellular levels that are difficult to observe, yet may be indicative of pathophysiological effects. The use and continued development of cutting-edge techniques to examine the coral transcriptome, or the set of all RNA molecules present at a particular time within an organism, will allow us to identify genes (or gene systems) that are actively expressed, including those involved in genomic stress responses. Cordes has conducted these experiments for both *P. biscaya* and *Callogorgia americana delta* during the GoMRI-funded work for the ECOGIG

consortium (DeLeo et al. in press). In this proposed work, Morrison will lead the studies of *Lophelia pertusa*. *L. pertusa* is a scleractinian found most commonly from 300-600 m depth and forms the largest biogenic habitats (deepwater reefs) in the GoM. *C. americana delta* is a primnoid octocoral found from 500-900 m depth, and is the only species known to date to derive some of its nutrition from natural hydrocarbon seep productivity. *P. biscaya* is a plexaurid octocoral that is the most common coral species found below 1000 m (total distribution 800-2600 m depth) and is also the most common species that showed an impact from the *DWH* oil spill. These studies will take place in three phases:

1. Laboratory exposures of *L. pertusa* to oil and/or dispersants,
2. Quantify transcriptomic responses of *L. pertusa* at several time intervals after exposure via next-generation sequencing (RNA-seq)
3. Develop qPCR gene expression assays to detect exposure, monitor recovery, and assess physiological changes brought about by mixtures of hydrocarbons and dispersants

A series of experiments will be conducted using surrogate oil, dispersant, and a mixture of oil and dispersant to determine relative toxicity on *L. pertusa*. The toxic concentrations of oil and Corexit dispersant have already been determined for *P. biscaya* and *C. americana delta* (DeLeo et al. in press). Treatments will include surrogate oil water-accommodated fraction (WAF), the WAF of oil plus Corexit dispersant, and Corexit dispersant alone. The sub-lethal genetic expression response of *L. pertusa* to different treatments will be documented using transcriptomic sequencing of samples collected during the laboratory exposure experiments (RNASeq, Vera et al. 2008). Morrison will generate transcriptomic data for *L. pertusa* from samples collected before and after the *DWH* incident (2009-2010), with additional samples from the Atlantic Ocean (2012-2013). The development of transcriptomes will include isolation of total RNA, creation of cDNA libraries, and sequencing libraries on Illumina next-generation sequencers (see Barshis et al., 2013). Bioinformatics pipelines to identify (annotate) coral genes are available at the Leetown Science Center, along with access to a bioinformaticist, Dr. Scott Cornman. The annotated transcriptomes will be interrogated for genomic stress response genes that will respond predictively to chemical stressors and may be queried in the future via qPCR.

Developing a suite of biomarkers that reflect cold water coral health will provide an inexpensive and effective method of monitoring the state of deep coral reefs exposed to oil spills, and will provide insight into the mechanisms of coral response to oil and dispersants. There is a wealth of existing transcriptomic data for all three target species from both the Morrison and Cordes groups, including reference samples preserved in situ, samples of *P. biscaya* colonies that were impacted during the spill, *L. pertusa* from ocean acidification experiments, and *P. biscaya* and *C. americana delta* from previous oil and dispersant exposure experiments. We will use these existing data along with the additional *L. pertusa* data generated in this study to design a series of primers for genes that are differentially expressed during oil and dispersant exposure. We will focus on those genes that are known to be involved in stress-response of hydrocarbon detoxification pathways. A series of three housekeeping genes will be developed for each species to serve as internal controls for the qPCR assays. Each PCR reaction will be checked for efficiency and specificity of the target gene. The ultimate goal will be to generate a series of gene expression markers that will be indicative of low-level hydrocarbon and/or dispersant exposure. This will provide the capacity for rapid response and improved diagnostic tools for evaluation of coral populations at any depth from 300-2600 m in the event of future oil spills in the GoM.

Deep-sea coral age: The age and growth rate data are a critical component in the construction of growth curve models (i.e., how much would a coral colony grow at each year of life). Deep-sea

corals, including a few whole colonies, will be collected by ROV for age and growth rate studies. Both dried and preserved tissue samples will be collected from each specimen and analyzed for radiocarbon and stable isotope analysis based on published methods (e.g., Sherwood et al. 2005, Roark et al. 2009, Prouty et al. 2011, Carreiro-Silva et al. 2013, Prouty et al., *in press*). This technique has been used successfully with proteinaceous black corals (*Leiopathes* sp.) and *Paramuricea* sp. collected in the GoM (Prouty et al. 2011; Prouty et al. *in press*). A cross-sectional disc will be prepared from the base (trunk) of each coral specimen. A transect across this disc will be sampled and analyzed to include polyp, tissue layer, center (inner), middle and outer portions across the radial transects. In addition, tips and polyps from the coral specimens will be analyzed in order to capture the radiocarbon signal in the most recently accreted material. Results of the coral age and growth rate studies will be analyzed in conjunction with the short term growth rates obtained from the time series imagery analyses (Obj. 1) in order to develop statistically robust methods for non-invasive age and growth rate determinations.

Benthic infaunal community assessment: The status of benthic communities has historically been assessed using traditional taxonomic methods for identification of fauna and diversity estimation (see Obj. 1). These methods, while effective, are time intensive, requiring extensive post-collection processing time for sorting and identification by specialists. Recent advances in high throughput environmental sequencing have made it possible to assess a wide range of metazoan taxa present in deep-sea sediments using molecular methods (Bik et al. 2012a). Environmental marker gene datasets (16S/18S rRNA barcodes) incorporate the traditional size classes studied using taxonomic methods (i.e. macrofauna, meiofauna) but also encompass the microbes, including bacteria, algae, fungi, and other unicellular eukaryotes, providing a complete picture of the sediment community. Environmental sequencing has been successfully used to assess biodiversity and genetic connectivity of deep-sea and coastal sediment communities (Bik et al. 2012a), as well as characterize pre- and post-spill beach sites affected by heavy oiling during the Deepwater Horizon spill (Bik et al. 2012b).

Environmental sequencing approaches result in the delimitation of molecular "Operational Taxonomic Units" (OTUs), constructed by clustering raw DNA sequences using a pairwise identity cutoff (e.g. lumping together sequences with 99% similarity); taxonomic assignment is subsequently carried out by comparing each OTU's DNA sequence to named representatives in public databases such as GenBank. While some portion of deep-sea samples will result in "no match" due to the paucity of information available, as individual genetic sequencing of organisms continues, the precision of environmental sequencing methods will increase. We will also create reference libraries (full-length rRNA genes sequenced via Sanger methods) from selected specimens collected in the cores to improve our identification of specific fauna. Environmental sequencing approaches may elucidate connectivity among habitats in the GoM, potentially identifying critical habitats for biodiversity maintenance, which is important for successful recovery. Sediment samples collected (Obj. 1) will be processed for environmental analysis to provide a rapid assessment of infaunal communities, to identify changes in their community structure, and to isolate species-specific responses to oil spills versus other types of disturbance (e.g., sedimentation). In combination with Obj. 1, results from DNA-based approaches can be directly compared to taxonomic results to assess for comparability of abundance and biodiversity estimates. Comparison among data sets will provide quantitative metrics to ground-truth the utility of molecular analyses in future assessments. This type of DNA-based method will be useful for understanding the effectiveness of restoration efforts by

providing rapid quantification of infaunal community changes with disturbance, and potentially the identification of new indicator species.

Sediment cores will be vertically sectioned upon retrieval and frozen for further processing. Sediment fractions will undergo standard meiofaunal extraction procedures including sieving over a 45-µm mesh and elutriation. Environmental DNA will be obtained from the extract via bead beating, followed by amplification and sequencing of a ~400bp diagnostic fragment of the 18S rRNA gene on the Illumina MiSeq platform. This primer set is effective over a broad taxonomic range (amplification of >20 metazoan phyla, as well as fungi, algae, and protists), and has been extensively tested and validated for high-throughput environmental DNA sequencing (Creer et al. 2010). This method has successfully elucidated metazoan communities from deep-sea systems (Bik et al. 2012a) and sediments affected by the Deepwater Horizon oil spill (Bik et al. 2012b). Processing and downstream analysis of high-throughput data will be carried out using the appropriate software tools and bioinformatic workflows. Although computational tools for high-throughput data are rapidly evolving, at a minimum we anticipate using the QIIME toolkit (currently the most widely used pipeline for microbial ecology studies; Caporaso et al. 2011). Bioinformatic analyses will incorporate a number of different approaches for clustering of Operational Taxonomic Units (OTUs; i.e., "species" as defined by molecular data) inferred from output of different software tools across a range of clustering cut-offs and computational parameters (cf., Bik et al. 2012ab).

Data collected for infaunal analyses will represent a combination of high-throughput sequencing methods and traditional taxonomic approaches (Obj. 1); this work will provide valuable data to track the recovery of impacted deep-sea coral sediment communities and guide long-term monitoring programs of deep-sea environments. This research will provide the long-term datasets that BOEM requires for impact assessments and to measure the success of mitigations developed through adaptive management for the protection of natural resources. In addition, these data will help inform the development of future restoration plans.

Objective 4: Develop and test methods for direct restoration of deep-sea corals (Cordes, Fisher)

Rationale and approach: In our view, the most viable approach for the direct restoration of the *P. biscaya* populations that were impacted by the spill is the fragmentation and transplantation of coral colonies. However, there is a wealth of information required before attempting this, and a pilot study is required to test the viability of this concept. The work proposed above will inform the selection of coral populations as sources of colonies for direct restoration and provide data on potential damage to colonies and recovery from sampling in host colonies.

Coral fragments will be collected using specially designed coral cutting attachments to ROV manipulators. Over the previous 8 years, we have worked with a variety of ROV pilots to design these, and a refined set of cutters will be developed and constructed as part of this proposal. As described above, we will monitor the colonies from which fragments are removed to quantify the impact of these collections and fine-tune our techniques to minimize damage to host colonies. Coral fragments will be returned to the surface where they will be implanted into small concrete blocks. In a previous study of transplanted *P. clavata* from the Mediterranean Sea (Linares et al. 2008), it was found that the highest survivorship (> 70%) was achieved when the coral fragments were attached to a small PVC rod as support, and then placed into small tubes which were fixed to the substrate using a two-part epoxy. Coral fragments will be approximately 10 cm high to avoid the higher mortality probability for small colonies (Doughty et al. 2014). A series of small

(< 1 m^2) concrete blocks will be poured with small depressions in them to secure the coral colonies using the epoxy. Four coral fragments will be attached to the block, one at each corner, to approximate natural densities in a high-density site. Replicate blocks will be placed back at the site of coral collection to test the viability of this technique. The transplanted corals will be imaged and monitored for mortality, damage, and growth.

This set of pilot studies will be completed in the first year. In the second year, the survivorship of transplanted colonies will be determined. By the third year, we will be able to compare growth to that of adjacent control colonies. If techniques tested in the first year fail, we will modify the techniques and try again in the second year.

Project Management (CVs of all scientists are located in the "Other" section): Dr. Amanda Demopoulos is a research benthic ecologist and biological oceanographer with the USGS. She will serve as Project Chief, responsible for project oversight and cruise coordination. She will lead the sediment community ecological studies (Objs. 1,3), lead the coordination of the instrumented moorings (Obj. 2), and supervise the personnel involved with those objectives, including oceanography and genetics postdoctoral fellows. **Dr. Erik Cordes** is a marine ecologist and an Associate Professor at Temple University. He will assist with identifying reference sites through mapping and exploration efforts and coral species and population identification (Obj. 2), co-lead the development of qPCR assays for rapid impact assessment (Obj. 3), and lead the coral transplant experiments (Obj. 4), see letter of collaboration (in "Other"). **Dr. Charles Fisher** is a Professor of Biology at the Pennsylvania State University. He will conduct in situ monitoring of corals and associated megafauna (Obl. 1), assist with identifying reference sites through mapping and exploration efforts (Obj. 2), and co-lead the coral transplant experiment (Obj. 4), see letter of collaboration (in "Other"). **Dr. Nancy Prouty** is a research oceanographer and geochemist with the USGS. She will lead the coral age and growth rates analyses (Obj. 3) and sediment geochemical analyses from the sediment trap collections (instrumented moorings) (Obj. 2). **Dr. Cheryl Morrison** is a research geneticist with the USGS and will co-lead the environmental sequencing work from the sediment trap material (Obj. 2) and lead the coral exposure experiments and transcriptomics analyses (Obj. 3). **Dr. Christina Kellogg** is a research microbiologist at the USGS. She will lead the sediment microbiology work in coordination with the sediment community ecology studies and provide support on microbial metagenomics (Obj. 1). **Kurt Rosenberger** is a physical and geological oceanographer with the USGS. He will lead the oceanographic-data-analysis techniques for the deep-sea observing systems in coordination with the post-doctoral oceanography fellow (Obj. 2). **Dr. Holly Bik** is a Birmingham fellow in the School of Biosciences at the University of Birmingham. She has extensive experience in taxonomy and molecular phylogenetics of meiofauna, including the application of environmental sequencing approaches to the study of sediment fauna. She will provide training and bioinformatics expertise for the genetics post-doctoral fellow in conducting high-throughput sequencing, data analysis, and will assist with publication preparation (Obj. 3), see letter of collaboration (in "Other"). **Greg Boland** is a biological oceanographer with BOEM. He will serve as liaison for the project on behalf of BOEM to provide guidance from the perspective of science needs for agency management and policy decisions regarding offshore energy and mineral development**. William Shedd** (Geophysicist, BOEM) will assist with reviewing 3D seismic and backscatter data to help identify potential target areas for reference coral sites.

Risks and uncertainties of the proposed activities: The proposed work represents the first phase of a multi-phased restoration project. Direct restoration of deep-sea corals has never been conducted to date. Given restoration in the deep sea is implicitly risky, this work will lay the foundation for future directed restoration activities. This restoration proposal will provide information on technical, scientific lessons that will benefit future restoration activities in deep-sea corals, including assisting with scaling of future efforts. Possible risks include activities that may disturb the restored colonies and additional impacts associated with oil and gas activities that may disturb the environment around the corals.

Outreach and education: We are proposing a highly interdisciplinary approach to examining the recovery and restoration of impacted deep-sea coral habitats. Public awareness and educational opportunities will be integrated into both the field sampling program as well as broad-based outreach material development resulting from research analysis and results. Young scientists, recent graduate and undergraduate students from the Gulf States will be actively recruited to assist with this program. This innovative project, involving both explorations of new deep-sea locations and applications of new methodologies are well suited as a NOAA OER Signature Expedition for all field sampling years. The NOAA OER program includes internal staff dedicated to creating outreach and educational materials and their expertise will be utilized for the development of lesson plans and other materials related to this Long-Term Damage Assessment, Recovery, and Restoration of Deep-water Coral Habitats project. Examples of these outreach products from past partnership studies involving BOEM, USGS, and NOAA include an ongoing study of Atlantic Canyons (http://goo.gl/pUXvss) and the previous deep-water coral study *Lophelia* II, also responsible for the initial discovery of the first impacted coral community in November 2010 at a depth of 1,370 m in lease block MC294 (http://goo.gl/okZcQ5). Similar outreach products would be anticipated as part of this monitoring and restoration project.

Leveraging of resources and partnerships:

Academia: (Cordes, Fisher): Long-term monitoring techniques described in this proposal tier directly from methods developed beginning with the discovery of the first impacted site during the BOEM/USGS/NOAA OER research cruise in 2010 through numerous additional expeditions funded by NSF, NRDA, GoMRI and NOAA OER (White et al. 2012; Fisher et al. 2014). The refined techniques developed by the same PIs (Hsing et al., 2013) will be invaluable to the continued success of long-term monitoring, discerning recovery trajectories of impacted communities and leading to monitoring of condition of both source and restored coral colonies.

NOAA Damage Assessment, Remediation, and Restoration Program: The PIs of this proposal wrote and lead several deep-water study plans as part of the NRDA process, and as this process is shifting to developing options for the Restoration work, Demopoulos, Cordes, and Fisher are involved as consultants in the scoping and writing of these restoration options. We remain in contact with the Deep-water Coral Restoration working group, and they support this proposed study as complementary, yet not duplicative with NRDA efforts, and a necessary precursor to some restoration options currently under consideration.

ECOGIG (Cordes, Fisher): We have another proposal pending with GoMRI ("ECOGIG 2") to continue monitoring the impacted sites and a subset of the others, and to conduct a variety of related laboratory and field studies investigating coral and microbiome response to oil and/or dispersant exposure. If that proposal is funded, it will complement the additional work we propose here in a number of ways. Results from the GOMRI-funded work will help to provide

additional oceanographic context for the data from the instrument deployments (**Obj. 2**). Time series coral and infaunal studies (**Obj. 1,2**) will reciprocally enrich the GoMRI work, and the proposed efforts at additional sites will provide important new data on the focal species' natural growth rates, background levels of damage to the corals, and fidelity of their normal associated megafauna. The transcriptomic data generated during ECOGIG and proposed in ECOGIG II for some of the focal coral species will enhance our ability to detect significant differences in gene regulation, which will facilitate the development of our qPCR biomarker approach proposed here (**Obj. 3**). Ship and ROV time are a limiting resource in all deep-sea work and with two complementary proposals that share many sites, the data collected at each will increase substantially. If that proposal is not funded, this proposal will allow continued monitoring of the three impacted coral sites in addition to the work we propose here.

USGS: The Leetown Science Center has two new Illumina next-generation sequencers that bring the flexibility, speed and scalability to efficiently meet sequencing needs of this project (**Obj. 2,3**). The MiSeq can produce up to 15 gigabases of sequence per run and is ideal for targeted amplicon (eDNA) and small genome sequencing (e.g. microbe or virus genomes). The Next Seq 500 can produce up to 120 gigabases of sequence data per run, and can be utilized for transcriptome and RNASeq sequencing. Computational resources, such as cloud data storage and BaseSpace Genomics computing, are also available, making data storage and sharing straightforward. The addition of this capability offers outstanding potential for utilizing novel genomic tools that will increase understanding of ecosystem functioning and lead to inexpensive and effective monitoring methods. In addition, the following mooring equipment will be provided to the project: current meters, microcats, Honjo sediment traps, and acoustic releases, which amounts to $185,770. Information regarding additional facilities and laboratory assets that will be used in this program is included in the detailed Budget Narrative section below.

BOEM: BOEM will be a major user of research results proposed here, and is serving in a lead role, providing guidance for science required for effective management decisions. BOEM is also providing an important in-kind contribution through the use of the industry-acquired 3D seismic data housed in BOEM's Gulf of Mexico's Resource Evaluation (RE) Office. These data have proven invaluable for several BOEM studies in the past as well as numerous NRDA efforts since the *DWH* spill in 2010. Although the dataset of shapefiles representing approximate locations of various kinds of seismic anomalies has been made publically available through the efforts of the BOEM RE office (http://www.boem.gov/Seismic-Water-Bottom-Anomalies-Map-Gallery), the use of the entire proprietary database including sub-surface data for individual research needs is possible in-house at the New Orleans BOEM office. This highly valuable data source will be used to identify potential hard-bottom features, including sources of coral restoration stock. An example product from this database is illustrated in Fig. 6. This contribution through BOEM has played a major role in the success of numerous scientific missions including the original discovery of the impacted habitat at MC294 (White et al., 2012), and the subsequent discovery of additional impacted coral communities around the Macondo well (Fisher et al., 2014a).

NOAA OER: Direct allocation to NOAA OER will enable leveraged cost savings of $1.2M from indirect costs (25%). In addition to overhead savings, NOAA has the potential to negotiate internal vessel lease rates providing in-kind cost savings of approximately $1.74M.

Broader impact of this work: Deep-sea environments and the Mississippi River watershed are physically, chemically, and biologically linked. Whether changes to the Mississippi River watershed will lead to improved health of downstream deep-sea ecosystems is unknown and

requires long-term monitoring. This study will provide a unique and future-focused approach to assessing the recovery and restoration of impacted deep-sea coral habitats that is applicable to both shallow and deep-sea sediments. The taxonomic and environmental data obtained through traditional methods will provide a continuation of our studies of temporal change in deep-sea coral communities (**Obj. 1,2**). Sediment traps from three year-long deployments will be analyzed for a suite of geochemical tracers (e.g., trace metals, lipid biomarkers, compound specific stable isotopes) to investigate the existing conditions around the sites, and track larval and particulate supply (**Obj. 2**). It will also establish a monitoring program at key sites that will be invaluable in the event of future accidents. One of the key findings coming out of the oil spill response was the production of an oil-fouled marine snow (the "dirty blizzard") that is a likely cause of much of the impact on deep-sea communities (Fisher et al. 2014b). It is essential that this monitoring capacity be in place to determine the impacts of future events.

This study will be the first to use environmental sequencing to assess the community adjacent to deep-sea corals, from microbes to macrofauna, and provide baseline data for future restoration and management decisions. DNA sequences resulting from environmental approaches will be deposited in publicly available databases for use by other researchers and future studies. The high-throughput sequencing data, assessed in the context of the taxonomic results for taxa abundance and diversity, will allow for the development of a rapid assessment protocol for tracking the recovery trajectory for deep-sea communities and for long-term monitoring (**Obj. 3**). A rapid assessment protocol is required to decrease the time and costs associated with the deep-sea studies needed to assess the long-term impacts from different environmental stressors and provide baseline data for future remediation and mitigation. Molecular methods will facilitate timely delivery of results to managers, allowing for quicker policy implementation.

As partners in the U.S. Department of Interior (DOI), the USGS has a long-standing commitment (10 + years) working with BOEM to fulfill information needs regarding the location and ecology of sensitive, long-lived deep-sea coral communities on the Outer Continental Shelf (OCS). This partnership is particularly important given that BOEM manages the exploration and development of the nation's offshore energy and OCS marine minerals in parallel to the USGS evaluating the science and knowledge gaps for OCS energy development. BOEM works with other Federal agencies, state governments, academia, industry, non-governmental organizations, and the public to identify data needs related to ocean resource management and to utilize the best available science for informed decision-making. A major source of scientific research is realized through the BOEM Environmental Studies Program http://www.boem.gov/studies/ that includes interdisciplinary studies including USGS and NOAA similar to the project in this proposal. We have worked over the last decade to develop a multidisciplinary research program, focusing on understanding complex deep-sea marine communities and providing ecosystem-based scientific studies in areas that are being considered for oil and gas leasing (e.g., Gulf of Mexico and Atlantic regions). Partnerships such as the joint collaboration between the USGS, BOEM, and NOAA maximize the utility of research results, enhancing the ability to achieve conservation goals of all agencies (see letter of collaboration from NOAA, in "Other"). This DOI nominated proposal directly addresses the overall mission of the DOI; protection and management of the Nation's natural resources and providing scientific information about those resources. The science resulting from this project will be directly utilized within environmental analysis documents and applied through management policies in the future.

Location information:

Six study sites have been chosen as described in Table 1 ranging in distance from the *Deepwater Horizon* spill site from 6 to 58 km. Fig. 1 (in "Other") illustrates the general location in relation to the Mississippi Delta. Fig. 6 illustrates the three documented impact sites together with detailed background 3D seismic reflectivity data of the seabed. Additional figures include images of corals and instrumentation mooring design (see "Other").

Table 1. Location of study sites with water depth and latitude/longitude.

Lease Block #	Depth (m)	Latitude	Longitude
MC294 (original site)	1,370	28.6722º	-88.4765º
MC297	1,560	28.6825º	-88.3450º
MC344	1,850	28.6337º	-88.1698º
MC203	951	28.7873º	-88.6347º
MC507	1,040	28.4857º	-88.8509º
VK826	500	29.1560º	-88.0165º

High level budget narrative

Budget Summary (all offices/agencies)

Study Title: Long-Term Damage Assessment, Recovery, and Restoration of Deep-water Coral Habitats Impacted by the *Deepwater Horizon* Oil Spill

Principal Investigators:
Amanda W.J. Demopoulos, USGS-SESC
Greg Boland, BOEM
Cheryl Morrison, USGS-LSC
Christina Kellogg, USGS-SPCMSC
Nancy Prouty, USGS-PCMSC
Charles Fisher, The Pennsylvania State University
Erik Cordes, Temple University
William Shedd, BOEM
Holly Bik, University of Birmingham

	FY16 request	FY17 request	FY18 request	Total Request
Total Salaries	$ 469,197	$ 614,045	$ 765,138	$ 1,848,380
Material and Supplies	$ 30,594	$ 22,500	$ 16,500	$ 69,594
Publications	$ 2,000	$ 10,000	$ 10,000	$ 22,000
Travel	$ 16,200	$ 21,200	$ 18,200	$ 55,600
Analyses	$ 173,122	$ 155,102	$ 139,622	$ 467,846
Equipment	$ 1,029,205	$ 30,000	$ 30,000	$ 1,089,205
Contractual Services	$ 345,872	$ 357,434	$ 386,126	$ 1,089,432
BOEM-IAA	$ 55,000	$ 55,000	$ 55,000	$ 165,000
Shiptime	$ 2,130,000	$ 2,000,000	$ 1,200,000	$ 5,330,000
Total Direct Costs	$ 4,251,190	$ 3,265,281	$ 2,620,586	$ 10,137,058
Indirect Costs	$ 498,728	$ 283,410	$ 315,183	$ 1,097,321
Total Request	**$ 4,749,918**	**$ 3,548,691**	**$ 2,935,769**	**$ 11,234,379**

Budget Justification Summary: 3 year study: $11,234,379. Shiptime (Global Class Vessel, ROV, AUV): $5,330,000, travel, analyses, supplies, equipment, publications, contracts, salary (assistants, post-doctoral fellowship, students, and operating expenses): $4,807,058, indirect costs: $1,097,321. Cost match: $877K from USGS salaries, OE, and equipment and >$2.5M from proposed complementary GOMRI ECOGIG project.

The budget represents 2 separate allocations, one to USGS and a separate direct allocation of shiptime funding from RESTORE to NOAA OER for the ship, ROV, and AUV contracts. Detailed information regarding subcontracts (Pennsylvania State University, Temple University), direct transfers (USGS center allocations), and interagency agreements (BOEM) are included below.

Detailed Budget Separated by Participating Institution

USGS, Southeast Ecological Science Center (SESC), Gainesville, FL

	FY16 request	FY17 request	FY18 request	Total Request
Total Salaries	$ 117,879	$ 246,274	$ 258,587	$ 622,740
Material and Supplies	$ 12,669	$ 4,500	$ 4,500	$ 21,669
Publications	$ -	$ 3,000	$ 3,000	$ 6,000
Travel	$ 4,000	$ 9,000	$ 9,000	$ 22,000
Analyses	$ 12,128	$ 5,108	$ 8,628	$ 25,864
Equipment	$ 1,029,205	$ 30,000	$ 30,000	$ 1,089,205
Contractual Services - Pennsylvania State University	$ 110,910	$ 113,637	$ 107,366	$ 331,913
Contractual Services - Temple University	$ 152,477	$ 157,187	$ 187,819	$ 497,484
Contractual Services-Personnel services	$ 82,462	$ 86,585	$ 90,914	$ 259,960
BOEM-IAA	$ 55,000	$ 55,000	$ 55,000	$ 165,000
Total Direct Costs	$ 1,576,730	$ 710,291	$ 754,815	$ 3,041,835
Indirect Costs (25 %)	$ 394,182	$ 177,573	$ 188,704	$ 760,459
Total SESC Request	$ 1,970,912	$ 887,863	$ 943,519	$ 3,802,294

USGS, Leetown Science Center (LSC), WV

	FY16 request	FY17 request	FY18 request	Total Request
Total Salaries	$ 100,496	$ 100,496	$ 136,192	$ 337,184
Material and Supplies	$ 12,000	$ 12,000	$ 6,000	$ 30,000
Publications	$ 2,000	$ 2,000	$ 2,000	$ 6,000
Travel	$ 6,000	$ 6,000	$ 3,000	$ 15,000
Analyses	$ 65,000	$ 54,000	$ 35,000	$ 154,000
Total Direct Costs	$ 185,496	$ 174,496	$ 182,192	$ 542,184
Indirect Costs (22.4 %)	$ 41,529	$ 39,066	$ 40,789	$ 121,384
Total LSC Request	$ 227,025	$ 213,562	$ 222,981	$ 663,568

USGS, St. Petersburg Coastal & Marine Science Center (SPCMSC), St. Petersburg, FL

	FY16 request	FY17 request	FY18 request	Total Request
Total Salaries	$ 127,880	$ 132,040	$ 221,600	$ 481,520
Material and Supplies	$ 6,000	$ 6,000	$ 6,000	$ 18,000
Publications	$ -	$ 5,000	$ 5,000	$ 10,000
Travel	$ 5,000	$ 5,000	$ 5,000	$ 15,000
Analyses	$ 39,000	$ 39,000	$ 39,000	$ 117,000
Total Direct Costs	$ 177,880	$ 187,040	$ 276,600	$ 641,520
Indirect Costs (18.632 %)	$ 33,143	$ 34,849	$ 51,536	$ 119,528
Total SPCMSC Request	$ 211,023	$ 221,889	$ 328,136	$ 761,048

USGS, Pacific Coastal & Marine Science Center (PCMSC), Santa Cruz, CA

	FY16 request	FY17 request	FY18 request	Total Request
Total Salaries	$ 122,942	$ 135,236	$ 148,759	$ 406,936
Material and Supplies	$ -	$ -	$ -	$ -
Publications	$ -	$ -	$ -	$ -
Travel	$ 1,200	$ 1,200	$ 1,200	$ 3,600
Analyses	$ 56,994	$ 56,994	$ 56,994	$ 170,982
Total Direct Costs	$ 181,136	$ 193,430	$ 206,953	$ 581,518
Indirect Costs (16.5 %)	$ 29,887	$ 31,916	$ 34,147	$ 95,951
Total PCMSC Request	$ 211,023	$ 225,346	$ 241,100	$ 677,469

Subcontract to Temple University-Budget detail

	FY16 request	FY17 request	FY18 request	Total Request
Total Salaries	$ 64,642	$ 66,581	$ 81,417	$ 212,640

Material and Supplies	$ 25,300	$ 24,880	$ 24,880	$ 75,060
Publications	$ -	$ 1,500	$ 1,500	$ 3,000
Travel	$ 7,800	$ 7,800	$ 12,600	$ 28,200
Total Direct Costs	$ 97,742	$ 100,761	$ 120,397	$ 318,900
Modified Total Direct Costs (MTDC)	$ 97,742	$ 100,761	$ 120,397	$ 318,900
F&A: 56.0% of (MTDC)	$ 54,735	$ 56,426	$ 67,422	$ 178,584
Total Project Costs	$ 152,477	$ 157,187	$ 187,819	$ 497,484

Subcontract to Pennsylvania State University-Budget detail

	FY16 request	FY17 request	FY18 request	Total Request
Total Salaries	$ 75,180	$ 76,933	$ 81,368	$ 233,481
Material and Supplies	$ -	$ -	$ -	$ -
Publications	$ -	$ -	$ -	$ -
Travel	$ 5,000	$ 5,000	$ 5,000	$ 15,000
Tuition remission	$ 16,698	$ 17,366	$ 5,884	$ 39,948
Modified Total Direct Costs (MTDC)	$ 80,180	$ 81,933	$ 86,368	$ 248,481
Total Direct Costs	$ 96,878	$ 99,299	$ 92,252	$ 288,429
F&A: 17.5% of (MTDC)-note: not assessed on tuition	$ 14,032	$ 14,338	$ 15,114	$ 43,484
Total Project Costs	$ 110,910	$ 113,637	$ 107,366	$ 331,913

Detailed Budget Justification:

Shiptime: The proposed research represents a 3 year study with one cruise each year of the study. Cruises: Year 1, 2 cruises, one 10d cruise with *Sentry* AUV, *Ron Brown*, and one 18d cruise with *Ron Brown*/*Jason* ROV (Total = $2,130,000). Year 2: 1x 25d cruise, *Ron Brown*/*Jason* ROV (Total = $2,000,000), Year 3: 1 x 15d cruise, *Ron Brown*/*Jason* ROV ($1,200,000). Day rate for Ron Brown is $55,000, ROV Jason is $25,000, and AUV Sentry $14,000.

NOAA-Shiptime-Direct allocation from RESTORE to NOAA OER will enable a cost savings of $1.2M from indirect costs (25%). Currently, the budget does not include required overhead charges for accepting funds from another agency. It is anticipated funds from the RESTORE Council will be capable of transferring funds directly to NOAA. In addition to overhead savings, NOAA would then have the potential to negotiate internal vessel lease rates that could provide in-kind cost savings of approximately $1.74M.

USGS-Southeast Ecological Science Center:

Labor: Four pay periods per year are requested for Dr. Demopoulos to provide project oversight, lead mission planning, cruise planning, and draft reports. In addition, she will lead the benthic infaunal community studies (Obj. 1, 3) and provide oversight of the monitoring instruments deployed each year. Salary is requested for technical assistance (federal, contractor, and student positions) for pre-cruise preparation of the moorings, post cruise demobilization, and laboratory analyses, including genetic analysis, meio and macrofaunal sorting and identification, and chemical analyses of the sediments. Salary support is requested for 2 full time post-doctoral positions (GS-11/1) to lead the analysis of the hydrological data from the instruments (Obj.2) and the environmental sequencing of the sediment communities (Obj. 3) and publication preparation.

Supplies and Associated Shipping: Funds for benthic sampling supplies, small equipment, supplies for molecular analyses, chemicals (formalin, ethanol, reagents for environmental sequencing), computer for analysis of environmental sequencing data, media for data backups, and shipping costs, including equipment purchases.

Publications: Requested funds are to provide support for journal publication charges in years 2 and 3.

Travel: Travel funds in years 1-3 are requested for 1 trip to Gulfport or similar, for 4 scientists to participate in research cruises. In addition, travel funds are budgeted in years 2 and 3 to allow Dr. Holly Bik to train the GS-11 genetics post-doc sample preparation for environmental sequencing and post-processing and analysis of the sequence data, and for publication preparation. Travel funds are also budgeted to attend one conference in year 2 and year 3 and to enable joint PI coordination meetings for report and manuscript preparation.

Analyses: funds are requested to analyze sediments for a suite of parameters including hydrocarbon, metals, and stable carbon and nitrogen isotopes. Environmental sequencing costs are included here for analysis of the infaunal communities, including sequencing runs on Illumina MiSeq and HiSeq. $17,000 has been allocated for Illumina library preparation and sequencing for environmental DNA approcates. Sequencing will be conducted at USGS-Leetown Science Center (see facilities information included below).

Equipment: Funds are requested to purchase equipment necessary for assembling 6 sediment trap moorings. Equipment includes ADCP, CTD with oxygen and fluorescence sensors, PARFLUX Mark78HW-13 sediment traps, anchors, hardware, floats, batteries, and calibration costs.

Interagency Agreement (BOEM): an interagency agreement will be established with BOEM to facilitate funds transfer for a technician to work on analysis of the 3D seismic data and assist with identifying potential target locations for hard bottoms and site selection.

Contractual Services:

Subcontract from USGS-SESC to Pennsylvania State University

Labor: Funding is requested for salary support for 1 month per year for the P.I. Additional funds are requested for a technician to assist with mobilizing and demobilizing for each cruise and data management. Additional funds are requested for a graduate research assistant (6.5 months per year) to assist with the image analysis and synthesis. In addition, tuition remission is requested for the graduate research assistant.

Travel: Funds are requested for four people to participate in the research cruises each year and 1 trip to attend PI coordination meeting.

The total cost for these categories is $288,430 for the project, the indirect cost ($43,484) is assessed at the CESU rate of 17.50%, and the total cost of this subcontract is $331,914.

Subcontract from USGS-SESC to Temple University:

Labor: Included in the budget for Temple University is salary for 1 summer month per year for the P.I. (benefits @ 8.2%), plus a second month in the final year to assist with synthesis of the data, two semesters and summer support per year (plus benefits @ 20.5%) for a graduate student to participate in the cruises and oversee the lab work, and six months per year for a technician (@$30k per year) to assist with the development of the coral transplant pilot study, the qPCR assays and the microsatellite markers (at a benefits rate of 28.3%).

Travel is included for the P.I., student and an undergrad or technician to participate in an annual meeting and a research cruise in each year. There is an additional budget item for three people to travel to an additional scientific conference to present the results of the study in yr 3.

There are six sites with significant *P. biscaya* populations named in the proposal. In year 1, before the first cruise, we will work with knowledgeable ROV pilots and the machine shop at Temple University to construct a pair of coral cutting devices ($10,000). Materials are included for the coral transplant pilot study in year 1 ($2000). Costs are included for morphological and genetic identification of samples in each year ($3800/yr), and development of the microsattelite markers and qPCR primers in yr 1 ($4000). In years 2 and 3, each coral

sample will also be genotyped using microsattelite markers ($7200 per year). Coral samples collected in situ and additional existing samples from previous lab experiments will be used in the qPCR assays in years 2 and 3 ($8380 per year). There are also supplies for the cruises, including the preservatives for in situ preservation of some of the samples, shipping costs, media for video files, and general cruise supplies ($5500 per year). There is also an additional $1500 in year 2 and 3 for open access publication costs.

All of these items come to a total of $318,900 for the project and are overheaded at a rate of 56%, bringing the indirect cost total to $178,584 and a budget total of $497,484.

USGS-Pacific Science Coastal and Marine Science Center

Labor: Funds are requested to support Dr. Prouty for sample preparation and analysis of the deep-sea coral specimens and sediment trap samples. She will lead these investigations and be responsible for manuscript preparation and oversight of the radiocarbon, stable isotope, trace metals, grain size, biomarker, ^{210}Pb analyses. In addition, funds are requested for technical assistance to conduct the sample analysis. Salary support is requested for Rosenberger, a physical oceanographer who be analyzing the mooring instrument data (ADCP and CTD) in coordination with the oceanography post doc located at USGS SESC.

Analyses: Funds for analysis costs are included for radiocarbon, stable isotopes (C and N) and compound specific stable isotope analysis of deep-sea corals. Funds are requested for ^{210}Pb, biomarkers, stable isotopes, percent organic carbon, trace metals, grain size analyses of the sediment trap material.

Travel: Travel funds in years 1-3 are requested for 1 trip to Gulfport or similar, for 1 scientist to participate in the research cruises.

USGS-Leetown Science Center

Labor: Funds are requested for salary support for Dr. Morrison to lead the environmental sequencing (eDNA) of the sediment trap samples and transcriptomic analysis of *Lophelia pertusa*. She will provide oversight of all the sequencing work conducted at LSC. In addition, funds are requested for a post-doc to assist with sampling and sequencing throughout the study and to participate in publication preparation. Lastly, salary funds are requested for technical support for the sequencing work.

Supplies: Funds for molecular analyses, chemicals (ethanol, reagents for environmental sequencing), and media for data backups.

Publications: Requested funds are to provide support for journal publication charges in years 1,2, and 3.
Travel: Travel funds in years 1-3 are requested for 1 trip to Gulfport or similar, for 2 scientists to participate in research cruises.

Analysis: Environmental sequencing costs are included here for analysis of the coral and sediment trap samples, including sequencing runs on an Illumina MiSeq plus RNASeq runs on an Illumina NextSeq500.

USGS-St. Petersburg Coastal and Marine Science Center

Labor: Funds are requested for salary support for Dr. Kellogg to lead the sequencing of the sediment samples for microbial communities. In addition, funds are requested for a post-doc to assist with the sequencing work throughout the study and participate in publication preparation.

Supplies: Funds for molecular analyses, chemicals (ethanol, reagents for environmental sequencing), and media for data backups.

Publications: Requested funds are to provide support for journal publication charges in years 1,2, and 3.

Travel: Travel funds in years 1-3 are requested for 1 trip to Gulfport or similar, for 2 scientists to participate in research cruises.

Analysis: Sequencing and enumeration costs are included here for analysis of the sediment samples.

Federal Matching funds:

Federal matching funds includes USGS salary match: 50% time per year from Dr. Demopoulos, Dr. Prouty, Dr. Kellogg and Dr. Morrison. In addition, the following mooring equipment will be provided to the project: current meters, microcats, Honjo sediment traps, and acoustic releases, which amounts to $185,770. Total in-kind support amounts to $877,326.

In addition, all USGS facilities, Temple University, and Pennsylvania State University are fully equipped to conduct and execute this research program. Facilities details are included below.

Facilities:

USGS Southeast Ecological Science Center-Gainesville-Demopoulos Laboratory and Facilities

Laboratory – Dr. Demopoulos' lab has several dissecting and compound microscopes, centrifuges, fume hoods, drying ovens and is a fully functioning benthic infaunal analysis laboratory. The facility has a walk-in freezer, cold room, -80 and -20 freezers to fully support sample storage. In addition, the facility has extensive storage space and expertise for preparing and storing the instrumented moorings planned for Obj.2. **Computer** – The USGS SESC computer facilities include workstations and storage arrays to support data analysis, manuscript preparation, and digital data archiving. We have the necessary monitors and video analysis software for the habitat specificity study. **Office** – Office facilities are available at USGS SESC for visiting scientists and for the postdoctoral scholars and students involved in the project.

St. Petersburg Coastal and Marine Science Center –Kellogg Laboratory Equipment and Facilities

Laboratory- Dr. Kellogg's laboratory consists of ~800 sq. ft. of laboratory space, fully equipped with standard equipment for molecular and microbiology, a chemical fume hood, a laminar flow hood, and ethernet connections. **Computers**-Dr. Kellogg's facilities include three iMac desktops running OS10 as well as two MacBookPro laptops in the offices and laboratory. She also has access to a virtual Linux core processing server and a 42" wide-format printer. **Office-** Office space is available for all personnel working on this grant, and desk space is available in the laboratory for undergraduate volunteers.

Major Laboratory Equipment: For molecular biology: 2 Perkin Elmer GeneAmp PCR 9600 systems for standard PCR, 1 BioRad S1000 thermal cycler for gradient PCR, electrophoresis gel rigs and imaging system, refrigerated and standard benchtop microcentrifuges, water bath, Beadbeater, Sonicator, UV crosslinker, two refrigerators, a -20 freezer and a -80 ultrafreezer.

For microbiology: autoclave, one refrigerated and one standard shaking incubators, multiple stationary incubators, Beckman L8-80M ultracentrifuge, Beckman Coulter Avanti JE centrifuge, hotplates, one portable and one laboratory pH meters, Mettler Toledo toploading balance, Bantax colony counter, Fisher light microscope, Olympus BH-2 and BX51 epifluorescence microscopes.

USGS-Leetown Science Center Facilities- Morrison Laboratory Equipment and Facilities

Laboratory- Dr. Morrison's genomics laboratory at the Leetown Science Center (LSC) includes the necessary equipment for genetic analysis of DNA and RNA samples, plus a fume hood and laminar flow hood for PCR setup, and separate pre-PCR room (for eDNA work) and a PCR room. **Computers**-Several desktop computers

that run Windows 7, UNIX, or MacOS10 are available, along with three desktop computers that run instruments in the lab. Each employee has a desktop computer for use. Two laptop computers (Dell Inspiron and Mac Powerbook) are also available. Data storage includes a 2 TB back-up drive plus a 16 TB Drobo drive. Cloud data storage and BaseSpace Genomics computing software are available with our Illumina next-generation sequencers (see Major lab equipment below). Commercial software for processing next-generation sequencing data, such as CLC Genomics Workbench (CLCbio, Qiagen), Sequencher (GeneCodes), and Geneious Pro, is available to produce sequence alignments, assemblies, and perform phylogenetic and comparative analyses. **Offices**-Office space is available for all personnel working on this grant.

Major Laboratory Equipment includes an ABI 3130xL DNA Sequencer, an ABI ViiA7 and Rotor-Gene (Qiagen) quantitative PCR instruments, an Agilent bioanalyzer, Nanodrop spectrophotometer and Qubit fluorometer (Life Technologies) for quantification of DNA/RNA and quality checks, five thermocyclers for PCR (Bio-Rad, Eppendorf, MJ Research), mixer mill (Retsch), UV Stratalinker, six sets of pipettors, gel rigs and imaging system, centrifuges, hot plates, water baths, balances, shaker-incubator, hybridization oven, two -20^{0}C freezer, -80 ^{0}C freezer, and a refrigerator. Next-generation sequencing capacity at the LSC includes Illumina MiSeq and NextSeq 500 instruments.

Other resources: A bioinformaticist, Dr. Scott Cornman, is available to the USGS scientists involved in the proposed research. He regularly processes Illumina sequencing data generated for eDNA and RNA-Seq projects.

Dr. Cordes' Laboratory Equipment and Facilities

Laboratory- Dr. Cordes' laboratory consists of 1000 sq. ft. of laboratory space, and two walk-in cold rooms are available for this project. The laboratories are fully equipped with standard small equipment, two fume hoods, ethernet connections, gas and air. **Computers-**Dr. Cordes' facilities include four PC desktops with Windows Vista, a Mac Mini running a 32 Tb RAID5 server, two iMac desktops, plus 4 laptop PCs operating in the offices and laboratories. One of the laptops is dedicated to the real-time thermocycler and the spectrophotometer. The lab also contains a scanner and an HP color printer. **Office**-Office space is available for all personnel working on this grant, and desk space is available in the laboratory for undergraduate researchers.

Major Laboratory Equipment-Equipment housed in the molecular side of the Cordes laboratory includes an Eppendorf Mastercycler Realplex thermocycler for quantitative PCR, a Nanodrop spectrophotometer, benchtop centrifuges, hotplates, a shaker-incubator, a hybridization oven, gel rigs and an imaging system, two -80°C freezers, a -20°C freezer, and a refrigerator. The wet lab contains a Mettler Toledo DL15 Potentiometric Titrator, 2 pH meters, a muffle furnace, drying oven, Leica S6D dissecting microscope with attached Nikon D300 digital-SLR camera, Wild dissecting scope, two Zeiss compound microscopes and glassware. There are two 150-gallon marine aquaria used as a reservoir for all of the live corals currently housed in the laboratory, and a series of six experimental aquaria fully equipped to manipulate different aspects of the carbonate system. **Other Resources***:* Through the Department of Biology, and the Temple University Medical School, his group has access to a full spectrum of major equipment for molecular phylogenetic analyses; light, confocal, and electron microscopy; and technical assistance.

Dr. Fisher's Laboratory Equipment and Facilities (PSU)

Laboratory-Dr. Fisher's laboratory has 2,500 sq. feet of laboratory space and two walk-in cold rooms available for this project in addition to storage space for field equipment. The laboratory is fully equipped with standard small equipment, two fume hoods, easily accessible storage systems for preserved samples, hard and wireless ethernet connections, Milli-Q water, gas and air. **Computers-**We currently have 7 computers operating in the offices and laboratories. These include two Dell Dimension Desktop 9200 machines, a Dell Precision Laptop

M6400, a Sony Vaio Laptop, an iMac 21.5" Quad-Core i5, an iMac 27" Quad-Core i7, and an iMac 27" Quad-Core i5. All imaging computers are run with two displays. We recently purchased a 16 terabyte internally redundant data storage system which is housed in a climate controlled room managed by our College. The system provides a platform that we can work directly off of with our large image files as well providing independent back up for all files that are also stored locally. **Office-** Office space is available for all personnel working on this grant: In addition to 4 cubicles in one of the 3 rooms of the laboratory and desk space for undergraduate students in another room, there are additional offices in the building for senior graduate students and post docs who prefer more privacy.

Major Laboratory Equipment: Spectrophotometer (portable and non-), spectrofluorometer, centrifuges, two ultra-cold freezers, two refrigerators, and assorted drying and ashing ovens. Assorted microscopes including Olympus BH2 and SZ40 microscopes and portable "student" microscopes for routine use at sea. 2 Hi-8 video systems, 2 VHS systems, a Sony monitor, and a Sony DSR-25 DVCAM VTR linked to computers are available for digital video work. Through the department and ongoing collaborations, the Institute for Molecular Evolutionary Genetics, and the Life Sciences Consortium, we have access to a full spectrum of equipment for sequencing and molecular analyses, electron microscopes, and technical assistance.

Major Field Equipment: Most important for this proposal is our BFC6000, which is an AquaSLR underwater camera consisting of an 18 megapixel Cannon T5i in a custom 6000m titanium housing with optical dome and dedicated lights. We also have custom shipping containers for most major sea-going equipment and computers, a motion-compensated ship-board balance system for use at sea, and rings, nets, and insulated boxes for animal collections and recovery using ROVs.

USGS-PCMSC Geochemistry Laboratories and Capabilities-Dr. Prouty's Laboratory and Facilities
The Pacific Coastal and Marine Science Center Marine Facility staff provides mechanical and electronics support for marine field operations. This includes maintaining an inventory of state of the art instrumentation for measuring physical oceanographic parameters in-situ over long periods of time (4 to 12 months) and platforms to deploy the instruments (e.g., tripods, moorings). Parameters include current speed and direction, temperature, salinity, and turbidity. Data loggers are maintained that can be easily customized to accommodate a variety of sensors. The Facility develops new techniques, performs calibrations and bench test, and plans, manages, and executes fieldwork in estuarine, coastal, and continental shelf regions, deploying oceanographic moorings and tripods at depths from three to 3000 m. **Laboratory-**Organic Biomarker / Petroleum Geochemistry / Trace Greenhouse and Thermogenic Gas Facility: PCMSC has several state-of-the-art gas chromatography / mass spectrometers set up to determine the specific composition of organic and petroleum biomarkers, as well as gas hydrate / methane. The composition of sedimentary organic matter is determined by microwave-assisted solvent extraction, followed by polar fractionation into compound classes, and measured by gas chromatography and mass spectrometry. An Agilent 6890 gas chromatograph located in the Santa Cruz laboratory equipped with a 5973 mass spectrometer. The mass spectrometer has in electron ionization (EI) and a chemical ionization mode (CI) sources. The Trace Element Geochemistry Laboratory enables contaminant-free analyses of various sample types.
Other Laboratory Equipment available includes: Leitz Petrographic Microscope, with reflected and transmitted light for thin section studies of rocks; with camera**,** Binocular Microscope with camera**,** Philips X-ray diffractometer with carbon monochromator for identification and study of crystalline phases; and associated analytical software**,** Perkin-Elmer Fourier Transform Infrared Spectrophotometer (FTIR mid-and-far range). Stainless steel and polyethylene hoods, magnetic stirrers, oven, furnace, large centrifuge, analytical balance, small trim saws, micronizer grinding mill, electric agate mortar and pestle. PCMCS has a full complement of RADDEC and RAD7 detectors for the analyses of Rn and Ra. The lab has 16 alpha and 2 HPGe well detectors for ^{210}Pb of sediment by alpha and gamma spectrometry. One of the largest demands on this lab is for the analyses of alpha and gamma emitting radionuclides in marine and lacustrine sediment.

Appendix B: Gulf Coast Ecosystem Restoration Council Environmental Compliance Checklist

Please check all federal and state environmental compliance and permit requirements as appropriate to the proposed project/program.

Environmental Compliance Type	Yes	No	Applied For	N/A
FEDERAL				x
National Marine Sanctuaries Act (NMSA)				x
Coastal Zone Management Act (CZMA)				x
Fish and Wildlife Coordination Act				x
Farmland Protection Policy Act (FPPA)				x
NEPA – Categorical Exclusion				x
NEPA – Environmental Assessment				x
NEPA – Environmental Impact Statement				x
Clean Water Act – 404 – Individual Permit (USACOE)				x
Clean Water Act – 404 – General Permit(USACOE)				x
Clean Water Act – 404 – Letters of Permission(USACOE)				x
Clean Water Act – 401 – WQ certification				x
Clean Water Act – 402 – NPDES				x
Rivers and Harbors Act – Section 10 (USACOE)				x
Endangered Species Act – Section 7 – Informal and Formal Consultation (NMFS, USFWS)				x
Endangered Species Act – Section 7 - Biological Assessment (BOEM,USACOE)				x
Endangered Species Act – Section 7 – Biological Opinion (NMFS, USFWS)				x
Endangered Species Act – Section 7 – Permit for Take (NMFS, USFWS)				x
Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) – Consultation (NMFS) *coral collection permit	x*			
Marine Mammal Protection Act – Incidental Take Permit (106) (NMFS, USFWS)				x
Migratory Bird Treaty Act (USFWS)				x
Bald and Golden Eagle Protection Act – Consultation and Planning (USFWS)				x
Marine Protection, Research and Sanctuaries Act – Section 103 permit (NMFS)				x
BOEM Outer Continental Shelf Lands Act – Section 8 OCS Lands Sand permit				x
NHPA Section 106 – Consultation and Planning ACHP, SHPO(s), and/or THPO(s)				x
NHPA Section 106 – Memorandum of Agreement/Programmatic Agreement				x
Tribal Consultation (Government to Government)				x
Coastal Barriers Resource Act – CBRS (Consultation)				x
				x
STATE				
As Applicable per State				x

Data/Information Sharing

To provide clear, effective, and transparent implementation of data sharing, we have developed the following data management plan regarding access, sharing and archiving.

Mapping/Geophysics

Bathymetry and acoustic backscatter data collected during the proposed work will undergo preliminary data reduction, QA/QC, and will be gridded and merged with existing data to allow for dive planning and preliminary analysis. Following the cruise, data will undergo final processing for use by the PIs for geologic, biologic, and oceanographic data analyses and inclusion in peer-reviewed manuscripts/conference presentation. Processed data will be incorporated in existing publically-released USGS bathymetry mapping products for the GOM. Raw bathymetry, acoustic backscatter, and water column data files will be supplied to NOAA's National Geophysical Data Center (NGDC) one year after the cruise for archiving and public release. Sub-bottom profiles will be publicly released via USGS data release.

ROV video

Video data will be archived and compliant with ISO and/or other applicable Federal metadata standards. Copies will be archived at the NOAA Central Library or USGS data archive and be publicly available, but given the massive data volume of the HD video from the ROV, copies will be charged for the cost of duplication

Biological Samples

Samples of interest to the PI's and collaborators will be distributed and analyzed based on a sampling policy established prior to the cruise and discussed prior to each dive. After each dive, all samples will be catalogued prior to preservation. Results from analyses by each scientist/group will be disseminated via peer-reviewed manuscripts/conference presentations and archived with the appropriate repository/national database. Samples collected, but not assigned to specific PI/collaborators will be archived at the National Museum of Natural History, Smithsonian Institution.

Oceanographic Data

Oceanographic data acquired from the mooring instruments and routinely collected during each ROV dive (CTD data) will be made available to project scientists (directly or via ftp) for analysis and results will be incorporated into manuscripts/conference presentations by the PIs/collaborators. Raw and processed data will be publically released via USGS data release and submitted to NOAA's National Oceanographic Data Center (NODC) one year after the cruise. As with all data collected on this expedition, we will work closely with NOAA OER data managers to ensure that the data are made available in a timely manner.

Partnering with NOAA OER and their facilitation of research vessel and submergence facility logistics also provides a direct tie to their program's data archiving and sharing component. This group has been working closely with a current contractor for BOEM as part of the Atlantic Canyons BOEM/USGS/NOAA OER study previously mentioned and works directly to insure data archiving in proper repositories such as the National Oceanographic Data Center obtained through research associated with NOAA research vessels.

Additional components of data and information sharing beyond the described data management plan include the deposition of completed study reports within the BOEM archival system ESPIS (Environmental Studies Program Information System) that makes all completed BOEM reports available on-line as full electronic pdf

documents, including images and graphics (http://www.data.boem.gov/homepg/data_center/other/espis/espismaster.asp?appid=1) and also archival of collected specimens when appropriate with the Smithsonian National Museum of Natural History. BOEM has had a long-term contract with the Smithsonian's Museum Support Center (MSC) for the archival of invertebrate collections from all of their contracted studies since 1979. Collections from previous BOEM studies make up substantial proportions, and in some groups, the majority of specimens at the MSC. Recent expansion of this program now includes the archival of tissues for DNA archival in the new Biorepository at the MSC. It is anticipated that there will be a variety of biological collections that would warrant archiving at the end of their use for this research. This final important step in preservation of scientific information is critical to preserve Federally-funded biological samples and make them available to taxonomists and geneticists around the world into the future. Although much of the funding for this project will not be Federal dollars, many of the scientists will be supported by Federal taxpayer dollars. This preservation goal is a recent Federal priority for all government agencies and also recognized by the request for a description of data access and sharing by the RESTORE Council. In addition to the ability of scientists to directly visit the Smithsonian to work with specimens or tissue DNA, there is also an internet database for accession all collection information, http://invertebrates.si.edu/boem/boem.htm

References

Anderson, M.J., Gorley, R.N., Clarke, K.R. 2008. PERMANOVA+ for PRIMER: guide to software and statistical methods. Plymouth: PRIMER-E Ltd. 214 p.

Baillon S, Hamel JF, Wareham VE, Mercier A. 2012. Deep cold-water corals as nurseries for fish larvae. Frontiers in Ecology and the Environment 10: 351-356.

Barshis, D.J., J.T. Ladner, T.A. Oliver, F. O. Seneca, N. Traylor-Knowles, and S.R. Palumbi 2013. Genomic basis for coral resilience to climate change. PNAS 110(4):1387-1392.

Bik HM, Sung W, De Ley P, Baldwin JG, Sharma J, et al. 2012a. Metagenetic community analysis of microbial eukaryotes illuminates biogeographic patterns in deep-sea and shallow water sediments. Mol Ecol 21(5):1048–59.

Bik HM, Halanych KM, Sharma J, Thomas WK. 2012b. Dramatic shifts in benthic microbial eukaryote communities following the Deepwater Horizon oil spill. PLoS ONE 7(6):e38550.

Caporaso JG, Lauber CL, Costello EK, Berg-Lyons D, Gonzalez A, et al. 2011. Moving pictures of the human microbiome. Genome Biol 12(5):R50.

Carreiro-Silva M, Andrews AH, Braga-Henriques A, de Matos V, Porteiro FM, Santos RS. 2013. Variability in growth rates of long-lived black coral *Leiopathes* sp. from the Azores. Marine Ecology Progress Series 473:189-199.

Cordes EE, Bergquist DC, Fisher CR. 2009. Macro-ecology of Gulf of Mexico cold seeps. Annual Review of Marine Science 1: 143-168.

Creer S, Fonseca VG, Porazinska DL, Giblin-Davis RM, Sung W, et al. 2010. Ultrasequencing of the meiofaunal biosphere: practice, pitfalls and promises. Mol Ecol 19:4-20.

Danovaro R, Gambi C, Dell'Anno A, Corinaidesi C, Fraschetti S, Vanreusel A, Vincx M, Gooday AJ. 2008. Exponential decline of deep-sea ecosystem functioning linked to benthic biodiversity loss. Current Biology 18: 1-8.

Davies AJ, Duineveld GCA, van Weering TCE, Mienis F, Quattrini AM, Seim HE, Bane JM, Ross SW. 2010. Short-term environmental variability in cold-water coral habitat at Viosca Knoll, Gulf of Mexico. Deep-sea research Part I, Oceanographic research papers 57:199-212.

DeLeo, DM, Ruiz-Ramos D, Baums IB, Cordes EE. *In press*. Response of deep-water corals to oil and chemical dispersant exposure. Deep Sea Research Special Issue – The Gulf of Mexico Ecosystems: Before, During and After the Deepwater Horizon Oil Spill.

Demopoulos AWJ, Smith CR. 2010. Invasive mangroves alter macrofaunal community structure and facilitate opportunistic exotics. MEPS 404:51-67.

Demopoulos AWJ, Bourque JR, Frometa J. 2014. Biodiversity and community composition of sediment macrofauna associated with deep-sea *Lophelia pertusa* habitats in the Gulf of Mexico. Deep-sea Research I 93: 91-103.

Doughty CL, Quattrini AM, Cordes EE. 2014. Insights into the population dynamics of the deep-sea coral genus *Paramuricea* in the Gulf of Mexico. Deep Sea Research Part II: Topical Studies in Oceanography 99: 71-82.

Engel AS, Gupta AA. 2014. Regime shift in sandy beach microbial communities following *Deepwater Horizon* oil spill remediation efforts. PLoS ONE 9(7): e102934.

Fisher C.R., P-Y. Hsing, C. Kaiser, D. Yoerger, H.H. Roberts, W. Shedd, E.E. Cordes, T.S. Shank, S.P. Berlet, M. Saunders, E.A. Larcom, and J. Brooks. 2014a. Footprint of Deepwater Horizon blowout impact to deep-water coral communities. PNAS. 111: 11744-11749.

Fisher, C.R. A.W.J. Demopoulos, E.E. Cordes, I.B. Baums, H.K. White, J.R. Bourque. 2014b. Coral communities as indicators of ecosystem-level impacts of the Deepwater Horizon Spill. BioScience 2014 64 (9): 796-807 doi: 10.1093/biosci/biu129.

Georgian SE, Shedd W, Cordes EE. 2014. High resolution ecological niche modelling of the cold-water coral *Lophelia pertusa* in the Gulf of Mexico. Marine Ecology Progress Series 506: 145-161.

Goldberg, C.S., D.S. Pilliod, R.S. Arkle, and L.P. Waits. 2011. Molecular detection of vertebrates in stream water: a demonstration using rocky mountain tailed frogs and Idaho giant salamanders. PLoS ONE, 6, e22746.

Hsing, P., B. Fu., E.A. Larcom, S.B. Berlet, T.M. Shank, A.F. Govindarajan, A.J. Lukasiewicz, P.M. Dixon, C.R. Fisher. 2013. Evidence of lasting impact of the Deepwater Horizon oil spill on a deep Gulf of Mexico coral community. Elementa, doi: 10.12952/journal.elementa.000012.

Kellogg CA. 2010. Enumeration of viruses and prokaryotes in deep-sea sediments and cold seeps in the Gulf of Mexico. Deep-sea Research II 57: 21-23.

Levin LA, Mendoza GF, Gonzalez JP, Thurber AR, Cordes EE. 2010. Diversity of bathyal macrofauna on the northeastern Pacific margin: the influence of methane seeps and oxygen minimum zones. Marine Ecology 31:94-110.

Linares C, Coma R, Garrabou J, Díaz D, Zabala M. 2008. Size distribution, density and disturbance in two Mediterranean gorgonians: *Paramuricea clavata* and *Eunicella singularis*. Journal of Applied Ecology 45: 688-699.

Mason OU, Scott NM, Gonzalez A, Robbins-Pianka A, Bælum J, Kimbrel J, Bouskill NJ, Prestat E, Borglin S, Joyner DC. 2014. Metagenomics reveals sediment microbial community response to Deepwater Horizon oil spill. ISME Journal 8: 1464-1475.

Mienis F, Duineveld GCA, Davies AJ, Ross SW, Seim H, Bane J, van Weering TCE. 2012. The influence of near-bed hydrodynamic conditions on cold-water corals in the Viosca Knoll area, Gulf of Mexico. Deep-Sea Research Part I-Oceanographic Research Papers 60:32-45.

Montagna, P., J.G. Baguley, C. Cooksey, I. Hartwell, L.J. Hyde, J.L. Hyland, and R.D. Kalke, L.M. Kracker, M. Reuscher, and A.C. E. Rhodes. 2013. Deep-Sea Benthic Footprint of the Deepwater Horizon Blowout. 8: 1-8.

NTL 2009-G40. http://www.boem.gov/Regulations/Notices-To-Lessees/2009/09-G40.aspx

Prouty, N.G., E.B. Roark, N.A. Buster, and S.W. Ross. 2011. Growth-rate and age distribution of deep-sea black corals in the Gulf of Mexico. Mar. Ecol. Prog. Ser. 423:101-115.

Prouty, N.G. C.R. Fisher, A.W.J. Demopoulos, and E. Druffel. (*in press*). Growth rates and ages of deep-sea corals impacted by the Deepwater Horizon oil spill. Deep-sea Res. 10.1016/j.dsr2.2014.10.021

Roark EB, Gullderson TP, Dunbar RB, Fallon SJ, Mucclarone. 2009. Extreme longevity in proteinaceous deep-sea corals. PNAS 106:5204-5208.

Rowe, G.T., Kennicutt II, M.C. (Eds.), 2009. Northern Gulf of Mexico continental slope habitats and benthic ecology study: Final report, U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Sherwood OA, Scott DB, Risk MJ, Guilderson TP. 2005. Radiocarbon evidence for annual growth rings in the deep-sea octocoral *Primnoa resedaeformis*. Marine Ecology Progress Series 301:129-134.

Snelgrove PVR, Blackburn TH, Hutchings PA, Alongi DM, Grassle JF, Hummel H, King G, Koike I, Lambshead PJD, Ramsing NB, Solis-Weiss V, Freckman D. 1997. The importance of marine sediment biodiversity in ecosystem processes. Ambio 26: 578-583.

Thomsen, P.F., J. Kielgast, L.L. Iverssen,P.R. Møller, M. Rasmussen, and E. Willerslev. 2012. Detection of a diverse marine fish fauna using environmental DNA from seawater samples. PLOSone 7(8) e41732.

Thurber, A.R., A.K. Sweetman, B. E. Narayanaswamy, D. O. B. Jones, J. Ingels, and R. L. Hansman. 2014. Ecosystem function and services provided by the deep-sea. Biogeosciences, 11, 3941–3963 doi:10.5194/bg-11-3941-2014.

Valentine, D.L., G.B. Fisher, S.C. Bagby, R.K. Nelson, C.m. Reddy, S.P.Sylvia, and W.A. Woo. 2014. Fallout plume of submerged oil from *Deepwater Horizon*. PNAS. doi:10.1073/pnas.1414873111.

Van Dover CL, Ardron J, Pendleton L, Smith S, Arnaud-Haond S, Moreno-Mateos D, Barbier E, Billett D, Bowers K, Danovaro R, Edwards A, Kellert S, Morato T, Pollard E, Rogers A, Warner R. 2014. Ecological restoration in the deep sea: Desiderata. Marine Policy 44: 98-106.

Vera JC, Wheat CW, Fescemyer HW et al. 2008. Rapid transcriptome characterization for a nonmodel organism using 454 pyrosequencing. Molecular Ecology, 17, 1636–1647.

Wei, C.L., G.T. Rowe, G. Fain Hubbard, A.H. Scheltema, G.D.F. Wilson, I. Petrescu, J.M. Foster, M.K. Wicksten, M. Chen, R. Davenport, Y. Soliman, and Y. Wang. 2010. Bathymetric zonation of deep-sea macrofauna in relation to export of surface phytoplankton production. Marine Ecology Progress Series 399: 1-14.

White, H.K., P. Hsing, W. Cho, T. M. Shank, E.E. Cordes, A.M. Quattrini, R.K. Nelson, R. Camilli, A. W. J. Demopoulos, C.R. German, J.M. Brooks, H.H. Roberts, W. Shedd, C. M. Reddy, and C. R. Fisher. 2012. Impact of the Deepwater Horizon oil spill on a deep-water coral community in the Gulf of Mexico. PNAS. doi:10.1073/pnas.1118029109.

Other

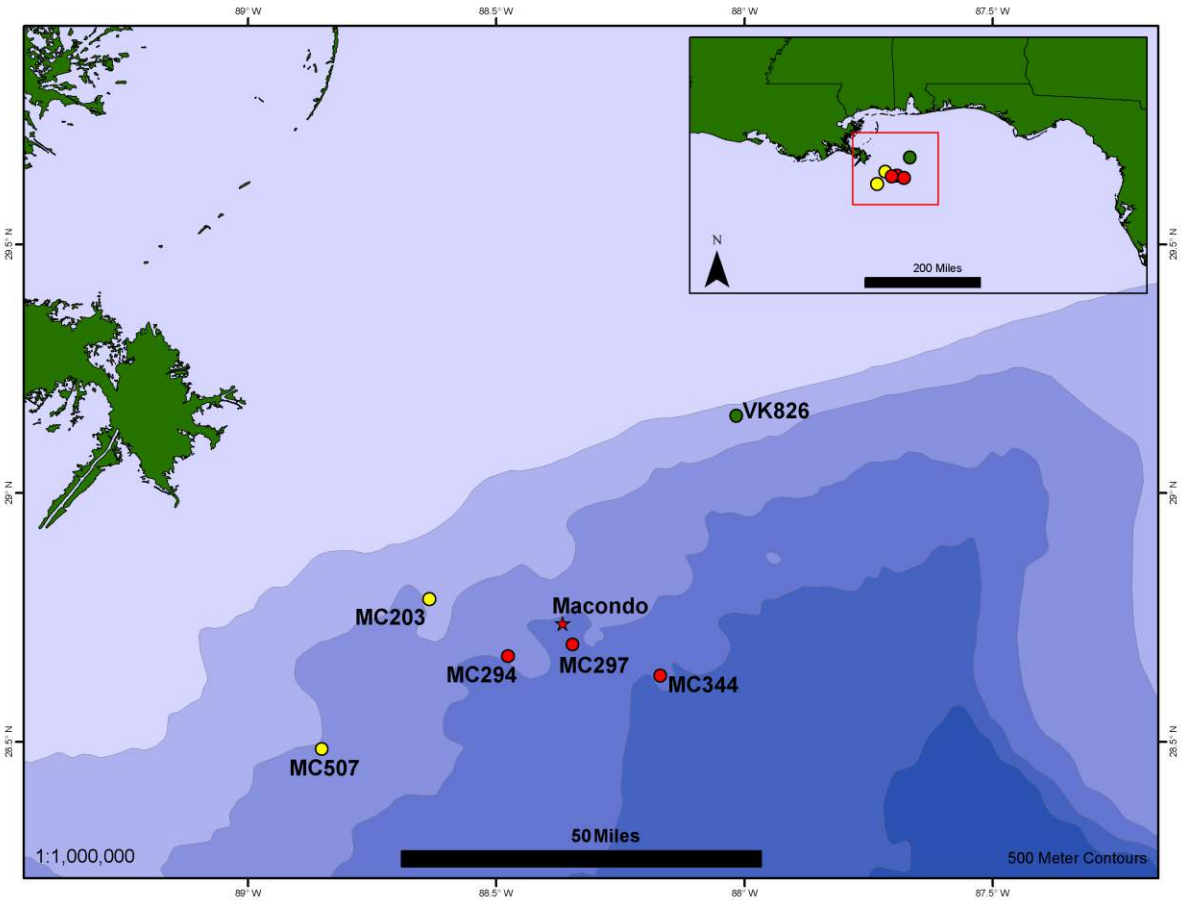


Figure 1: Map including study locations of impacted and un-impacted coral habitats and the Macondo Well.

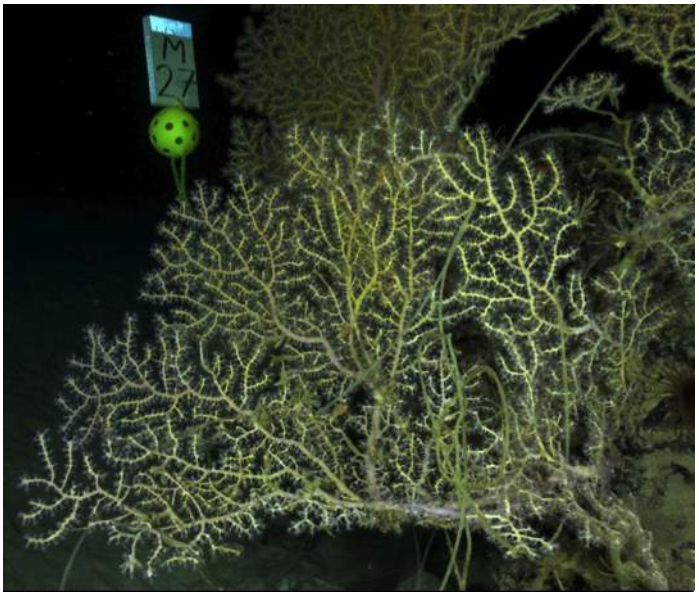


Figure 2. Fishing line entangled around *Paramuricea* sp. B. at MC 507.

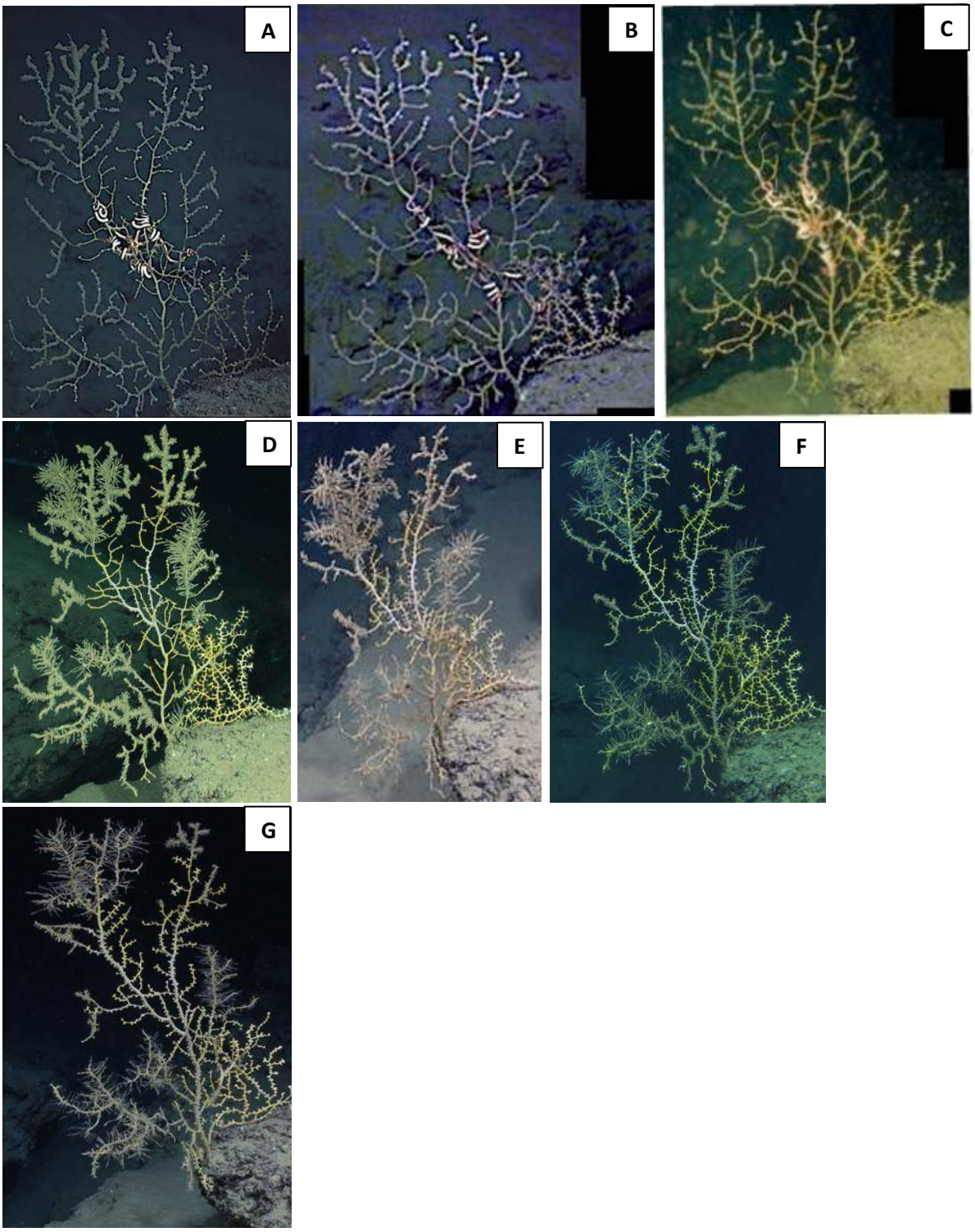


Figure 3. Time series of images taken of octocoral from October 2010 (A), December 2010 (B), March 2011 (C), October 2011 (D), March 2012 (E), November 2012 (F) and June 2013 (G)

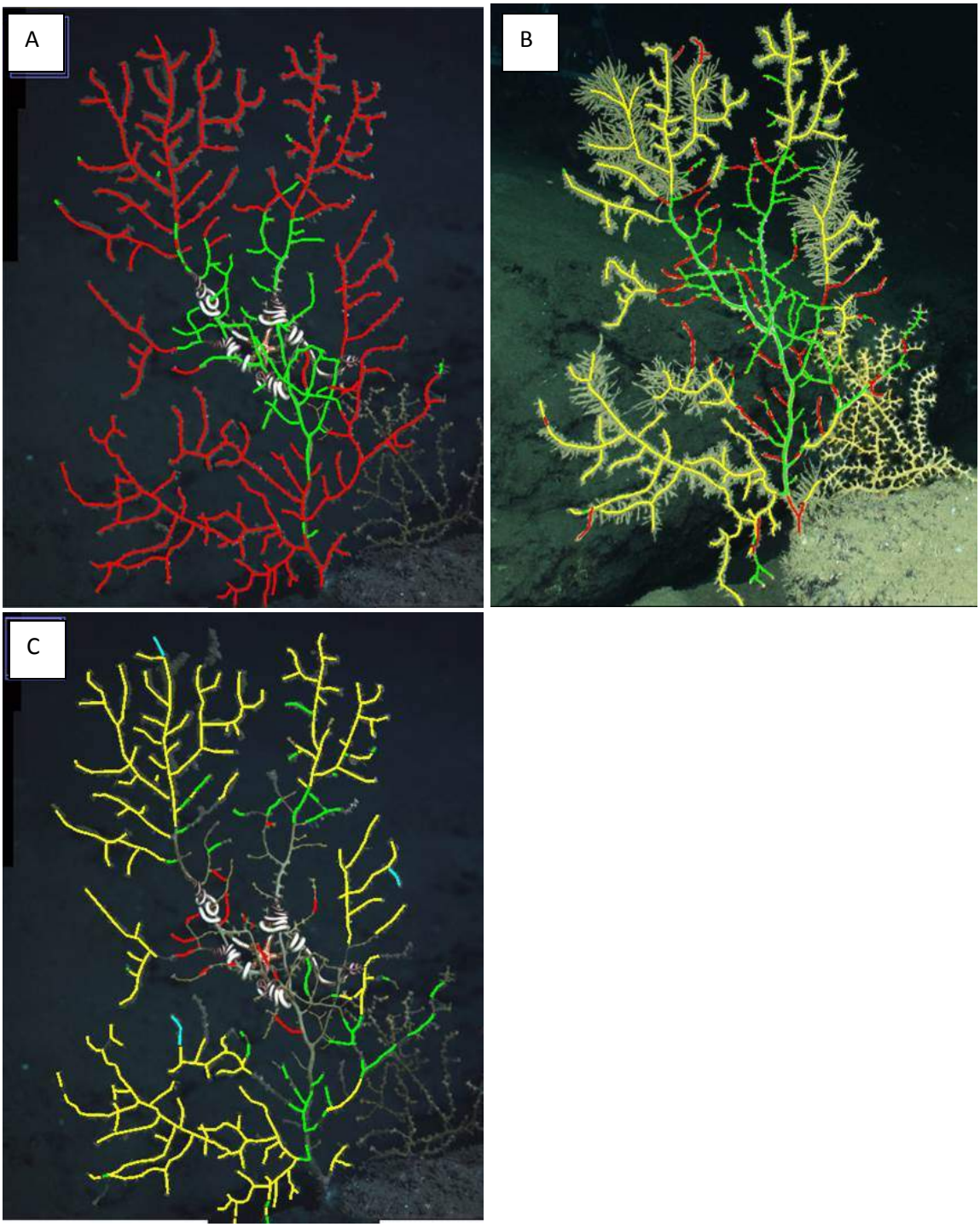
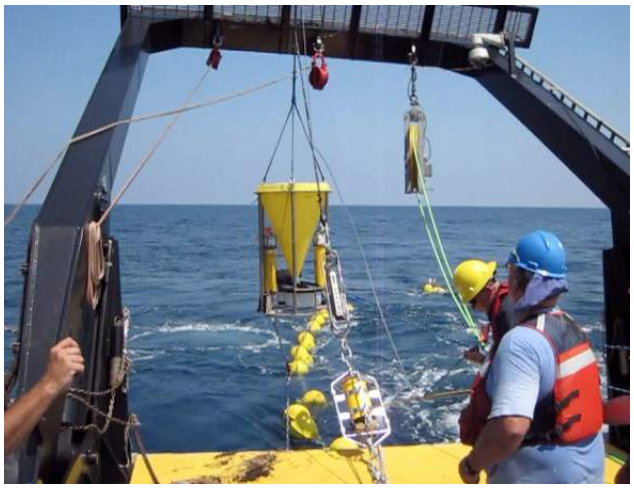


Figure 4. Digitization of octocoral. A represents image taken in November 2010, B represents image of same coral in October 2011. Red indicates visibly impacted areas, yellow areas covered with hydroids and green not visibly impacted areas in frames A and B. In frame C changes between states are shown with yellow indicating a change to hydroid coverage, red a change from not visibly impacted to visibly impacted, green a change to not visibly impacted and blue branch loss.



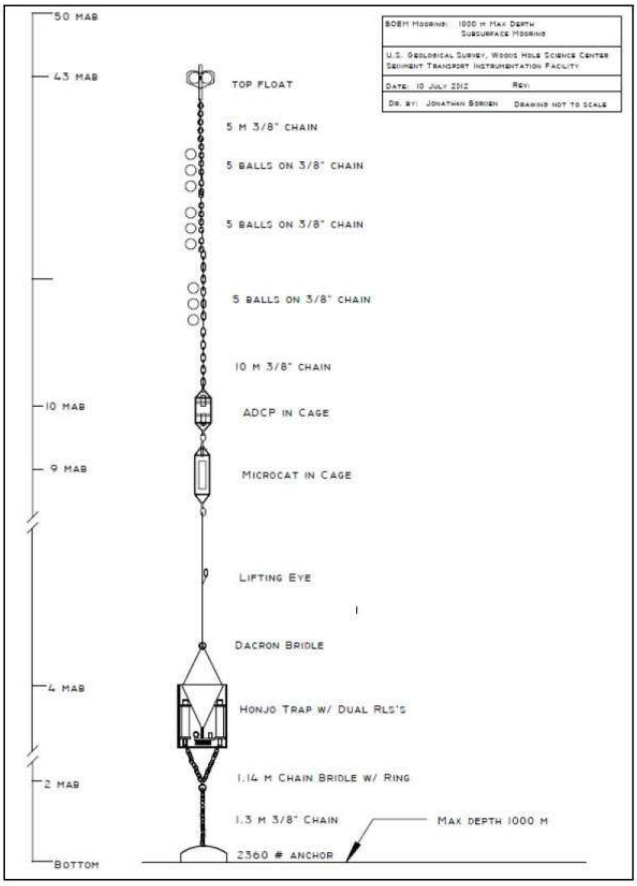


Figure 5. Marine technicians and ships' crew working together to deploy a bottom-moored sediment trap (left). Schematic sketch (right) of oceanographic mooring designed to investigate the flux of sediment particles and organic matter to the ocean floor (Honjo sediment trap) and to measure direction and velocity of ocean currents (ADCP) and other oceanographic parameters (Microcat).

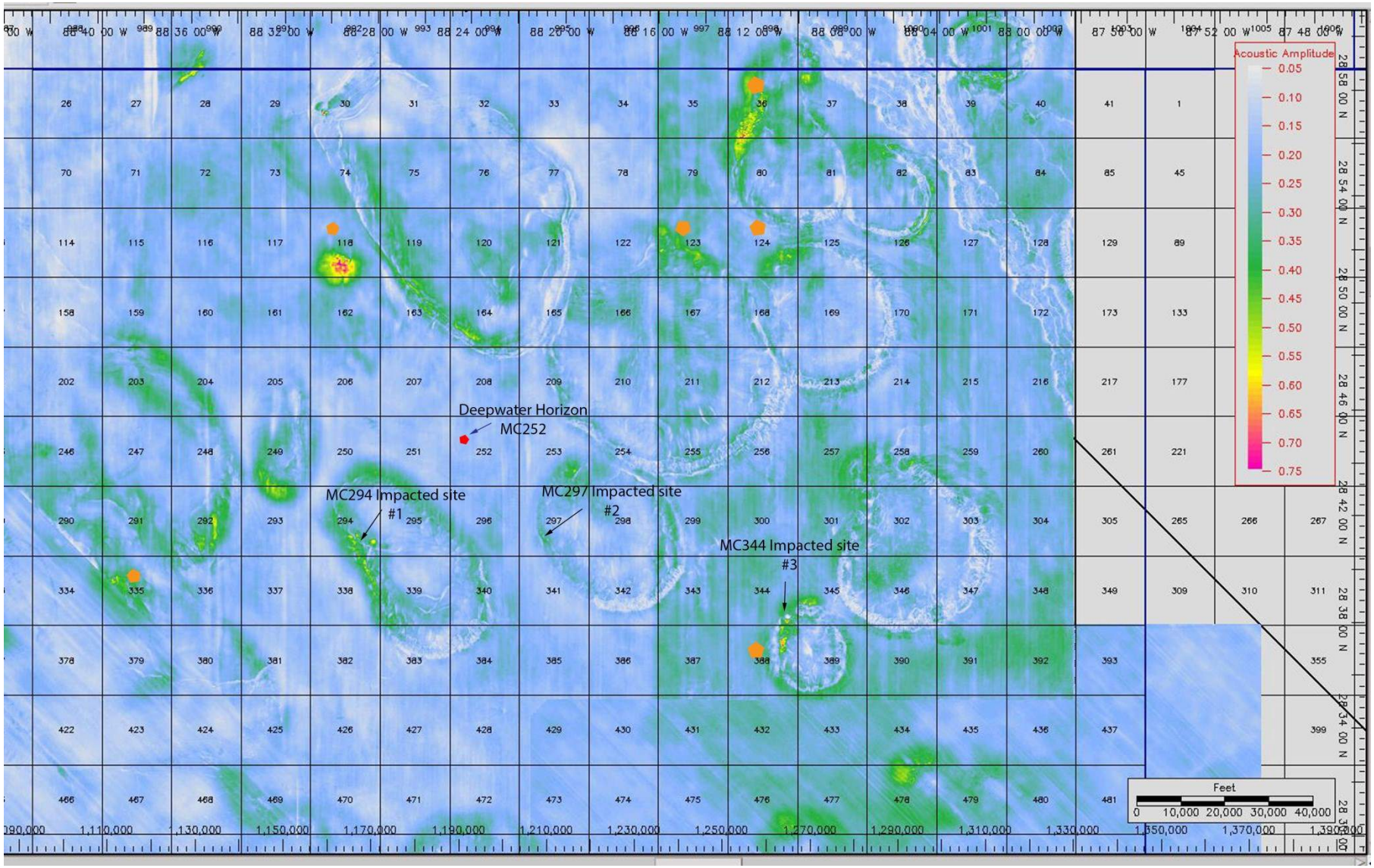


Figure 6. Locations of impacted coral habitat in MC294 (#1) from White et al. (2012), and two additional impacted coral habitats in MC297 (#2), and MC344 (#3). Color shades represent intensity of reflectivity from 3D seismic air gun surveys. Orange polygons are locatednear other areas with numerous observed octocorals. (Amplitude map from the Emergency Response Management Application (ERMA) database prepared by BOEM using proprietary data courtesy of TGS.)

Other (cont.)

Biographical Sketch-Dr. Amanda W.J. Demopoulos, USGS Southeast Ecological Science Center

Professional Preparation:

- B.S., Oceanography (Minor: Chemistry), College of Oceanography, U. of Washington, June 1996
- M.S., Biological Oceanography, Department of Oceanography, UH Manoa, December 2000
- Ph.D., Biological Oceanography, Department of Oceanography, UH Manoa, August 2004
- Postdoctoral Scholar, Scripps Institution of Oceanography, UC, San Diego, 2004-2006

Appointments:

- 2007-Present Research Ecologist (Benthic), US Geological Survey, Southeast Ecological Science Center, Gainesville, FL.
- 2007-present Courtesy Assistant Professor, Fisheries and Aquatic Sciences, University of Florida
- 2006 Lecturer, Life in the Ocean (ENVI 121), Department of Marine Science and Environmental Studies, University of San Diego.
- 2004-2006 Postdoctoral Scholar, Scripps Institution of Oceanography, University of California, San Diego
- 2003-2004 Sea Grant Research Trainee, UH Manoa.
- 1999-2004 Graduate Research Assistant-Lead Scientist, Hawaiian mangrove research program, Sea Grant, UH Manoa.
- 1999-2003 Graduate Research Fellow-Lead Scientist, NOAA/National Estuarine Research Reserve (NERR), Puerto Rico.
- 1997-1999 Graduate Research Assistant, Age Dependent Mixing in Deep-Sea Sediments Program, NSF, UH Manoa.
- 1996 Research Student, NSF Research Experience for Undergraduates (REU), SIO, UCSD.

Publications - 5 most relevant:

- Demopoulos, A.W.J., J.R. Bourque, and J. Frometa. 2014. Biodiversity and community composition of sediment macrofauna associated with deep-sea *Lophelia pertusa* habitats in the Gulf of Mexico. Deep-Sea Res. I, 93:91-103. http://dx.doi.org/10.1016/j.dsr.2014.07.014
- Fisher, C. R., A. Demopoulos, E. Cordes, I. Baums, H. White, J. Bourque. 2014. Deep-sea coral communities as indicators of ecosystem-level impacts resulting from the Deepwater Horizon oil spill. BioScience. 64 (9): 796-807. doi: 10.1093/biosci/biu129
- Demopoulos, A.W.J., D. Gualtieri, and K. Kovacs. 2010. Food-web structure of seep sediment macrobenthos from the Gulf of Mexico. Deep-Sea Res. II. 57:1972-1981.
- White HK, Hsing PY, Cho W, Shank TM, Cordes EE, Quattrini AM, Nelson RK, Camilli R, Demopoulos A, German CR, Brooks JM, Roberts HH, Shedd W, Reddy CM, Fisher CR. (2012) Impact of the Deepwater Horizon oil spill on a deep-water coral community in the Gulf of Mexico. PNAS 109: 20303-20308.
- Demopoulos, A.W.J. and D.G. Strom. Benthic community structure and composition in sediment from the northern Gulf of Mexico shoreline, Texas to Florida. 2012. USGS Open File Report 2012-1153, 15 p.

Publications – 5 other selected:

- Demopoulos, A.W.J., C.R. Smith, D.J. DeMaster and W. Fornes. 2003. Evaluation of excess ^{234}Th activity in sediments as an indicator of food quality for deep-sea deposit feeders. J. Mar. Res. 61:267-284.
- Demopoulos, A.W.J. and C.R. Smith. 2010. Invasive mangroves alter macrofaunal community structure and facilitate opportunistic exotics. Mar. Ecol. Prog. Ser. 404:51-67

- Sweetman, A.K., J.J. Middelburg, A.M. Berle, A.F. Bernardino, C. Schander, A.W.J. Demopoulos, & C.R. Smith. 2010. Impacts of exotic mangrove forests and mangrove deforestation on carbon remineralization and ecosystem functioning in marine sediments. Biogeosciences 7: 2129-2145.
- Nico, L. G., A. Demopoulos, D. Gualtieri, and C. Wieser. 2011. Use of stable isotopes and mercury to assess trophic positions of black carp and other large fishes in the Red-Atchafalaya River system, Louisiana, USA. Pages 105-119 in D. C. Chapman, and M. H. Hoff, editors. Invasive Asian Carps in North America. American Fisheries Society Symposium 74, Bethesda, Maryland.
- Demopoulos, A.W.J., C.R. Smith, and P.A. Tyler. 2003. Ecology of the deep Indian Ocean floor. In: Ecosystems of the World Volume 28: Ecosystems of the Deep Ocean, P.A. Tyler, ed., Elsevier, Amsterdam. 569 pp.

Synergistic activities:

1. Offshore expeditions: I have participated in 27 oceanographic research expeditions over the last 17 years, accumulated over 1 year of sea time, served as chief/co-chief/lead scientist on multiple expeditions, and have directly worked with several different ROVs, including Hercules, Jason, Deep-Discoverer, and the Global Explorer, and the AUV Sentry.
2. Boards and Committees: I have been appointed as a Special Government Employee to the Ocean Exploration Advisory Board by the Undersecretary of Commerce, Kathryn Sullivan. I am a member of the following committees and working groups: Deep-Submergence Science Committee, providing science advisory and oversight for the USA's Deep Submergence Facility, Gulf of Mexico Restoration Deep-Benthic Focus Group, NOAA Office of Response and Restoration, and the Oil and Gas Working Group, Deep Ocean Stewardship Initiative.
3. Selected to provide scientific expertise on the Alvin Science Verification cruise following the Alvin upgrade, March 2014.
4. USGS Project Chief, Mid-Atlantic Canyons, joint BOEM/USGS/NOAA project 2011-present, Project Chief for the NOAA-OER funded study: Exploration of Caribbean seamounts within the Greater and Lesser Antilles transition zone: characterization of the benthic ecology and geology, 2014-2015.
5. Recipient, with collaborators, of the 2011 National Oceanographic Partnership Program Excellence in Partnering Award for Exploration and Research of Northern Gulf of Mexico Deepwater Natural and Artificial Hard Bottom Habitats with Emphasis on Coral Communities: Reefs, Rigs, and Wrecks
6. Recipient, with collaborators, of the 2013 DOI Partners in Conservation Award for Deepwater Canyons.
7. Telepresence research expedition experience: In 2013 and 2014, I facilitated both detailed and technical communication among scientists, students, and the public during research expeditions on the Exploration Vessel (E/V) Nautilus and the NOAA ship Okeanos Explorer.
8. Research mentor for two NSF-STEM Scholars, 2011
9. Research mentor for two National Association of Geoscience Teachers (NAGT)/USGS Cooperative Summer Field Training Program undergraduates, 2011, 2013.
10. Research mentor for an undergraduate in the UC LEADS Program, UCSD, a program preparing students for advanced education in science and technology, 2005.
11. Currently serving as a committee member of 3 graduate students and supervisor of 4 undergraduates.

Collaborators and other affiliations:

Steve Ross (UNCW), Sandra Brooke (FSU), Jason Chaytor (USGS), Erik Cordes (Temple), Katherine C. Ewel (UF, Gainesville), Chuck Fisher (Penn State), Brian Fry (Griffith University), Mandy Joye (U.Georgia), Ray Lee (WSU), Lisa Levin (UCSD-SIO), Daryl Parkyn (UF, Gainesville), Paul Montagna (TAMU-CC), Debra Murie (UF, Gainesville), Martha Nizinski (NOAA/NMFS), Christine Whitcraft (CSU, Long Beach), Helen White (Haverford College).

Graduate Advisors and Postdoctoral Sponsors:

Craig R. Smith, University of Hawaii, Manoa, thesis and dissertation advisor,
Lisa A. Levin, Scripps Institution of Oceanography, UCSD, La Jolla, postdoctoral supervisor

Graduate Student Advisees (committee member):

R. Welicky (Ph.D.), W. Jenkins (MS), and T. Washburn (Ph.D).

Biographical Sketch – Dr. Charles R. Fisher, Pennsylvania State University

Professional Preparation:

B.S.-- Biology, Michigan State University -- 1976
M.A.-- Biological Sciences, University of California, Santa Barbara --1981
Ph.D.-- Biological Sciences, University of California, Santa Barbara. -- 1985

Appointments:

Associate Dean, College of Science, 11/13 - present
Associate Dept. Head for Equity and Diversity, Biology, PSU 9/11 - present.
Acting Associate Dean for Research, Eberly College of Science, PSU 8/09 – 9/10.
Professor, Penn State Univ. 7/99 - present.
Associate Dept. Head for Graduate Affairs. Dept. of Biology, PSU. 6/98 – present
Associate Professor, Penn State Univ. 8/95 – 7/99.
Assistant Professor, Penn State Univ., 8/90 - 7/95.
Assistant Research Biologist, Univ. of Calif., Santa Barbara, 1/87-7/90.
Postdoctoral Research Biologist, Univ. of Calif., Santa Barbara, 12/84-12/86
Research Assistant, Univ. of Calif., Santa Barbara, 1/82-12/84.

Publications - 5 most relevant to this project (* indicates undergraduate student co-author):

Fisher, C. R., P-Y. Hsing, C. Kaiser, D. Yoerger, H. Roberts, W. Shedd, E. E. Cordes, T. M. Shank, S. P. Berlet*, M. Saunders, E. A. Larcom, and J. M. Brooks. 2014. Footprint of Deepwater Horizon blowout impact to deep-water coral communities. Proc. Nat. Acad. Sci. 111: 11744-11749. doi 10.1073/pnas.1403492111

Fisher, C. R., A. Demopoulos, E. Cordes, I. Baums, H. White, J. Bourque. 2014. Deep-sea coral communities as indicators of ecosystem-level impacts resulting from the Deepwater Horizon oil spill. BioScience. 64 (9): 796-807. doi: 10.1093/biosci/biu129

Hsing, P.-Y., B. Fu, E. A. Larcom, S. P. Berlet*, T. M. Shank, A. Frese Govindarajan, A. J. Lukasiewicz*, P. M. Dixon, and C. R. Fisher. 2013. Lasting impact of the Deepwater Horizon oil spill on a deep Gulf of Mexico coral community. Elementa: Science of the Anthropocene 1 : 0000012 doi:10.12952/journal.elementa.0000012

White, H. K., P.-Y. Hsing, T. M. Shank, E. E. Cordes, A. M. Quattrini, R. K. Nelson, R. Camilli, A. Demopouls, C. R. German, J. M. Brooks, H. H. Roberts, W. Shedd, C. M. Reddy, and C. R. Fisher. 2012. Impact of the *Deepwater Horizon* oil spill on a deep-water coral community in the Gulf of Mexico. PNAS, doi: 10.1073/pnas.1118029109

Cordes E.E., M. McGinley *, E. L. Podowski*, E. L. Becker, S. Lessard-Pilon, S. Viada, and C. R. Fisher CR (2008) Coral communities of the deep Gulf of Mexico. Deep-Sea Res I 55: 777-787.

Publications 5 other selected from 164 peer reviewed (* indicates undergraduate student co-author)

Bergquist, D. C., F. M. Williams, and C. R. Fisher. 2000. Longevity record for deep-sea invertebrate. Nature. 403; 499-500.

Freytag, J. K., P. Girguis, D. C. Bergquist, J. P. Andras*, J. J. Childress, and C. R. Fisher. 2001. Sulfide acquisition by roots of seep tubeworms sustains net chemoautotrophy. Proc. Nat. Acad. Sci. 98; 13408-13413.

Cordes, E. E., M. A. Arthur, K. Shea, and C. R. Fisher. 2005. Modeling the mutualistic interactions between tubeworms and microbial consortia. PLoS Biol. 3: e77.

Flores, J. R., Fisher, C. R., Carney, S. K., Green, B. N., Freytag, J. K., Schaeffer, S. W., and W. E. Royer. 2005. Sulfide binding is mediated by zinc moieties that were discovered in the crystal structure of a hydrothermal vent tubeworm hemoglobins. Proc. Nat. Acad. Sci. 102: 2713-2718.

White, H. K., P.-Y. Hsing, T. M. Shank, E. E. Cordes, A. M. Quattrini, R. K. Nelson, R. Camilli, A. Demopouls, C. R. German, J. M. Brooks, H. H. Roberts, W. Shedd, C. M. Reddy, and C. R. Fisher. 2012. Reply to Boehm and Carragher: Multiple lines of evidence link deep-water coral damage to Deepwater Horizon oil spill. PNAS, doi: 10.1073/pnas.1210413109

Synergistic Activities:

1) I have participated in 68 oceanographic expeditions over the last 33 years, spent over 234 days at sea with ROVs, and have served as Chief Scientist on 36 expeditions.

2) I remain actively involved working with NOAA NRDA assessing damage to deepwater ecosystems and planning restoration efforts in connection with the Deepwater Horizon blowout in the Gulf of Mexico.
3) I served on a SOPAC/UNEP steering committee for production of an informational package on deep sea mining for the use of policy makers from small island countries in the W. Pacific, worked with SOPAC and the ISA on EIA protocols for off shore mining activities, and was a primary instructors for a capacity building workshop on Deep Sea Mining, offered by the SPC in Nadi Fiji in 2012 with attendees from 10 Pacific Island countries.

Co-authors and collaborators from other institutions (PhDs) in the last 4 years: J. Bourque (USGS), M. Bright (Univ. Vienna), J. Brooks (TDI Brooks Int.), R. Camilli (WHOI), A. Demopoulos (USGS), P. M. Dixon (Iowa State), A. Frese Govindarajan (WHOI), C. German (WHOI), P. Girguis (Harvard), K. M. Halanych (U. Alabama), S. Hourdez (Station Biologique, Roscoff, France), J. F. Imhoff (R. F-W Uni, Bonn, Germany), S. B. Joye, (UGA), C. Langmuir (Harvard), N. Le Bris (IFREMER, France), R. W. Lee (W.Wash), L. Levin (SCRIPPS), G. Luther III (U. Delaware), S. Ma (UC Berkley), I. MacDonald (TAMU), S. Macko (Univ. VA), T. Maruyama (JAMSTEK), P. Michael (Univ. Kansas), M. Nishijima (JAMSTEK), K. Olu (IFREMER), N. Prouty (USGS), C. Reddy (WHOI), A-L. Reysenbach (Oregon), H. Roberts (LSU), J. S. Seewald (WHOI), T. Shank (WHOI), W. Shedd (BOEM), M. Sibuet (IFREMER), S. Smith (UH), T. Shank (WHOI), M. Tivey (WHOI), C. L. Van Dover (Duke), H. White (Haverford), D. Yoerger (WHOI).

Graduate Advisor: R. K. Trench (retired) **Post Doctoral Advisor:** J. J. Childress (retired)

Graduate Students last 5 years: Sephanie Lessard-Pilon (Currently an assistant professor at the Smithsonian-Mason School of Conservation), Erin Becker (Currently a postdoctoral scholar at the Universidade Federal Rural do Rio de Janeiro), Pen Yuan Hsing (MS student, currently in PhD program in Durham Univ., UK), Dominique Cowart (Currently a postdoctoral scholar at IFREMER in Sen France), Arunima Sen (Currently a postdoctoral scholar at IFREMER in Brest France), Betsy Larcom (MS student, currently in the DED program at Penn State).

Post Doctoral Advisees last 5 years: B. Faure (Biotope, Service Recherche et Développement), P. Miglietta (Notre Dame)

There are currently 3 Ph.D. students and 5 undergraduates working in my laboratory and I have previously advised a total of 15 Ph.D. Students, 7 MS students, 6 postdoctoral scholars, and between 5 and 15 undergraduates every semester for the past 25 year.

Biographical Sketch - Dr. Erik E Cordes, Temple University

Professional Preparation:

- Southampton College, Marine Science / Biology, B.S. 1993
- Moss Landing Marine Laboratories, Marine Science, M.S. 1999
- Penn State University, Biology, Ph.D. 2004

Appointments:

- 2014-present Associate Professor, Biology Department, Temple University. Affiliated Faculty in Environmental Sciences Program.
- 2008-2014 Assistant Professor, Biology Department, Temple University. Affiliated Faculty in Environmental Sciences Program.
- 2005-2008 Postdoctoral Fellow (NSF Ridge2000), Harvard University. Microbial ecology of Juan de Fuca Ridge hydrothermal vent chimneys.
- 2005-2008 Postdoctoral Researcher, Penn State University. Supported as coPI on BOEM contract to investigate the biology and ecology of Lophelia pertusa in the Gulf of Mexico.
- 2000-2004 Research Assistant, Penn State University. Supported as NOAA Nancy Foster Scholar, Penn State University Graduate Fellow, Center for Environmental Chemistry and Geochemistry Fellow, as well as NSF, NOAA/NURP, OE, and MMS funding.
- 1999-2000 Research Associate, Moss Landing Marine Laboratories. Supported as senior personnel on North Pacific Research Initiative grant to study *Primnoa reseadiformis*.
- 1999-2000 Biological Consultant, ABA Consulting, Moss Landing CA
- 1998-2000 Adjunct Faculty, Hartnell College, Salinas CA
- 1998-1999 Museum Curator, Moss Landing Marine Labs
- 1995 Research Assistant, Moss Landing Marine Labs. Supported on Navy contract to assess the impact of trawl disposal on deep-sea soft-bottom communities.

Publications – 5 most relevant (* indicates undergraduate co-author):

- Doughty CL*, Quattrini AM, Cordes EE. (2013) Insights into the population dynamics of the deep-sea coral genus Paramuricea in the Gulf of Mexico. Deep-Sea Res II. Available online June 17, 2013.
- Fisher CR, Demopoulos AWJ, Cordes EE, Baums IB, White HK, Bourque JR. (2014) Deep-sea coral communities as indicators of ecosystem-level impacts resulting from the Deepwater Horizon oil spill. Bioscience. 64: 796-807. doi: 10.1093/biosci/biu129
- Fisher CR, Hsing P-Y, Kaiser C, Yoerger D, Roberts HH, Shedd W, Cordes EE, Shank TS, Berlet SP*, Saunders M, Larcom EA*, Brooks J. (2014) Footprint of Deepwater Horizon blowout impact to deep-water coral communities. PNAS. 111: 11744-11749.
- Georgian SE, Shedd W, Cordes EE. (2014) High resolution ecological niche modelling of the cold-water coral *Lophelia pertusa* in the Gulf of Mexico. Mar Ecol Prog Ser 506: 145-161. doi: 10.3354/meps10816
- White HK, Hsing PY, Cho W, Shank TM, Cordes EE, Quattrini AM, Nelson RK, Camilli R, Demopoulos A, German CR, Brooks JM, Roberts HH, Shedd W, Reddy CM, Fisher CR. (2012) Impact of the Deepwater Horizon oil spill on a deep-water coral community in the Gulf of Mexico. PNAS. 109: 20303-20308.

Publications – 5 other selected (* indicates undergraduate co-author):

- Quattrini AM, Etnoyer PJ, Doughty CL*, English L*, Falco R*, Remon N, Rittinghouse M, **Cordes EE**. (2014) A phylogenetic approach to octocoral community structure in the deep Gulf of Mexico. Deep-Sea Res II. 99: 92-102. doi: 10.1016/j.dsr2.2013.05.027
- Lunden JJ, Georgian SE, Cordes EE (2013) Aragonite saturation states at cold-water coral reefs structured by *Lophelia pertusa* in the northern Gulf of Mexico. Limnol Oceanogr 58: 354-362.

- Quattrini AM, Georgian SE, Byrnes L*, Stevens A*, Falco R*, Cordes EE (2013) Niche divergence by deep-sea octocorals in the genus Callogorgia across the continental slope of the Gulf of Mexico. Mol Ecol. 22: 4123-4140.
- Cordes EE, Cunha MM, Galeron J, Mora C, Olu-Le Roy K, Sibuet M, Van Gaever S, Vanreusel A, Levin L. (2010) The influence of geological, geochemical, and biogenic habitat heterogeneity on seep biodiversity. Mar Ecol 31: 51-65.
- Cordes EE, Bergquist DC, Fisher CR (2009) Macro-ecology of Gulf of Mexico cold seeps. Ann Rev Mar Sci 1: 143-168.

Synergistic Activities:

1. Boards and Committees: Member of Pool of Experts, U.N. World Ocean Assessment. Editorial Board, Frontiers in Microbiology. Board of Directors, Star Island Corporation (Non-profit conference center on the Isles of Shoals, New Hampshire). Gulf of Mexico Restoration Deep-Benthic Focus Group, NOAA Office of Response and Restoration. Chair of Oil & Gas Working Group, Deep Ocean Stewardship Initiative. Coral Working Group, Gulf of Mexico Fishery Management Council. Temple University Honors Program Oversight Committee.
2. Reviewer of manuscripts for 36 different journals and proposals for funding agencies from 7 different countries and 2 international programs.
3. Serving as the "Expert Scientist" for GLOBE's FLEXE Forum program including leading a workshop for 20 High School teachers titled "Bringing Deep-sea Science into the Earth Science Classroom" in Ocean Springs, MS in July 2009.
4. Telepresence research cruise. ECOGIG cruise, E/V Nautilus. Live coverage of research cruise on Nautilus Live and Exploration Now web sites. Interactions with approximately 8,300 different web site visitors and 6000-8000 people through live interactive shows with the Mystic Aquarium, Aquarium of the Pacific in Long Beach CA, Houston Museum of Natural Science, and Texas State Aquarium.
5. Involved with public outreach through public seminars (TEDx, Metcalf Institute URI, Philadelphia Science Festival, Philadelphia Magazine "ThinkFest", Philadelphia Academy of Natural Sciences, Stockton College NJ); content for websites (NOAA's "Ocean Explorer", "Acid Horizon", "Deep-Sea News", WHOI "Dive and Discover"); interviews on television (CNN, Dan Rather Reports, CBS and FOX Philadelphia), radio (NPR, BBC), print articles (Associated Press, New York Times, Philadelphia Inquirer, Science), and websites (Nature, Science, Discovery, National Geographic, Audubon Society).

Collaborators and Other Affiliations:

Vernon Asper (U Southern Miss), Jeff Chanton (FSU), Jason Chaytor (USGS), Amanda Demopoulos (USGS), Peter Etnoyer (NOAA), Chris German (WHOI), Stephane Hourdez (CNRS, Roscoff France), Mandy Joye (U. Georgia), Ray Lee (Washington St), Lisa Levin (SIO), Ian MacDonald (Florida State University), Chris Martens (UNCW), Joe Montoya (Georgia Tech), Cheryl Morrison (USGS), Nancy Prouty (USGS), Harry Roberts (LSU), Tim Shank (WHOI), Helen White (Haverford College)

Graduate and Postdoctoral Advisors:

James Nybakken (M.S. advisor, Moss Landing Marine Labs), Chuck Fisher (PhD advisor, PSU), Pete Girguis (Post-doc advisor, Harvard)

Thesis Advisor and Postgraduate-Scholar Sponsor:

Graduate students (7 total). Current: Alanna Durkin, Sam Georgian, Carlos Gomez, Danielle Young. Former: Jay Lunden, Ph.D., Andrea Quattrini, Ph.D., Michele Grinar, M.S. Post-Docs (1 total). Former: Benedict Ritt.

Biographical Sketch - Dr. Cheryl L. Morrison, USGS Leetown Science Center

Professional Preparation:

- University of North Carolina, Wilmington, Marine Biology, B.S. 1991
- Florida State University, Biology, Ph.D., 1997

Appointments:

- 2011-present Research Geneticist, USGS Leetown Science Center
- 2006-2010 Geneticist, USGS Leetown Science Center
- 2002-2006 Biologist, USGS Leetown Science Center
- 2000-2001 Post-doctoral Research Associate, Aquaculture Genetics and Breeding Technology Center, Virginia Institute of Marine Science, College of William and Mary, American oyster genomics
- 1999-2000 Post-doctoral Research Associate, Virginia Institute of Marine Science, College of William and Mary, snapping shrimp phylogeography
- 1997-1999 Post-doctoral Research Associate, Duke University, hermit crab phylogeny, mitogenomics

Publications – 5 most relevant:

- Henry, L.A., Frank N., Hebbeln, D., Wienberg, C., Robinson, L., van de Flierdt, T., Dahl, M., Douarin, M., Morrison, C.L., Correa, M.L., Rogers, A.D., Ruckelshausen, M., and J.M. Roberts. 2014. Global ocean conveyor lowers extinction risk in the deep sea. *Deep-Sea Research I* 88: 8-16. http://dx.doi.org/10.1016/j.dsr.2014.03.004
- Hennige, S.J., Morrison, C.L., Form, A.U., Büscher, J., Kamenos, N.A., and J.M. Roberts. Self-recognition in corals facilitates deep-sea habitat engineering. *Nature Scientific Reports*, in press.
- Coykendall, D.K, Morrison, C.L. 2013. Polymorphic microsatellite markers developed from next generation sequencing in the cold water coral - associated squat lobster species, *Eumunida picta* (Galatheoidea: Chirostylidae). *Conservation Genetics Resources* 5(2):495-498, DOI 10.1007/s12686-012-9836-x.
- Morrison, C.L., Ross, S.W., Nizinski, M.S., Brooke, S., Waller, R.G., Johnson R.L. and T.L. King. 2011. Genetic discontinuity among regional populations of *Lophelia pertusa* in the North Atlantic Ocean. *Conservation Genetics,* 12(3):713-729. DOI: 10.1007/s10592-010-0178-5.
- Morrison, C.L., Eackles, M.E., Johnson, R.L., and T.L. King. 2008. Characterization of 13 microsatellite loci for the deep-sea coral *Lophelia pertusa* (Linnaeus 1758) from the northwestern Atlantic Ocean. *Molecular Ecology Resources*, 8:1037-1039.

Publications – 5 other selected:

- Morrison, C.L., Baco, A.R., Nizinski, M.S., Coykendall, D.K., Demopoulos, A.W.J., Cho, W., Shank, T.M. Population connectivity of deep-sea corals. In: T.F. Hourigan, P. Etnoyer (Eds). The State of Deep Coral Ecosystems of the United States: 2012. NOAA Technical Memorandum. Silver Spring, MD. In Press.
- Roberts, H., R. Carney, M. Kupehik, C. Fisher, K. Nelson, E. Becker, L. Goehring, S. Lessard-Pilon, G. Teleneski, B. Bernard, J. Brooks, M. Bright, E. Cordes, S. Hourdez, J. Hunt Jr., W. Shedd, G. Boland, S. Joye, V. Samarkin, M. Bernier, M. Bowles, C. Morrison, I. MacDonald, H. Niemann, C. Petersen, and J. Potter. 2007. ALVIN explores the deep Northern Gulf of Mexico Slope. EOS, 88(35):341-342.
- Morrison, C.L., D.P. LeMarie, R.W. Wood, and T.L. King. 2006. Phylogeographic analyses suggest multiple lineages of Crystallaria asprella (Percidae: Etheostominae). Conservation Genetics 7:129-147.
- Morrison, C.L., Duffy, J.E., and R. Rios. 2004. Phylogenetic hypothesis suggests rapid radiation of Caribbean sponge-dwelling snapping shrimps (Synalpheus). Molecular Phylogenetics and Evolution 30:563-581.
- Morrison, C.L., A.W. Harvey, S. Lavery, K. Tieu, and Y. Huang, Cunningham, C.W. 2002. Mitochondrial gene rearrangements confirm parallel evolution of the crab-like form. Proceedings of the Royal Society of London, Series B 269(1489): 345-350.

Synergistic Activities:

- Boards and Committees: Technical Proposal Evaluation Committee: Bureau of Ocean Energy Management, Regulation and Enforcement, Atlantic Canyons Study. Trans-Atlantic Coral Ecosystem Study: One of 35 North American delegates. South Atlantic Fisheries Management Council. USGS Fisheries, Aquatic and Endangered Resources: member of 5-year planning committee

- Reviewer of manuscripts for 15 scientific journals and proposals for NSF, NOAA-Ocean Exploration, and National Geographic.
- Instructor: Applied Conservation Genetics, U.S. Fish and Wildlife Service National Conservation Training Center.
- Involved in public outreach through public seminars (Shepherd University, George Mason University, Virginia Tech), content for websites (NOAA's "Ocean Explorer", North Carolina Museum of Natural Sciences "Life on the Edge".
- Scientist: aboard 20 deep-sea research cruises in the northwestern Atlantic Ocean, the Gulf of Mexico, and the northeastern Pacific Ocean using submersibles (Johnson-Sea-Link I & II, Alvin), remotely operated vehicles (JasonII, Kraken2, DOER ROV), and other gear (box cores, CTDs, drop cameras, various trawls) for data collection, sampling and observation.

Collaborators and Other Affiliations:
Sophie Arnaud-Haond (IFREMER), Sandra Brooke (Florida State University), Geoff Cook (USFWS), Erik Cordes (Temple University), Mikael Dahl (University of Tromsø), Amanda Demopoulos (USGS), Jonathan Gardner (Victoria University of Wellington), Sebastian Hennige (Heriot-Watt University), Lea-Anne Henry (Heriot-Watt University) Deb Iwanowicz (USGS), Luke Iwanowicz (USGS), Christina Kellogg (USGS), Tim King (USGS), Jay Lunden (University of California, Santa Barbara), Martha Nizinski (NOAA-NMFS), Nancy Prouty (USGS), Steve Ross (University of North Carolina, Wilmington), Robert Stone (NOAA), Wendy Stott (USGS), Rhian Waller (University of Maine), Thierry Work (USGS)

Graduate and Postdoctoral Advisors:
Larry Abele (PhD advisor, FSU), Cliff Cunningham (post-doctoral advisor, Duke University), J. Emmett Duffy (post-doctoral advisor, Virginia Institute of Marine Science), Kimberly Reese (post-doctoral advisor, Virginia Institute of Marine Science)

Thesis Advisor and Postgraduate-Scholar Sponsor:
Current, Katharine Coykendall

Biographical Sketch – Kurt Rosenberger, U.S. Geological Survey

Professional Preparation:

- Bates College, Lewiston, ME; Geology / Physics, B.S. 1994
- University of Rhode Island, Graduate School of Oceanography; Physical Oceanography, M.S. 2001

Appointments:

- 2005-present Oceanographer, U.S. Geological Survey, Coastal and Marine Geology Program, Santa Cruz, CA.
- 2001-2005 Oceanographer, Science Applications International Corporation. Project Manager for studies on the fate and transport of dredged material in the coastal ocean.
- 1999-2001 Research Assistant, URI/GSO. Supported on NSF contract to examine exchange of water masses between Rhode Island Sound and Narragansett Bay.
- 1998-2001 Physical Scientist, Science Applications International Corporation. Conducted sediment sampling geophysical, and sediment transport studies in the coastal ocean.

Publications – 5 most relevant (* indicates undergraduate co-author):

- Rosenberger, K.J., Storlazzi, C.D. and Cheriton, O.M., 2014; Variability of the internal tide on the southern Monterey Bay continental shelf and associated bottom boundary layer sediment transport. Submitted, Continental Shelf Research.
- Rosenberger, K.J., Noble, M.A., and Norris, B.K., 2014; Measurements of Slope Currents and Internal Tides on the Continental Shelf and Slope off Newport Beach, California, U.S. Geological Survey Open-File Report 2014-1014, 65p.
- Noble, M.A., Rosenberger, K.J., Rosenfeld, L.K., Robertson, G.L., 2012; Temporal and spatial patterns in wind stress and wind stress curl over the central Southern California Bight. Continental Shelf Research (2012), http://dx.doi.org/10.1016/j.csr.2012.03.006
- Noble, M. A., K. J. Rosenberger, P. Hamilton and J. P. Xu, 2008; Coastal ocean transport patterns in the central southern California Bight. In Earth science in the urban ocean: The southern California continental borderland, H. J Lee and B. Normark, eds. Geological Society of America Special Paper 454, 34 p. doi:10.1130/2009.2454(3.3)
- Noble, M. A., J. X. Xu, J. Kolak. A. L. Gartner, K. Rosenberger, 2006; Measurements of slope currents and environmental geochemistry near the western boundary of the Gulf of the Farallones National Marine Sanctuary. U.S. Geological Survey Open-File Report 2006-1288. Available on the World Wide Web at http://pubs.usgs.gov/of/2006/1288/

Publications – 5 other selected (* indicates undergraduate co-author):

- Cheriton, O.M, McPhee-Shaw, E., Storlazzi, C.D., Rosenberger, K.J., Shaw, W. and Ranaan, Ben, 2014; Upwelling rebound, ephemeral secondary pycnoclines, and the creation of a near-bottom wave-guide over the Monterey Bay continental shelf. Submitted, Geophysical Research Letters.
- Noble, M.A., Rosenberger, K.J. and Robertson, G.L., 2014; Strongly-sheared wind-forced currents in the nearshore regions of the central Southern California Bight. Submitted, Continental Shelf Research.
- Noble, M.A., Rosenberger, K.J., Paulson, A.J., Gartner, A.L., 2013; Circulation and Exchange patterns in Sinclair Inlet, WA, U.S. Geological Survey Open-File Report 2013-1117, 65p.
- Kincaid, C., D. Bergondo and K. Rosenberger, 2008; Circulation and exchange between lower Narragansett Bay and Rhode Island Sound, in Ecosystem-based Estuary Management: A Case Study of Narragansett Bay, Springer Publ., ed. A. Desbonet, B. Costa-Pierce, 301-324
- Noble, M.A., Rosenberger, K., Hamilton, P., and Xu, J.P., 2008; Connections among the spatial and temporal structures in tidal currents, internal bores and surficial sediment distributions over the shelf off Palos Verdes California: USGS Scientific Investigations Report, 2008-5094.

Synergistic Activities:

6. Co-Investigator, Monterey Canyon Coordinated Experiment, 2015; NERC-UK, MBARI, USGS.
7. Co-Investigator, Huntington Beach Near-shore Circulation Experiment, 2006; USGS, SIO, SAIC.

8. Co-Investigator, Palos Verdes Sediment Transport Experiment, 2004; EPA,USGS, SAIC.

Collaborators and Other Affiliations:
Peter Talling (NERC-UK), Charlie Paull (MBARI), Peter Hamilton (SAIC), Chris Sherwood (USGS, Woods Hole), George Robertson (OCSD), Robert Eganhouse (USGS)

Graduate and Postdoctoral Advisors:
Christopher Kincaid (M.S. advisor, URI/GSO)

Biographical Sketch – Dr. Christina A. Kellogg, U.S. Geological Survey (USGS)

Professional Preparation

- Georgetown University, Biology, BS (Cum Laude), 1991
- University of South Florida, Marine Microbiology, Ph.D., 1998

Appointments

- 2006-present Research Microbiologist, Principal Investigator, U.S. Geological Survey. Coral Microbial Ecology lead PI in BOEM/NOAA/USGS coordinated projects on deep-sea coral habitats in the Gulf of Mexico and Atlantic Canyons.
- 2001-2006 Mendenhall Fellow, USGS. Microbial ecology of aerosols, beaches, tropical and deep-sea corals.
- 2000 Post-doctoral researcher, Human Genome Sciences. Microarrays and bioinformatics data mining.
- 1998-2001, Post-doctoral researcher, Georgetown University Medical Center, Microbiology Department. Fungal pathogenesis and drug discovery.
- 1991-1998, Research Assistant, University of South Florida, Marine Science Department. Biogeography and genetics of marine viruses.

Publications – 5 most relevant

- Galkiewicz, J.P., S.H. Stellick, M.A. Gray, and C.A. Kellogg (2012). Cultured fungal associates from the deep-sea coral *Lophelia pertusa*. *Deep-Sea Research I* 67: 12-20.
- Galkiewicz, J.P., Z.A. Pratte, M.A. Gray, and C.A. Kellogg (2011) Characterization of culturable bacteria isolated from the cold-water coral *Lophelia pertusa*. *FEMS Microbiology Ecology* 77:333-346.
- Gray, M.A., R.P. Stone, M.R. McLaughlin and C.A. Kellogg (2011) Microbial consortia of gorgonian corals from the Aleutian islands. *FEMS Microbiology Ecology* 76: 109-120.
- Kellogg, C.A. (2010). Enumeration of viruses and prokaryotes in deep-sea sediments and cold seeps of the Gulf of Mexico. *Deep-Sea Research II* 57:2002-2007.
- Kellogg, C.A., J.T. Lisle and J.P. Galkiewicz (2009). Culture-independent characterization of bacterial communities associated with the cold-water coral *Lophelia pertusa* in the northeastern Gulf of Mexico. *Applied and Environmental Microbiology* 75 (8): 2294-2303.

Publications – 5 other selected

- Kellogg, C.A., Y.M. Piceno, L.M. Tom, T.Z. DeSantis, M.A. Gray, D.G. Zawada, and G.L. Andersen (2013). Comparing bacterial community composition between healthy and white plague-like disease states in *Orbicella annularis* using PhyloChip™ G3 microarrays. PLOS ONE 8(11): e79801.
- Gray, M.A., Z.A. Pratte, and C.A. Kellogg (2013). Comparison of DNA preservation methods for environmental bacterial-community samples. *FEMS Microbiology Ecology* 83:468-477.
- Kellogg, C.A., Y.M. Piceno, L.M. Tom, T.Z. DeSantis, D.G. Zawada and G.L. Andersen (2012). PhyloChip™ microarray comparison of sampling methods used for coral microbial ecology. *Journal of Microbiological Methods* 88:103-109.
- Galkiewicz, J.P. and C.A. Kellogg (2008). Cross-kingdom amplification using bacterial-specific primers: complications for coral microbial ecology. *Applied and Environmental Microbiology* 74 (24): 7828-7831.
- Kellogg, C.A. (2004). Tropical Archaea: diversity associated with the surface microlayer of corals. *Marine Ecology Progress Series* 273: 81-88.

Synergistic Activities

1. Boards and committees: Member of the executive board of the American Society for Microbiology and past president of the Florida Branch of the American Society for Microbiology. Editorial Board, Frontiers in Microbiology, PLOS ONE.
2. Reviewer of manuscripts for 22 different journals and proposals for 5 different countries.
3. Serving as a scientist-on-call for telepresence cruises on R/V *Okeanos Explorer* and R/V *Nautlilus*.

4. Social media outreach through Twitter (>1000 followers), content for web sites (NOAA's Ocean Explorer, Deep-Sea News, USGS DISCOVRE, Soundwaves, Lophelia.org), podcasts, and television programming ("Mysterious Microbes" – Our Changing Seas).

Collaborators & Other Affiliations

Gary L. Andersen, Yvette M. Piceno, Lauren M. Tom (Lawrence Berkeley National Laboratory), Todd Z. DeSantis (Second Genome, Inc.), Zoe Pratte (FIU), Steve W. Ross (UNC-Wilmington), Sandra Brooke (FSU), Lea-Anne Henry (Heriot-Watt University), Martha Nizinski (NOAA-NMFS), Robert P. Stone (NOAA-NMFS), Rhian Waller (University of Maine), Jack Gilbert (Argonne National Laboratory), Furu Mienis (NIOZ Royal Netherlands Institute for Sea Research), Johanna Järnegren (Norwegian Institute for Nature Research), Thierry Baussant (International Research Institute of Stavanger)

Graduate and Postdoctoral Advisors:

John H. Paul (Ph.D. advisor, University of South FloridaRonald L. Cihlar (Post-doc advisor, Georgetown University Medical Center), Eugene A. Shinn (Post-doc advisor, U.S. Geological Survey)

Thesis Advisor:

Graduate students: Current – Stephanie N. Lawler, Former – Julia P. Galkiewicz

Biographical Sketch - Dr. Nancy Grumet Prouty

Professional Preparation

- Whitman College / Geology, B.S. 1993
- University of New Hampshire, Climate Change Research Center, M.S. 1997
- Stanford University, Oceanography Ph.D. 2004

Appointments

- 2009-present Research Oceanographer, Pacific Coastal and Marine Science Center, Santa Cruz US Geological Survey
- 2009-present Research Associate, Institute of Marine Sciences University of California, Santa Cruz
- 2010 Science Program Coordinator Advisor, Schmidt Ocean Institute, Palo Alto, CA Served as liaison between the individual scientific researchers and the Institute to implement and execute a scientific strategy
- 2007-2009 USGS Mendenhall Postdoctoral Fellow. Historic Land-Use Patterns Recorded by Coral Reef Chemistry: Linkages Between Watershed Change and Ecosystem Health. Pacific Coastal and Marine Science Center, Santa Cruz US Geological Survey
- 2004-2007 WHOI Cooperative Institute for Climate and Ocean Research Postdoctoral Scholar. Coral response to environmental stressors from both anthropogenic and natural perturbations. Woods Hole, MA
- 2004 University Instructor, University of California, Berkeley, Developed innovative student centered curriculum for an 8-weeek intensive summer course on oceanography
- 2000-2004 Graduate Research Environmental Fellow, Department of Energy (DOE), Stanford University. Lead investigator of international coral reef project in Kenya and Sumatra.
- 1995-1997 Teaching Assistant, University of New Hampshire
- 1994-1995 Research Assistant, University of New Hampshire. Supported as geochemist for Arctic ice core research on Baffin Island, Canada

Publications – 5 most relevant

Prouty, N.G. Fisher, C.R., Demopoulos, A.W.J, Druffel, E. (2014) Growth rates and ages of deep-sea corals impacted by the Deepwater oil spill. Deep Sea Res. (*in press*)

Prouty, N. G., E. B. Roark, A. E. Koenig, A. W. J. Demopoulos, F. C. Batista, B. D. Kocar, D. Selby, M. D. McCarthy, and F. Mienis (2014), Deep-sea coral record of human impact on watershed quality in the Mississippi River Basin, Global Biogeochem. Cycles, 28, doi:10.1002/2013GB004754.

Prouty, N.G., Roark, E. B., Andrews, A., Robinson, L., Hill, T., Sherwood, W., Williams, B., Guilderson, T., and Fallon, S. (*in press*) Age, growth rates, and paleoclimate studies in Etnoyer PJ, Hourigan TF (eds.) 2014. The State of Deep Coral Ecosystems of the United States. NOAA Technical Memorandum. Silver Spring MD

Robinson, L.F., Adkins, J.F., Frank, N., Gagnon, A.C, Prouty, N.G., and Roark, E.B. (2013) The geochemistry of deep-sea coral skeletons: a review of vital effects and applications for palaeoceanography. Deep Sea Research Part II.

Prouty, N.G., Roark, E.B., Buster, N.A., and Ross, S.W. Growth-rate and Age Distribution of Deep-Sea Black Corals in the Gulf of Mexico (2011) Mar. Ecol. Prog. Ser. 423:101-115.

Publications – 5 other selected

Prouty, N.G., Storlazzi, C.D., deVillers, A., and Jenson, J. (2014) Historic Impact of Watershed Change and Sedimentation to Reefs along Western Guam. *Coral Reefs* doi:10.1007/s00338-014-1166-x

Prouty, N.G., Goodkin, N.F., Jone, R., Storlazzi, C., and Hughen, K.A. (2103) Environmental Assessment of Metal Exposure to Corals Living in Castle Harbour, Bermuda. *Mar. Chem.* 154, 55-56.

Prouty, N.G., Field, M.E., Stock, J.D., Jupiter, S.D., and McCulloch, M.T., (2010) Coral Ba/Ca records of sediment input to the fringing reef of the south shore of Moloka`i, Hawai`i, over the last several decades. Marine Pollution Bulletin doi:10.1016/j.marpolbul.2010.05.024

Prouty, N.G., Field, M.E., Jupiter, S.D., and McCulloch, M.T. (2009) Coral Proxy Record for Decadal Scale Reduction in Base flow from Moloka`i, Hawai`i. Geochemistry, Geophysics, and Geosystems, 10(12) Q12018, doi:10.1029/2009GC002714, 2009

Prouty, N.G. Hughen, K., and Carilli, J. (2008) Geochemical signature of land-based activities in Caribbean coral surface samples. Coral Reefs doi: 10.1007/s00338-008-0413-4.

Synergistic Activities

1. Committees: Member of steering committee for Innovation Center for Earth Sciences (ICES) at USGS (Menlo Park);
2. Reviewer of manuscripts for 21 different journals and proposals for NOAA and NSF**.**
3. Involved with public outreach through public seminars (Careers in Science, Technology, Engineering, and Mathematics (STEM); briefings with the Hawaii Department of Aquatic Resources); Associated Press release (USGS finds 2,000-year-old coral near BP Gulf well) ScienceNews (Hawaiian corals could provide ancient rainfall record); USGS Sound Waves publication; USGS Menlo Park Center Open House; blog contributor for North Carolina Museum of Natural Sciences and NOAA OER Deepwater Canyons 2013: Pathways to the Abyss; Building Futures Now Mentor, East Palo Alto
4. Member of: American Geophysical Union, American Women in Science, Association for Women Geoscientists, Geological Society of America, International Society for Reef Studies and Sigma Xi.

Collaborators and Other Affiliations:
Amanda Demopoulos (USGS), John Jenson (U. of Guam), Karen Johannesson (Tulane University), Ben Kocar (MIT), Chuck Fisher (PSU), Alan Koenig (USGS), Furu Mienis (NIOZ), Brendan Roark (Texas A&M), Steve Ross (UNC-W), Curt Storlazzi (USGS), Peter Swarzenski (USGS)

Graduate and Postdoctoral Advisors: Cameron Wake (M.S. advisor, University of New Hampshire), Rob Dunbar (PhD advisor, Stanford University), Konrad Hughen (Post-doc advisor, Woods Hole Oceanographic Institution), Michael Field (USGS)

Thesis Advisor and Postgraduate-Scholar Sponsor: Amanda deVillers (U. of Guam), Joseph Murray (UCSC), John Schiff (UCSC)

Dr. Holly M. Bik

School of Biosciences, University of Birmingham UK

a) Professional Preparation:

University of California, Davis	Dec 2011 – Aug 2014	Postdoctoral Researcher
University of New Hampshire	Mar 2010 – Dec 2011	Postdoctoral Researcher
University of Southampton, UK	2010	Ph.D., Biology
King's College London (University of London), UK	2005	B.S., Biological Science

b) Appointments

School of Biosciences, University of Birmingham UK	Sept 2014 – present	Birmingham Fellow (Assistant Professor)

c) Five most relevant publications (out of 20 total):

1. **Bik, H.M.**, Halanych, K.M., Sharma, J. et al. (2012) Dramatic shifts in benthic microbial eukaryote communities following the Deepwater Horizon oil spill. *PLoS ONE*, 7(6):e38550. http://dx.plos.org/10.1371/journal.pone.0038550
2. **Bik, H.M.**, Sung, W., De Ley, P., Baldwin, J.G., Sharma, J., Rocha-Olivares, A. & Thomas, W.K.T. (2012) Metagenetic community analysis of microbial eukaryotes illuminates biogeographic patterns in deep-sea and shallow water sediments. *Molecular Ecology*, 21(12):1048-1059 doi: 10.1111/j.1365-294X.2011.05297.x
3. **Bik, H.M**., Porazinska, D., Caporaso, J.G, Knight, R., Thomas, W.K. (2012) Sequencing our way towards understanding global eukaryotic biodiversity. *Trends in Ecology and Evolution,* 27(4):233-243 http://dx.doi.org/10.1016/j.tree.2011.11.010
4. **Bik, H.M.** and Pitch Interactive (2014) Phinch: An interactive, exploratory data visualization framework for –Omic datasets, *bioRxiv,* doi: http://dx.doi.org/10.1101/009944
5. Darling A., **Bik H.M.,** Jospin G., Lowe E., Eisen, J.A. (2014) PhyloSift: A pipeline for phylogenetic taxonomy assignments from environmental metagenome data, *PeerJ*, 2:e243 http://dx.doi.org/10.7717/peerj.243

d) Five other publications:

1. **Bik H.M.** (invited review, in press) Deciphering diversity and ecological function from marine metagenomes, *The Biological Bulletin*
2. Chariton A., Ho K., Proestou D., **Bik H.**, Simpson S., Portis L., Cantwell M., Baguley J., Burgess R., Pelletier M., Perron M., & Gunsch C. (2014) A molecular-based approach for examining responses of microcosm-contained eukaryotes to contaminant-spiked estuarine sediments, *Environmental Toxicology and Chemistry*, 33(2): 359-369
3. Ho, K.T., **Bik, H.M.**, Gunsch, C., Proestou, D., Chariton, A. (2013) Use of a Novel Sediment Exposure to Determine the Effects of Triclosan on Estuarine Benthic Communities. *Environmental Toxicology and Chemistry,* 32(2):384–92.
4. **Bik H.M.**, Fournier D., Bergeron R.D., Sung W, Thomas W.K. (2013) Intragenomic rRNA variation in six nematode species, *PLoS ONE,* 8(10): e78230 doi:10.1371/journal.pone.0078230
5. **Bik, H.M**., Lamshead, P.J.D., Thomas, W.K., & Lunt, D.H. (2010) Moving towards a complete molecular phylogeny of the Nematoda: a focus on the Enoplida and early-branching clades. *BMC Evolutionary Biology*, **10**:353 doi:10.1186/1471-2148-10-353

e) Synergistic Activities

Invited Participant, NSF Ideas Lab for Advancing and Visualizing the Tree of Life (Lake Placid, NY, August 22-25, 2011); Member, Genomic Standards Consortium, Biodiversity Working Group (http://gensc.org/); iEvoBio 2013 Organizing Committee; Evolution of Caenorhabditis and other nematodes 2014 Organizing Committee; ASM 2013 Symposium Organizer "Phylogenomics and Microbial Species Concepts"; Project Personnel, Microbiology of the Built Environment Network (http://www.microbe.net - J.Eisen, PI at UC Davis)

Undergraduate Trainees: Evan Dube (UNH), Jordan Ramsdell (UNH), Alison Federer (SMBE 2012), Kayla Hinson (OSM 2012), Tamar Dickerson (OSM 2012)

Recent Teaching Activities include: Greater London Tutors, UK (Biology Tutor), 'Bioinformatics of Biodiversity' Undergraduate Workshop at Auburn University, Mentoring of undergraduate students at UNH, UC Davis and at Scientific Conferences

Recent Outreach Activities include: Scientific contributor to the marine science blog 'Deep-sea News' (http://deepseanews.com) and actively disseminate research highlights through other social media outlets (e.g. Twitter @hollybik); Co-organizer and lecturer, 'Bioinformatics of Biodiversity' Undergraduate Workshop held at Auburn University; 'Nature Live' public events and seminars to high school biology groups at the Natural History Museum, London, UK; Researchers in Residence program, St James' Senior Girls School, London, UK

Research Interests include: High-throughput sequencing as a method for intensive biodiversity assessment of microbial eukaryote communities (e.g. nematodes, fungi, protists, etc.), with a specific focus on benthic marine habitats. Integrated morphological/molecular approaches to investigate nematode phylogenetics and evolution. Advancing bioinformatic tools and cyberinfrastructure to aid the biological interpretation of large environmental sequence datasets (Illumina, 454). Novel and exploratory visualization tools for –Omic data.

f) Collaborators & Other Affiliations

Collaborators: Aaron Darling (UC Davis), Guillaume Jospin (UC Davis), Dongying Wu (UC Davis/JGI), Kenneth Halanych (Auburn University), Jyotsna Sharma (University of Texas at San Antonio), Erik Pilgrim (EPA Cincinnati), Anthony Chariton (CSIRO Australia), Kay Ho (EPA Narragansett), Rob Knight (University of Colorado at Boulder), Greg Caporaso (Northern Arizona University), David Lunt (Univeristy of Hull, UK), Punyasloke Bhadury, (Indian Institute of Science Education and Research-Kolkata), Dorota Porazinska (University of Florida), Robin Giblin-Davis (University of Florida), Simon Creer (University of Bangor, Wales, UK), Vera Fonseca (University of Bangor, Wales, UK), Natalie Barnes (The Natural History Museum, London), Timothy Ferrero (The Natural History Museum, London) Way Sung (Indiana University), Ashley Bateman (University of Oregon), James Meadow (University of Oregon), Rachel Adams (UC Berkeley)

Graduate Advisors: Prof. P. John D. Lambshead, The Natural History Museum, London; Dr. Lawrence Hawkins,University of Southampton, UK; Dr. Alan Hughes, University of Southampton, UK

Post-doctoral Advisors: Prof. Jonathan Eisen, University of California, Davis; Prof. W. Kelley Thomas, University of New Hampshire

Biographical Sketch-William W. Shedd

Professional Preparation:
University of Rochester, Rochester, NY, Bachelor's Degree 05/1973
Louisiana State University, Baton Rouge, LA, All courses toward MS complete, thesis incomplete

Appointments:
1997-present Department of Interior/Minerals Management Service and Bureau of Ocean Energy Management (BOEM)

Prior work experience:
Western Geophysical, 1974; Shell Oil Co., 1977-1981; Koch Exploration, 1981; Dorchester Exploration, 1981-1983; Amerada Hess Corp., 1983-1985; Ensource/UMC Petroleum, 1985-1989; ARKLA Exploration, 1989; Independent Energy Corp, co-founder, 1989-1993; Self-employed consulting geoscientist, 1993-1997; Subsurface Consultants, 1997.

Publications

- White, H. K., P.-Y. Hsing, T. M. Shank, E. E. Cordes, A. M. Quattrini, R. K. Nelson, R. Camilli, A. Demopouls, C. R. German, J. M. Brooks, H. H. Roberts, W. Shedd, C. M. Reddy, and C. R. Fisher. 2012. Impact of the *Deepwater Horizon* oil spill on a deep-water coral community in the Gulf of Mexico. PNAS, doi: 10.1073/pnas.1118029109
- Fisher, C. R., P-Y. Hsing, C. Kaiser, D. Yoerger, H. Roberts, W. Shedd, E. E. Cordes, T. M. Shank, S. P. Berlet, M. Saunders, E. A. Larcom, and J. M. Brooks. 2014. Footprint of Deepwater Horizon blowout impact to deep-water coral communities. Proc. Nat. Acad. Sci. 111: 11744-11749. doi 10.1073/pnas.1403492111
- Surface Amplitude Mapping of 3D-Seismic for Improved Interpretations of Seafloor Geology and Biology from Remotely Sensed Data, Harry Roberts, and James Coleman, Jesse Hunt, Jr., and William Shedd, GCAGS, 2001.
- ALVIN Explores the Deep Northern Gulf of Mexico Slope, Harry Roberts, Chuck Fisher, William Shedd, et al., "EOS", Transactions of the American Geophysical Union, 2007, (awarded “Cooperative Conservation Award” from the Secretary of the Department of the Interior for cooperation between governmental agencies and academia).
- Dive site geology: DSV ALVIN (2006) and ROV JASON II (2007) dives to the middle-lower continental slope, northern Gulf of Mexico, H.H. Roberts, W. Shedd, J. Hunt, Jr., Journal of Deep-Sea Research, Vol. 57, Issues 21-23, 2010.
- Acoustic Observations of Oil and Gas in the northern Gulf of Mexico during and after the Deepwater Horizon spill, T. Weber, L. Mayer, J. Beaudoin, K. Jerraim, M. Malik, W. Shedd, G. Rice, “OceanExplorer”, NOAA/OER website, 2011.
- Natural hydrocarbon seepage in the area of the Macondo Spill, Mississippi Canyon protraction, GoM, William Shedd and Harry Roberts, annual meeting of the American Chemical Society, 2012.

Synergistic Activities:

1. Created seafloor seismic amplitude database to plan and to participate in “Johnson SeaLink” submersible dive cruises to locate hydrate occurrences and natural hydrocarbon seepage on the seafloor of the upper slope of the Gulf of Mexico (GoM), led by Dr. Harry Roberts, LSU (2000 and 2002).
2. Used seafloor amplitude maps to predict seep sites in the deepwater GoM for the Chemo III study, funded by MMS. Participated in 2 cruises on the "RV Alantis", using the "Alvin" submersible to photograph, video, and sample chemosynthetic communities across the GoM.
3. Awarded the “Cooperative Conservation Award” from the Secretary of the Department of the Interior for cooperation between governmental agencies and academia, 2007
4. Presented seafloor amplitude maps, with known natural sea surface slicks, and maps of the Macondo reservoir to the Federal science committee and BP management at BP's Houston office (Macondo incident central command) and convinced them that it was unlikely the casing had failed after the stacking cap was put on the blownout well, resulting in the decision to keep the cap on the Macondo wellhead. My conclusions about the reservoir isolation have since been proven to be correct after LLOG drilled offset wells a few thousand feet away with normal wellhead pressures.
5. Used BOEM's seafloor amplitude maps to choose sites that the Natural Resource Damage Assessment (NRDA) cruises visited after the BP Macondo spill. We assessed damage from the Macondo oil spill to deepwater benthic communities and sampled soft sediments for oil contamination.

6. Helped NOAA scientists plan the 2011/2012/2014 cruises of NOAA's "Okeanos Explorer" to locate deepwater natural gas plumes in the deepwater Gulf of Mexico (GoM). The cruises resulted in the confirmation of over 200 of BOEM's seismic amplitude anomalies as being active seep sites.
7. Published on BOEM's public website the shapefiles of seismic seafloor amplitude anomalies interpreted to be seeps and seep related features, submarine fans of sand, seafloor outcrops of salt, sediment slumps at the base of over steepened slopes, outcrops of Cretaceous aged rocks on the Florida Escarpment
8. Received the National Ocean Partnership Program's (NOPP) "Excellence in Partnering" award, along with several biologists and geologists from NOAA, USGS, and academia, for our collaboration on the Lophelia cruises (8/12).
9. Oversaw identifying and mapping BSRs with other BOEM (now totaling over 276) in the GoM and updating the predicted sand distribution to contribute to the update of the GoM hydrate assessment.

Biographical Sketch – Gregory S. Boland, Bureau of Ocean Energy Management

Education:

- Colorado State University / Zoology, B.S. 1974
- Texas A&M University, College Station / Biological Oceanography, M.S. 1980

Employment History:

- 2009-present Biological Oceanographer, Division of Environmental Sciences, Bureau of Ocean Energy Management Headquarters, Herndon Virginia. Subject matter lead for benthic community study development and contract management nation-wide.
- 1998-2009 Biological Oceanographer/Fisheries Biologist, Biological Sciences Unit, Minerals Management Service, Gulf of Mexico Region, New Orleans Louisiana. Subject matter expert for fisheries and benthic communities for studies development, contract management and post-lease and pre-lease National Environmental Policy Act document writing.
- 1988-1998 Senior Research Associate, Department of Oceanography, Texas A&M University. Research involving variety of benthic ecology studies worldwide including the development and operation of a deep-sea benthic lander. Also principal investigator on projects including long-term monitoring of Flower Garden Banks coral reefs. Involved in first observations in western hemisphere of mass coral spawning, 1991.
- 1978-1988 Biological Oceanographer with LGL Ecological Research Associates, Bryan, Texas. Served as principal investigator on numerous large Gulf of Mexico studies including offshore platform studies, deep-sea biology and coral reef monitoring projects. Operated camera system that imaged the first hydrocarbon seep chemosynthetic communities in the northern Gulf of Mexico.
- 1974-1977 Graduate Research Assistant, Department of Oceanography, Texas A&M University, College Station, Texas. Participated in Gulf of Mexico field sampling, submersible dives and analysis of video records obtained from initial exploration of numerous topographic features on the Gulf of Mexico continental shelf leading to initial protective measures initiated by Bureau of Land Management as mitigations for offshore oil and gas activities.

Publications – Selected:

Sammarco, P.W., A.D. Atchison, G.S. Boland, J. Sinclair and A. Lirette. 2012. Geographic expansion of hermatypic and ahermatypic corals in the Gulf of Mexico, and implications for dispersal and recruitment. Journal of Experimental Biology and Ecology 436-437:36-49.

Wei, C-L, G.T. Rowe, R.L. Haedrich and G.S. Boland. 2012. Long-term observations of epibenthic fish zonation in the deep northern Gulf of Mexico. http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0046707

Van Dover C.L., C.R. Smith , J. Ardron, D. Dunn, K. Gjerde, L. Levin, S. Smith, S. Arnaud-Haond, Y. Beaudoin, J. Bezaury, G. Boland, D. Billett, M. Carr, G. Cherkashov, A. Cook, F. DeLeo, C.R. Fisher, L. Godet, P. Halpin, M. Lodge, L. Menot, K. Miller, L. Naudts, C. Nugent, L. Pendleton, S. Plouviez, A.A. Rowden, R.S. Santos, T. Shank, C. Tao, A. Tawake, A. Thurnherr, and T. Treude. 2011. Designating networks of chemosynthetic ecosystem reserves in the deep sea. Marine Policy 36(2012):378-381.

Roberts, H.R. and G.S. Boland. 2010. Preface to Special Issue, Gulf of Mexico Cold Seeps. pp. 1835-1836. *In*: Roberts, H.R. (ed.) Gulf of Mexico Cold Seeps. Special Issue, Deep-Sea Research Part II. 57(21-23).

Boland, G.S. 2010. Challenges in Adaptive Management: Chemosynthetic Communities in the Gulf of Mexico. Sea Grant Law and Policy Journal, 3 (1): 19-30. http://nsglc.olemiss.edu/SGLPJ/Vol3No1/Boland.pdf

Rowe, G.T., J. Morse, C. Nunnally and G.S. Boland. 2008. Sediment community oxygen consumption in the deep Gulf of Mexico. Deep Sea Research II. 55 (24-26): 2686-2691.

Boland, G.S. and P.W. Sammarco. 2005. Observations of the antipatharian "black coral" *Plumapathes pennacea* (Pallas, 1766) (Cnidaria: Anthozoa), northwest Gulf of Mexico. Gulf of Mexico Science 23: 127-132.

Precht, W.F., M.L. Robbart, and G.S. Boland. 2005. Establishment and initial analysis of deep reef stations (32-40 m) at the East Flower Garden Bank. Gulf of Mexico Science 23: 124-127.

Sammarco, P.W., A.D. Atchison, D.A. Brazeau, G.S. Boland, and D.F. Gleason. 2004. Expansion of coral communities

within the northern Gulf of Mexico via offshore oil and gas platforms. Marine Ecology Progress Series. 280:129-143.
Rowe, G. T., M. E. Cruz-Kaegi, J. Morse, G. Boland and E. Escobar Briones. 2002. Sediment community metabolism associated with continental shelf hypoxia, northern Gulf of Mexico. Estuaries 25, 1097-11-6.
Boland, G.S. 2002. Fish and epifaunal community observations at an artificial reef near a natural coral reef: Nineteen years at High Island platform A-389A, from bare steel to coral habitat. In: Proceedings: Gulf of Mexico Fish and Fisheries: Bringing together new and recent research. 673 p. New Orleans, LA October 24-26, 2000. MMS 2002-004, p 372-392.
Lugo-Fernandez, A., K.J.P. Deslarzes, J.M. Price, G.S. Boland and M.V. Morin. 2001. Inferring probable dispersal of Flower Garden Banks Coral Larvae (Gulf of Mexico) using observed and simulated drifter trajectories. Continental Shelf Research. 21:47-67.
Boland, G.S. 1999. Spawning observations of the Scleractinian coral *Colpophylia natans* in the northwest Gulf of Mexico. Gulf of Mexico Science. 16(2): 226-228.
Morse, J., G. Boland and G. T. Rowe. 1999. A "gilled" benthic chamber for extended measurement of sediment - water fluxes. Marine Chemistry. 66:225-230.
Rowe, G.T., G.S. Boland, E.G. Escobar Briones, M.E. Cruz-Kaegi, A. Newton, D. Pipenburg, I.D. Walsh and J.W. Deming. 1997. Sediment community biomass and respiration in the Northeast Water Polynya, Greenland: a numerical simulation of benthic lander and spade core data. J. Marine Systems. 10:497-515.
Tenberg, A., P. Hall, U. Anderson, B. Lindén, O. Styrenius, G. Boland, F. De Bovee, B. Carlsson, S. Ceradini, A. Devol, G. Duineveld, J-U. Friemann, R.N. Glud, A. Khripounoff, J. Leather, P. Linke, L. Lund-Hansen, G. Rowe, P. Santschi, P. DeWilde, and U. Witte. 1997. Intercalibration of benthic flux chambers II. Hydrodynamic characterization and flux comparisons of 14 different designs. Marine Chemistry. March 2005; 94(1-4):147-173
Miller-Way, T., G. Boland, G. Rowe and R. Twilley. 1994. Sediment oxygen consumption and benthic nutrient fluxes on the Louisiana Continental Shelf: A methodological comparison. Estuaries. 17: 809-815.
Rowe, G.T., G. Boland, W. Phoel, R. Anderson and P. Biscaye. 1994. Deep sea-floor respiration as an indication of lateral input of biogenic detritus from continental margins. Deep-sea Research II. 41:657-668.
Gittings, S.R., G.S. Boland, K.J. Deslarzes, C.L. Combs, B.S. Holland and T.J. Bright. 1992. Mass spawning and reproductive viability of reef corals at the East Flower Garden Bank, northwest Gulf of Mexico. Bull. Mar. Sci., 51(3): 420-428.
Boland G.S., and G.T. Rowe. 1991. Deep-sea benthic sampling using the GOMEX box corer. Limnology and Oceanography. 36: 1015-1020.
MacDonald, I.R., G.S. Boland, J.S. Baker, J.M. Brooks, M.C. Kennicutt, and R.R. Bidigare. 1989. Gulf of Mexico hydrocarbon seep communities, II. Spatial distribution of seep organisms and hydrocarbons at Bush Hill. Mar. Bio. 101: 235-247.
Rosman, I., G.S. Boland, and J.S. Baker. 1987. Aggregations of Vesicomyidae on the continental slope off Louisiana. Deep-Sea Res. 34(11): 1811-1820.
Boland, G.S. 1986. Discovery of co-occurring bivalve *Acesta* sp. and chemosynthetic tube worms *Lamellibrachia* sp. (Photograph and text). Nature, 323 (6091): 759.
Boland, G.S., B.J. Gallaway, J.S. Baker, G.S. Lewbel. 1983. Ecological effects of energy development on reef fish of the Flower Garden Banks. National Marine Fisheries, Galveston, Texas. Contract No. NA80-GA-C-00057. 466 p.

Other information: While working with MMS/BOEM, had lead role in three major interagency collaboration studies involving BOEM, USGS and NOAA OER including basic study designs, writing of Request for Proposals, and ongoing project management. All were sponsored by the National Oceanographic Partnership Program (NOPP).

Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico (Chemo III).	Received Department of the Interior Cooperative Conservation Award 2007
Exploration and Research of Northern Gulf of Mexico Deepwater Natural and Artificial Hard Bottom Habitats with Emphasis on Coral Communities: Reefs, Rigs, and Wrecks (*Lophelia* II)	Received NOPP Excellence in Partnering award 2012
Exploration and Research of Mid-Atlantic Deepwater Hard Bottom Habitats and Shipwrecks with Emphasis on Canyons and Coral Communities	Received Department of the Interior Partners in Conservation Award 2013

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
OCEANIC AND ATMOSPHERIC RESEARCH
Office of Ocean Exploration and Research
Silver Spring, MD 20910

October 9, 2014

Gregory S. Boland
Biological Oceanographer
Bureau of Ocean Energy Management
Division of Environmental Sciences
Environmental Studies Program
381 Elden St.
Herndon, VA 20170

Dear Greg,

Since 2004 the partnership between the Bureau of Ocean Energy Management (BOEM) Environmental Studies Program and the NOAA Office of Ocean Exploration and Research has set a new standard for successful partnerships between federal government agencies. Our collaborative work to investigate and document chemosynthetic and deep coral communities, as well as other habitats we discovered in the Gulf of Mexico, and most recently in the Mid-Atlantic canyons has proven invaluable for meeting the mission of both BOEM and NOAA, as well as a growing national need to understand more about our marine environment.

This letter demonstrates our support for the BOEM proposal to continue to investigate and monitor several of the coral sites we discovered in the Gulf of Mexico to better understand their health and condition, thus providing critical information in consideration of potential restoration efforts.

If you have any questions please contact me directly at john.mcdonough@noaa.gov or call 301-734-1023.

Sincerely,

John J. McDonough
Deputy Director
NOAA Office of Ocean Exploration
and Research

PENNSTATE

Department of Biology

The Pennsylvania State University
208 Mueller Laboratory
University Park, PA 16802

(814) 863-0278

Dr. Amanda Demopoulos
Research Benthic Ecologist
U.S. Geological Survey
Southeast Ecological Science Center
7920 NW 71st St.
Gainesville, FL 32653

10/8/2014

Dear Amanda:

The letter is to confirm my commitment to collaborate with you on this Restoration Council proposal. Specifically, my team will participate in all research cruises proposed and lead the exploration, navigation, and coral imaging components of the proposed work. We will use the techniques we have developed for repetitive imaging and subsequent image digitization and analysis for deep-water octocorals to monitor coral condition, growth and mortality. We will establish monitoring stations and monitor corals at up to two new control sites discovered as part of this project. We will return to coral colonies discovered in the MC 507 and MC 203 lease blocks, image all corals and conduct a quantitative analysis of their change in condition and growth rates based on comparison to images collected in 2011. We will use data from control sites and these two previously discovered sites to further establish background rates of growth, mortality, and coral associate-host fidelity for comparison to impacted sites and species. We will assist in developing appropriate collection techniques to collect fragments of deep-sea corals without damaging the mother colony and document the recovery time after fragment collection. We will monitor growth and survival of any "transplanted" corals.

Yours sincerely,

Dr. Charles Fisher
Professor and Associate Dean for Graduate Studies
Eberly College of Science
The Pennsylvania State University

College of
Science and Technology
TEMPLE UNIVERSITY®

Department of Biology
1900 N. 12th Street
Philadelphia, PA 19122
phone: 215-204-8851
fax: 215-204-6646

October 9, 2014

Dear Amanda,

I am writing to indicate my support and involvement in the RESTORE Act study proposed by the Department of the Interior. I will assist in any way I can, through my activities and resources available in my lab at Temple University, this interdisciplinary and collaborative proposal. Specifically, I will be involved with the exploration for new deep-sea coral sites using techniques we have developed over the past 10+ years. We will collaborate on the development of genetic markers of oil exposure for deep-water coral species using existing transcriptomic data that we have been generating for some of the species listed in the proposal. We will lead the population genetics work on deep-water coral species, and lead the pilot restoration project for *Paramuricea biscaya*. I will also participate in the field programs and the overall oversight and management of the project, as necessary.

Sincerely,

Dr. Erik E. Cordes
Associate Professor
Biology Department
Temple University

UNIVERSITY OF BIRMINGHAM

School of Biosciences
Birmingham, B15 2TT
United Kingdom

October 6, 2014

Dr. Amanda Demopoulos
U.S. Geological Survey
Southeast Ecological Science Center
7920 NW 71st St.
Gainesville, FL 32653

Dear Amanda,

I am delighted to submit a letter of collaboration for the RESTORE Act Proposal entitled "**Recovery and Restoration of Deep-water Coral Habitats in the Gulf of Mexico,**" in support of my planned involvement during the proposed grant period (September 2015 – August 2019). Based on our extensive phone conversations, I know we are both invested in a mutual commitment to work together on this project and I am very enthusiastic about the outlined scope of research.

My research is intensely interdisciplinary, utilizing high-throughput sequencing and novel computational approaches to characterize neglected microbial eukaryote taxa from diverse environments—species representing the "dark matter" of biology. In marine environments such as the Gulf of Mexico, these taxa play fundamental ecological roles and underpin ecosystem functioning. Thus, characterizing these groups using 'Omic methods will be a central aim of the proposed research, and directly relate to my previous work applying environmental sequencing approaches in the context of the *Deepwater Horizon* oil spill (Bik et al. 2012, *PLoS ONE*, 7(6):e38550).

In this proposal, I affirm my commitment to provide training and guidance on sample preparation and laboratory protocols (sample processing, DNA extraction, PCR and Illumina library preparation), as well as computational assistance related to the bioinformatic analysis of the resulting environmental sequence datasets.

Thank you for this collaborative opportunity, and I look forward to working together.

Sincerely,

Holly M. Bik,
Birmingham Fellow (Assistant Professor), University of Birmingham, UK
Email: h.bik@bham.ac.uk Tel: +44 121 414 5421

ELIGIBILITY REVIEW

Bucket 2 – Council Selected Restoration Component

PROPOSAL TITLE

Recovery and Restoration of Deep-water Coral Habitats in the Gulf of Mexico

PROPOSAL NUMBER

DOI-1

LOCATION

Gulf of Mexico continental slope in vicinity of DWH oil spill

SPONSOR(S)

Department of the Interior

TYPE OF FUNDING REQUESTED (Planning, Technical Assistance, Implementation)

Implementation

REVIEWED BY:

Bethany Carl Kraft/ Ben Scaggs

DATE:

November 18, 2014

1. Does the project aim to restore and/or protect natural resources, ecosystems, fisheries, marine and wildlife habitat, beaches, coastal wetlands and economy of the Gulf Coast Region?

◉ YES ○ NO

Notes:

Proposal seeks funding for research to help reveal the potential recovery of deep-sea coral habitats, provide baseline information to gauge future impacts, and initiate the first-ever application of direct restoration of deep-sea corals.

2. Is the proposal a project?

◉ YES ○ NO

If yes, is the proposed activity a discrete project or group of projects where the full scope of the restoration or protection activity has been defined?

◉ YES ○ NO

Notes:

3. Is the proposal a program?

◯ YES ◉ NO

If yes, does the proposed activity establish a program where the program manager will solicit, evaluate, select, and carry out discrete projects that best meet the program's restoration objectives and evaluation criteria?

◯ YES ◯ NO

Notes:

4. Is the project within the Gulf Coast Region of the respective Gulf States?

◉ YES ◯ NO

If no, do project benefits accrue in the Gulf Coast Region?

◯ YES ◯ NO

Notes:

Eligibility Determination

ELIGIBLE

Additional Information

Proposal Submission Requirements

1. Is the project submission overall layout complete? ***Check if included and formatted correctly.***

A. Summary sheet	☑	F. Environmental compliance checklist	☑
B. Executive summary	☑	G. Data/Information sharing plan	☑
C. Proposal narrative	☑	H. Reference list	☑
D. Location information	☑	I. Other	☑
E. High level budget narrative	☑		

If any items are NOT included - please list and provide details

2. Are all proposal components presented within the specified page limits (if applicable)?

◉ YES ○ NO

Notes: