Mississippi Canyon 252 Incident

NRDA Tier 1 for Deepwater Communities

July 2, 2010

Incorporates ENTRIX/BP comments

Approval of this work plan is for the purposes of obtaining data for the Natural Resource Damage Assessment. Each Party reserves its right to produce its own independent interpretation and analysis of any data collected pursuant to this work plan.

APPROVED:

7/2/10

Department of Commerce Trustee Representative: Date

7/2/10

BP Representative: Date

Mississippi Canyon 252 Incident
NRDA Tier 1 for Deepwater Communities:
Work Plan and SOPs

June 27, 2010
Incorporates ENTRIX/BP comments

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Above: *Callogorgia americana* and *Asteroschema* sp.

Proposed Dates: Initial mobilization, July 13; Departure and Cruise, July 16-August 3, 2010
Cruise duration, two legs, about 8 days each
Port of mobilization/demobilization: Pascagoula
Project Duration 10-18 months

Purpose and Need Statement

The northern Gulf of Mexico (GOM) is a geologically diverse basin, described as the most complex continental slope region in the world. Regional topography of the slope consists of basins, knolls, ridges, and mounds derived from the dynamic adjustments of salt and the introduction of large volumes of sediment over long time scales. More than 99% of the sea floor in the GOM consists of soft sediment made up of various mixtures of primarily silt and clay. These wide-spread soft bottom communities are described in reports from major MMS studies by Gallaway et al. (1988) and Rowe and Kennicutt (2009). Relative to soft bottoms, hard bottoms and their associated communities are relatively uncommon but are notable for their high biodiversity and complexity.

Seabed structural faulting and the migration of hydrocarbons to the sediment surface have been previously related to the presence of significant biological communities in the deep GOM (See references contained in Appendix 1). . The well site of the Deepwater Horizon is located in a depressed area among a number of raised "domes" related to salt diapirs. Several are named, including Gloria, Biloxi, Mitchell, and Whiting Domes, and are visible on Google Earth. With 3D seismic data obtained by the oil and gas industry for geophysical exploration for subsurface hydrocarbons and archived by MMS, it is possible to extract reflectivity data representing the seabed of the deep GOM.

Although the entire MC 252 block is devoid of any hard bottom, the immediate region surrounding MC 252 includes more than 200 individual seabed hard bottom structures within a distance of 15 miles (24 km). At shallower depths (60-110 m) off Mississippi and Alabama, topographic prominences form hard bottom, reef-like structures known as the Pinnacles, which were mapped and described geologically by Gardner et al. (2000, 2001, 2002a). East of DeSoto Canyon, at similar depths off West Florida, elevated shelf-edge hard-bottom features represent drowned indurated (carbonate) beach stands (Gardner et al 2002b). Associated with all of these various GOM hard bottom features are three principal types of communities considered sensitive to human impacts, including chemosynthetic, deep-water (aka cold-water) coral, and mesophotic coral.

Non-chemosynthetic deep-reef communities (*Lophelia* and mesophotic reef communities) depend on sinking surface plankton and particulates as their primary food source. The dominant deep-reef organisms are particulate feeding sessile invertebrates (hard corals, gorgonians, black corals, sponges), assorted invertebrates, and very small abundant planktivorous fishes in the mesophotic habitats. Oil fouling and death of surface plankton and *Sargassum* could significantly impact the fundamental deep-reef food chain. Deprivation of surface-derived food resources could be devastating to the deep-reef community. Light deprivation under a mantle of surface oil is potentially an additional problem for those mesophotic reef organisms that do depend in part on symbiotic photosynthesis (e.g., *Madracis* and *Madrepora* hard corals, red and orange encrusting sponges).

Chemosynthetic communities are groups of animals living in the deep sea [deeper than 300 m (984 ft)] that live on dissolved gasses (sulfide and/or methane). Many of the animals in these communities get their energy directly from these gases through a symbiotic association with bacteria living inside their tissues. They are remarkable because these are the only large animals that utilize energy sources that are independent of photosynthesis. One of the foundation species in the seep communities, tube worms, are very long lived with life spans in excess of 250 years. Due to their longevity, unique ecology and proximity to the spill, an assessment of their injury should be included as part of the NRDA evaluation. Baseline information is available, including detailed photomosaics of the habitat. Two major studies of GOM chemosynthetic communities, funded by MMS, have been completed (MacDonald et al.. 1995, 2002). A third study targeting communities below 1,000 m (3,280 ft) began in 2007, with support from MMS and USGS, and final reports are in preparation (*Deep Sea Research*, in press).

Deep water corals have only recently been studied intensely with multidisciplinary work in the GOM that began in 2004 (Continental Shelf Associates, Inc. 2007 and Sulak et al. 2008), although trawl collections from large communities were known since the 1950's (Moore and Bullis 1960). This work was summarized by Brooke and Schroeder (2007). Two complementary interagency studies, known as *Lophelia II*, are currently investigating cold-water corals in the GOM. These efforts include the MMS/NOAA OER-funded project formally titled *Exploration and Research of Northern Gulf of Mexico Deepwater Natural and Artificial Hard Bottom Habitats with Emphasis on Coral Communities: Reefs, Rigs and Wrecks* and the USGS-funded *Deepwater Program: Lophelia II: Continuing Ecological Research on Deep-Sea Corals and Deep Reef Habitats in the Gulf of Mexico.*

These ongoing projects may obtain timely data to help determine any direct impacts from oil and/or dispersant related to the MC 252 incident. These projects are directly funded by MMS, NOAA OER, and USGS. The two of the largest examples of deep corals in the GOM, located in blocks VK 906 and 826 and including the major habitat-former *Lophelia pertusa* as well as other species are located to the north and north east of the spill site (25 and 36 miles respectively). These communities include the major habitat-former *Lophelia pertusa,* as well as other large and long lived colonial species. The VK 906 and 826 locations appear to have been directly under major portions of the oil spill since the beginning of May based on the Trajectory Forecast Mississippi Canyon 252 maps provided by NOAA (e.g., http://www.deepwaterhorizonresponse.com/posted/2931/forecast_20100509_0600CDT_201007_1300CDT.542583.pdf. The *Lophelia* habitat harbors a diversity of species, including fishes, crustaceans, sponges, other invertebrates, and unique suites of microbes. Deep water corals, particularly the black-corals, are long-lived (Roark et al. 2009). Ages documented in the Gulf of Mexico range from approximately 600-1700 years old (N. Prouty, pers. comm.).

The joint *Lophelia* project sampled these sites and other sites not directly under the current spill areas as recently as September 2009. Another area on the West Florida slope, recently surveyed by both the MMS/NOAA OER and the USGS teams, may represent a deep coral area of equal significance, and it may come under the influence of oil/dispersants if they become entrained by the Loop Current. A number of components from these ongoing MMS/NOAA OER/USGS studies will be utilized in this proposal. In-hand data components include digital photomosaics and *in situ* time-series sediment and larval traps at sites under and away from the spill site. Other areas, including a nearby chemosynthetic community site visited in 2007, also have historical sampling including photomosaic sampling.

The mesophotic Pinnacle communities were studied by complementary MMS and USGS projects and described by Continental Shelf Associates, Inc (2001) and Weaver et al. (2002). Although major habitat-forming corals are absent in the Pinnacle communities, a variety of ahermatypic (non-reef building) hard corals, gorgonians, black corals, sponges, bryozoans, calcareous worms, and other calcium depositing organisms provide habitat for

numerous (>160 species) Pinnacle-associated fishes. Some of the reefs have been visited as recently as 2005 primarily targeting work on fishes, total reef community structure, and reef community food webs (Sulak *et al.* 2010).

Strategy, priorities, and sampling design

The availability of existing data and sample collections from study sites associated with the Chemosynthetic, *Lophelia*, and Pinnacles studies mentioned above afford an opportunity to evaluate possible impacts of oil/dispersants to these biotic communities. The amount of pre-spill data, combined with the surveys proposed here may allow us to employ the quantitative assessment design of "before and after, control and impact" ("BACI) comparisons. The proposed research cruise provides the opportunity to make limited collections of live specimens and animal tissues. If warranted by the results of the July cruise, these collections may be used in subsequent laboratory analyses to test potential adverse impacts to the biota that may have been caused by Deepwater Horizon incident. Support for such laboratory studies, however, is not included in this proposal. If limited Tier 1 resources dictate the need to prioritize field efforts among these areas, priority should be given to *Lophelia*, Chemosynthetic, and Pinnacles sites, in that order. The availability of recent, comprehensive survey data and ongoing research at the *Lophelia* and Chemosynthetic sites provides a scientific basis for NRDA studies. Comparative reference sites for all three community types may be able to be evaluated and decisions made, once the oil leak is stopped and the oil distribution determined. If resources permit, nearby deepwater oil platforms can also be surveyed, but because baseline data are limited and ship operations are restricted by required special inspection certificates, platform sampling should be a lower priority. The vertical portions of the platforms provide a span of hard substrate throughout the water column. Recently documented extensive *Lophelia* and gorgonian coral colonies at depth on several platform structures could potentially provide an opportunity to identify toxic impacts of oil and dispersant across a well defined depth gradient, and oiling/dispersant gradient, at a single geographic location. In addition to quantifying impacts for NRDA purposes, these investigations may provide symptomatic diagnostic information to be used in causality determinations (e.g., eco-epidemiological analyses) for resource injuries in other habitats.

In this initial Tier 1 project, high priority should be given to the following sampling procedures at the known *Lophelia*, chemosynthetic, and Pinnacles (mesophotic) sites:

1. Repeating the photomosaic surveys to determine the state of the biotic communities,
2. To document exposure/non-exposure to Deepwater Horizon oil/dispersant, the deployment of time series sediment sampling devices; collection of sediment cores; deployment/retrieval of SPMDs
3. Collection of tissue samples sufficient for hydrocarbon analysis plus additional tissue preserved for analyses of reproductive abnormalities and other analyses which may be conducted in Tier 2 and Tier 3 activities or supported by other activities.

Sediment traps, sediment cores/grabs/box cores, tissue collections, and SPMDs will be utilized with sufficient distribution and replication to ensure statistical rigor. The ROV dive strategy will consider acquisition of imagery as the first priority, and then sufficient replicate collections (minimum of 6 individuals) of individuals or pieces of key foundation species next. These will include the dominant colonial cnidarians and dominant large biomass species-specific associates (for example the ophiuroid *Asteroschema* sp. which is associated with *Callogorgia americana* wherever *Callogorgia* is present in the GoM). Although analyses of certain samples are not included in this Tier 1 proposal, using this opportunity to collect tissue samples for potential future analyses would provide considerable cost savings for potential Tier 2 and Tier 3 work, rather than mounting special deep water revisits to collect samples. All potential future analyses are expressly not part of this work plan.

Objectives

- Systematic photo-surveys of previously surveyed sites of mesophotic reefs, deep water corals, and chemosynthetic communities to (1) increase baseline data, (2) document ephemeral data for initial injury, if any, such as visible pathologies/abnormalities on the corals and associated biota. This includes quantitative documentation of discoloration, sloughing tissue, necrosis, excessive mucus production, abnormal polyps, and other visible indicators of adverse effects of the MC 252 incident, if any. Such data will be used in an attempt to quantitatively assess the impacts caused by the MC 252 oil spill and dispersant use, if any.

- Increase pre-exposure baseline data for biota at non-oil exposed sites, if any.

- Obtain tissue samples for the following purposes:

    - To document potential transient, ephemeral, exposure of deep water biota to petroleum hydrocarbons and dispersants from the MC 252 incident. The tissue will be sent to an approved laboratory for hydrocarbon "fingerprinting."
    - Possible necropsy analysis of ephemeral pathologies and other abnormalities.
    - Possible quantitative assessment of reproductive abnormalities (Tier 2 activity). Tier 2 analyses are expressly not part of this plan.
    - Possible examination for other abnormalities that could result in decreased productivity, decreased survival, and other quantifiable adverse impacts (Tier 2). Tier 2 analyses are expressly not part of this plan.
    - Preservation of tissue for potential Tier 2 and 3 NRDA assessments of indicators and impacts of exposure to be determined. Tier 2 or 3 analyses are expressly not part of this plan.
    - Preservation of tissue for potential use within possible Tier 2 or 3 plans at a later date. Tier 2 or 3 analyses are expressly not part of this plan. These

samples shall be made available for basic research supported and funded outside of the NRDA, which may provide information on molecular and cellular responses and mechanisms of resilience to hydrocarbon and dispersant exposure, should a determination be made that the tissue will not be used within potential Tier 2 or 3 NRDA, and/or if any samples exist that are superfluous to the needs of the potential Tier 2 and 3 NRDA activities.

- Document and measure other initial injuries, if any, to deep water biota potentially caused by the MC 252 incident that can be tracked and quantified in follow-up surveys.

- Deploy two new sediment trap moorings at sites to be selected (e.g. VK 862 and VK 906), for collection during subsequent research cruises, to increase the spatial coverage afforded by on-going studies at two *Lophelia II* study sites.

- Retrieve passive oil samplers (SPMDs), deployed previously by a complementary Tier 1 effort.

Tasks

A. Station Selection

Final site selection will be determined by the latest information regarding actual or potential exposure of the deep water habitats to oil and oil/dispersant from the MC 252 incident, in combination with the constraints of the assets employed, ports, cruise length, and cruise logistics. There are three categories of sites for consideration:

1. Deep *Lophelia* sites and 2. Chemosynthetic sites

There are well marked and navigated photomosaics from VK 826 (4), VK 906 (2), and MC 751 (3). Two sites, VK 826 and MC 751 have abundant coral and tubeworm communities. Thus, these can serve as both coral and seep sites (with respect to tubeworms and their associated fauna). They are at similar depths, but MC 751 is about 80 nm to the WNW of the leak site while the VK sites are about 30 nmi to the north so they may have experienced very different exposure loads. VK 862 and VK 906 are both within 20 mi of VK 826, but are at different depths (VK 826 is in 425 m, 862 is in about 315 m of water and VK 906 is in 400 m). All have abundant *Lophelia* and *Leiopathes*, with several different color morphs of *Leiopathes* occupying different habitats at 906. *Callogorgia* is present in VK 906 and VK 826. Although we do not have mosaics to replicate at VK 862, we have imagery of this spatially constrained site and may be able to make robust comparisons on the scale of the site. It is important to visit this site if time allows because it is in the same region but at a very different depth.

Another site close to the leaking well that is fairly well known is MC 118, the "hydrate observatory site". However, there are no well-navigated mosaics we know of at this site, and very little previous macrobiological collections or work. However, there are significant *Madrepora* assemblages at this slightly deeper site and imagery showing an abundant living aggregation. This site was not visited during *Lophelia* II, but has been visited by one of the principal investigators of the *Lophelia* II project. It is recommended that collaborations be established with some of the hydrate observatory team if we work at this site and that it be considered a serious option as we learn more about the nature and extent of the potential deep water plume.

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Summary

a. VK 826 and 906 primary sites VK 826 for coral and chemo tubeworms
b. VK 862 a shallower site in the immediate region
c. MC 751, 80 nm distant, for coral and chemo tubeworms
d. MC 118 Hydrate observatory (little megafauna work done)
e. There are numerous other well-known sites in the vicinity to choose from if proven desirable by newer data.

2. Pinnacle Sites (mesophotic coral, "soft" coral, sponges)

Over 1,000 imaging and sampling stations have been conducted on Pinnacle (MS, AL) and West Florida shelf-edge reef features (60-200 m) during 12 USGS/MMS scientific missions. Additionally, nearly all of the MS, AL, WFL shelf edge (4,500 km^2) has been mapped using high-resolution multibeam methods. High-profile (10-15 m relief), high-biodiversity reef sites at a location that appears to have been underneath the surface location of the DWH spill at some point in time, include the 'Alabama Alps' (40 nmi north of DWH) and 'Roughtongue Reef' (~100 nmi NE of DWH), both under consideration for inclusion in a potential National Marine Sanctuary. Alabama Alps has appears to have been under a surface oil plume from the spill since at least 29 April, Roughtongue Reef since ~20 May suggesting that at least Alabama Alps reefs may be under the direct impacts of the spill. USGS has sampled fishes, invertebrates, tissues, and sediments and conducted ROV imagery on both potentially impacted sites (1997-2005). All ROV sites are resolved by GPS and depth coordinates. This information provides background of knowledge and imagery for comparisons with current conditions. This information will be used to determine baseline, where possible and, depending on patterns of oil exposure, to conduct BACI-type analyses for quantitative NRDAs.

Additional comparison of potentially impacted versus unimpacted reefs will come from GOM shelf-edge reefs well outside the area of surface oil spread (to date). This is provided by high-profile, high biodiversity reefs on the West Florida shelf edge, sampled and imaged by USGS, 2001-2003,including the "North Ridge" and "South Ridge" reefs within the Madison-Swanson grouper spawning preserve, and the "Coral Trees" reef site, all within close physical proximity. In addition to ROV video imagery, USGS also has high quality ROV digital still imagery for these sites from these 2001-2003 field efforts. Sediment sampling using a box grab was also accomplished on these comparative W. Florida deep reef sites during these efforts. Sediment sampling to determine potential oil

substrate impacts on-reef and off-reef is important since many species sheltering in the reef forage on sediment organisms, possibly transferring carbon particles back to reef particulate feeding invertebrates as feces.

For both Pinnacle and comparative W. Florida shelf-edge reef sites, the video/digital image archive has been accessed to determine the optimal high biological diversity (hard corals, gorgonians, black corals) stations to utilize as repeat station sites in 2010. Refer to maps (see Appendix 2) for location of proposed Pinnacle and comparative W. Florida study sites (general reef top reference coordinates indicated below; specific stations will match prior coordinates for ROV imagery, sediment samples, etc.):

a.	Alabama Alps Reef	29.25167	88.33833	70m
b.	Roughtongue Reef	29.43907	87.57642	66m
c.	Control W. Florida Pinnacle reefs:			
	Madison-Swanson N. Ridge Reef	29.26023	85.69412	60m
	Madison-Swanson S. Ridge Reef	29.18717	85.67848	70m
	Coral Trees Reef	29.50688	86.14520	80m

B. Determination of Research Platforms

- First choice: NOAA's R/V *Nancy Foster* (see Appendix 3)
- Alternate: NOAA's R/V *Pisces* (see Appendix 3)
- Remotely Operated Vehicle (ROV)
    - *Global Explorer* (Deep Sea Systems International)- Capabilities and specification needs (see Appendix 4):
        - An asset with excellent navigational capability to locate relatively small (but very well navigated) mosaic sites within large seep and coral areas.
        - An asset with multiple excellent imaging capabilities and/or the ability to accommodate high quality digital camera and strobes we will supply.
        - An asset with precision collection capability.
        - An asset with a moderate collection capacity: At the least we need to be able to collect 12 push cores and 20 discrete biological samples per site, and preferably per dive.
        - An asset with operators experienced in the collection of scientific data and quantitative measurements.

- Pinnacle work conducted on second leg will use the same assets, in addition to surface-deployed box-grab and small dredge assets for off-reef soft-sediment sampling, and ROV deployed SPMD near-bottom water-column hydrocarbon detection devices.

C. Field Sampling (principal scientists listed)

To reiterate the overarching objective of this NRDA project, focus will be the collection of samples and data in close proximity to the MC 252 site. These data will be used to determine the presence of impacts from the spill event, if any, and directly applied to damage assessment.

Deep coral sites where applicable

1. Photomosaics (Fisher): A total of 24 high quality photomosaics from 7 coral sites exist, including mosaics at 3 of the 4 sites provisionally proposed above. There are many other sites with previous knowledge and a variety of physical markers on the sea floor that should allow us to recognize both any isolated damage and gross loss of fauna, if any (see photos in Appendices). If no previous photomosaics exist, we will survey known areas to visually assess and record gross levels of organism mortality, behavioral/association changes or ecosystem loss, if any.
    a. Document changes in sessile fauna, if any.
    b. Document changes in community composition, if any.

NRDA Objective: Employing a BACI or related design, repeated high-resolution photomosaic imagery should quantify changes in community structure, composition and species distributions spanning a time period before the accident to after, if any. Differences may quantify impact from oil and/or dispersant exposure. Causation may be further tested with additional data regarding exposure to DWH oil/dispersants and eco-epidemiological examinations of the injured resources and injury circumstances.

2. High quality digital or HD video imaging of colonies to assess condition, macro and megafaunal associates, individual behavior and fish occurrence (Fisher, Shank, Ross).
    a. Concentrate on well documented species-specific associations (Shank, Ross) because of robustness of data interpretation.

NRDA Objective: Obtain direct high-resolution photography to assess population densities and frequencies of biota, including those recently killed or exhibiting pathologies and other abnormalities, if any. These data will be compared with previous imagery to obtain before and after comparisons and with unimpacted reference sites to obtain control-impact comparisons.

1. Sediment/larval trap deployment (German)
    a. Deployment of two additional traps with different collection timing: deploy at VK 906 and VK 862

In September 2009, two time-series sediment trap and current meter moorings were deployed in the northern Gulf of Mexico to investigate biogenic fluxes settling to the seafloor, and larval recruitment at MC751 and VK 826 (see earlier), two well-characterized and significant sites of combined deep-water coral and chemosynthetic tube-worm colonies (Fisher et al., 2007). Each of these traps, set just above the seabed

and in water depths of 400-450 m, has been collecting a new sample of settling material every two weeks since 11 September 2009 and, through on-going work funded by MMS-NOAA-OER and a new NSF-RAPID grant those time-series will continue until Oct-Nov 2010. At the adjacent VK 906 and at the significantly different depth VK 862 sites, by contrast, we currently have no time-series established to monitor the composition of particulate material settling to the seafloor. Our priority in this work, therefore, will be to deploy two additional moorings at these sites to expand the coverage of time-series sample collection to four key targets sites on the GoM seafloor. Of course, the exact locations of these 3rd and 4th deployments may be revised, closer to the dates of the cruise, informed by our prior knowledge of deepwater corals and chemosynthetic communities elsewhere in the northern Gulf of Mexico (see maps in Appendix 2) and whatever the most recent data available may suggest on directions of possible plume dispersion - both at the ocean surface and at depth. For illustration, a schematic of the sediment trap moorings is shown in Fig. 1.

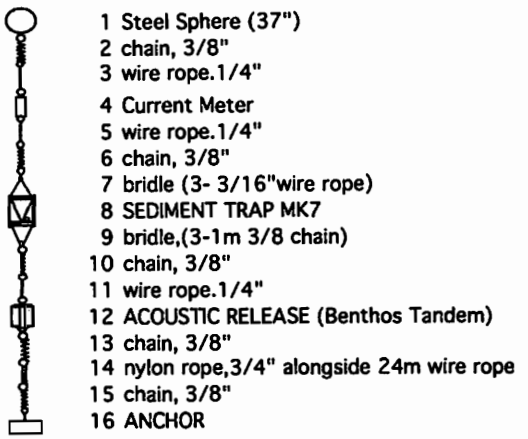

Fig. 1. Schematic illustration of the short (~50 m) moorings that we seek to deploy in the northern Gulf of Mexico in July 2010 to ensure continuity of time-series sample collection – provisionally at the VK 862 and VK 906 sites. Two sets of similar moorings, already in place since September 2009, will continue to collect samples over a time series at the MC751 and VK 826 sites until at least Oct/Nov 2010 when they are due to be collected on an already-funded MMS/NOAA-OER cruise. These 3rd and 4th trap moorings, to be deployed as part of the NRDA effort and recovered on that same Oct-Nov cruise, will double our spatial coverage of instantaneous settling fluxes at the seafloor - at locations to be finalized based on our prior knowledge of strategically significant deep-water ecosystems (maps in Appendices) and the most up-to-date information available at the time of the cruise sailing dates on potential oil-spill dispersion at the ocean surface and at depth.

NRDA Objectives: (1) Quantify sinking inorganic particulate matter and plankton/larvae taken in time-series that began before the spill and continues during and after the spill. (2) Conduct analysis to quantify and fingerprint petroleum hydrocarbons and dispersants, if any, in the traps. These data will be used in an attempt to quantitatively assess prespill/postspill changes, if any, in pelagic input to the sea floor as well as to possibly provide direct evidence of a potential route of input of Deepwater Horizon hydrocarbons to these communities and the seabed

2. Collections of coral branches and whole bodies of key indicator species-specific associates. Concentrate on *Lophelia, Leiopathes,* and *Callogorgia,* and larger specific associates for analyses requiring biomass, but also others abundant species as time and resources allow (for example holothuroids) (Fisher, Cordes, Shank).
    a. Collection of tissue samples for hydrocarbon and potential dispersant signature analyses.

b. Collection of ephemeral and unique samples for potential future studies. We will use a range of tissue, DNA, and RNA preservations to assure collections from this timely effort are available for possible future work that is expressly not part of this proposal.

NRDA Objective: Obtain tissue collections that may provide direct evidence of exposure to Deepwater Horizon oil and provide tissue samples for potential Tier 2 analyses.

3. Sediment coring (Demopoulos).
   a. Existing baseline samples for both chemistry and biology (ROV-operated push cores, box cores). A total of 46 sediment cores (33 cm^2 area x 10 cm depth and section at 0-2, 2-5, and 5-10 cm intervals) for benthic infaunal community analyses were collected during August-September 2009 from three deep-sea coral sites: VK 906, VK 826, and MC 751. These sites correspond to locations of the existing photomosaics. At VK 906, 9 sediment cores were collected, at VK 826, 14 cores were collected, and at MC 751, 7 cores were collected, all corresponding to locations where high resolution photo mosaics were conducted. An additional 16 sediment cores were collected near corals at VK 906 and 826 not associated with photo mosaics. Lastly, 29 sediment cores were collected in soft sediments located away from coral ecosystems to be used as background samples. In addition to the preserved cores from the August-September 2009 cruise, 3 sediment cores were frozen from VK826 and 1 core frozen from VK 862. Also, 8 box core samples were collected at VK 826 and these sediments were frozen.
   b. We propose to collect new sediment push cores at the same locations that were sampled in August-September 2009 to quantify changes in community abundance, composition, and diversity of the infauna, if any. The biota will be examined for lesions and other visible pathologies that may be diagnostic of exposure to the spill. Hydrocarbon and dispersant analyses of the sediments (conducted by TDI Brooks or other appropriate lab) would be consistent and complementary to the overall effort to quantify oil contamination, if any, and identify the source of the oil. Box coring would be used as back-up and supplement, as needed, to the ROV-operated push cores. Sample sizes will be appropriate to differentiate the natural variability within these communities from changes associated with the spill, if any.

NRDA Objectives: 1. Obtain sediment and sediment-dwelling biota for analysis of hydrocarbon and dispersant concentrations and oil identification. 2. Measure changes in population densities of sediment dwelling fauna, if any. 3. Quantify lesions and other pathologies in the sediment-dwelling biota, if any. 4. Compare population densities in pre-spill/post-spill core samples at the same sites. If control sites can be added, we will add BACI or related analysis to the population comparisons to quantify changes, or to document no changes, in population densities. The results will be used in an effort to quantify losses, if any, of the sediment-dwelling fauna caused by the Deepwater Horizon incident.

4. Retrieval and deployment of SPMDs (deployed as per a complementary proposal)
    a. Quantify hydrocarbon concentrations in the environment associated with deep-sea corals and reference sites.

NRDA Objective: SPMD devices may be able to obtain an integrated history of oil exposure where the SPMDs are located. The SPMDs should document the exposure, or non-exposure of adjacent biota. Results may then be able to be related to changes observed in imagery and community condition and applied to quantitative assessment of losses.

Chemosynthetic Community Sites

1. Generally same as for Deep Coral sites. In some cases both fauna are present at the same sites. We have similar data and sample sets from these types of communities (Fisher, Cordes).
2. For tubeworm communities, we will specifically survey for evidence of morbidity and/or death of smaller and entire aggregations, as this has never been recorded before (Fisher).

NRDA Objectives for the Chemosynthetic Community Sites are the same as described for the deep coral habitats.

Pinnacle (mesophotic) sites (Leg-2 of same cruise, with 1-day scientific crew and gear turnaround)

1. Imagery: ROV HD video plus still digital imaging, repeating surveys of sites surveyed on earlier USGS ROV missions using timed linear transect methodology. Emphasis on documenting status, condition and potential injury to sessile hard and soft corals, quantifying soft and hard corals as per frame by frame image analysis using Coral PointCount software for comparative analyses, and any potential oil deposition on corals and substrate (Sulak).
2. Specimen sampling – dominant deep-reef food chain organisms (Sulak).
    a. ROV manipulator sampling of hard corals, gorgonians, black corals to document identifications of potentially impacted coral organisms, and to obtain tissue samples for possible future (Tier 2) isotope analysis to document potential oil carbon that has entered the planktivore/particulate feeder level of the food chain. Any possible Tier 2 analyses are expressly not part of this plan.
    b. ROV suction sampling of on-reef sediments for contaminants analyses, assessment of integrity of key benthic organisms serving as critical deep-reef food resources, and to obtain tissue samples for possible future (Tier 2) isotope analysis to document potential oil carbon that has entered the microvore level of the food chain. Any possible Tier 2 analyses are expressly not part of this plan.

c. ROV suction sampling of small reef forage base fishes amenable to ROV collection to obtain tissue samples for possible future (Tier 2) isotope analysis to document potential oil carbon that has entered the secondary consumer level of the food chain. Fish specimens may provide sufficient mass of tissue to conduct oil hydrocarbon and dispersant contaminants analyses. Any possible Tier 2 analyses are expressly not part of this plan.

NRDA Objective: Direct high-resolution observations of species recently killed or in declining condition, if any, can be quantified and compared to recent baseline information. Changes can potentially be utilized in an assessment of losses to mesophotic coral habitat species.

3. Retrieval of previously deployed SPMDs and deployment of new SPMDs for possible Tier-2 retrieval.

NRDA Objective: SPMD devices may be able to obtain an integrated history of contaminants where they are located. Oil will be analyzed to identify source. Resulting data may indicate exposure to oil as experienced by habitat components in the same vicinity. Results can then be related to possible changes observed in imagery and community condition and applied to quantitative assessment of losses.

4. Box-grab deployment from surface over near-reef soft sediment sites, repeating station sites from previous USGS Pinnacles and West Florida deep reef studies. Sampling will follow same basic design used for Deep Water habitats (Demopoulos).

NRDA Objectives for the Pinnacle (mesophotic) sites are the same as described for the deep coral habitats.

5. Collection of samples for possible future analyses to be determined. Those future analyses are explicitly not part of this plan.

NRDA Objective: Same as described for deeper water habitats.

D. Laboratory Analyses

1. Lophelia and Chemo-Site Samples:

a. Analysis of mosaics and aggregation imagery (Fisher)
b. Analysis of imagery for specific associations (Shank)
c. Analysis of sediment traps (German, Shank)
d. Benthic community analysis of sediment cores (Demopoulos)
e. Analysis of imagery for fish identifications (Ross)
f. Analysis of hydrocarbon and dispersant chemicals, if any, in animal tissue samples, sediments and sediment trap samples (TDI-Brooks)

2. **Mesophotic Reef Samples:**

   a. Analysis of digital and video imagery from repeat ROV dives on previously imaged USGS station sites:
      i. ID of sessile invertebrates
      ii. Determination of indications of sub-lethal impacts, if any, with quantification, (Etnoyer) for dominant taxa, and comparison across the west-east potential high oil impact to low/no oil impact gradient (Alabama Alps to Madison-Swanson).
      iii. Same for dominant species for reef-fish planktivores (e.g., *Pronotogrammus marticensis, Hemanthias vivanus, Serranus*) (Sulak, Randall) amenable to ROV suction sampler collection.
      iv. ROV station will repeat GPS coordinates of previous USGS ROV station sites, 12 cruises (1997-2005). Comparative background is voucher imagery from 12 previous USGS cruises, and additional Reed Pinnacles and West Florida Shelf cruises, employing voucher ROV video and digital imagery at the indicated target study reefs. Sample 'N' frames to be accomplished from each target site (ca 40 hrs ROV time per site) = several thousand frame grabs.
      v. Quantitative (Coral PointCount methodology) using mission individual frame grabs as per methods in Sulak et al. (2007), scoring healthy and potentially impacted sessile epifauna (Sulak, Randall and tech staff). Objective is not percent cover, but quantification of dominant taxa via projection of random dots onto each image, allowing statistical estimation of rank order abundance of each dominant taxa. Sample 'N' frames to be accomplished from each target site (ca 40 hrs ROV time per site) = several thousand frame grabs. ROV station will repeat GPS coordinates of previous USGS ROV station sites.
      vi. Taxon ID by Sulak, Etnoyer; quality control University of Louisiana-Lafayette laboratory (France). Quantification by trained USGS image analysts.
      vii. Definitive laboratory identification and specimen vouchering of ROV sampled reef invertebrate taxa (Univ. Louisiana-Lafayette, France)
   b. Analysis of imagery for other reef invertebrate identifications (Etnoyer).
   c. Analysis of imagery for fish identifications and community structure comparison to previous USGS ROV studies (Sulak, Randall).
   d. Laboratory analysis of tissue and sediment petroleum hydrocarbons for comparison with known background levels.
      i. PAHs to be analyzed by TDI-Brooks laboratory
   e. Laboratory analysis of recent DWH event sediment samples and frozen comparative Pinnacles voucher sediment samples from previous USGS cruises for quantification and characterization of infaunal taxa abundance and rank order dominance, pre- and post- DWH event (Demopoulos).

f. SPMD extraction to be accomplished by EST laboratories, hydrocarbon analyses to be accomplished by TDI-Brooks or other appropriate laboratories. SPMD hydrocarbon composition and concentration to be interpreted by Bargar, USGS.
g. SPMD results interpretation (Bargar, USGS SESC, FL).

E. Data Analysis and Reporting

1. Imagery, samples and data obtained from sampling cruises must be processed in a timely manner. Initial expectations are for an Interim Report product within nine (9) months from the end of the cruise. Some components will take longer to complete. The final report is targeted at 18 months initially. QAP information may be found in Appendix 5.
2. Unless otherwise agreed upon by the Trustees and BP, all samples will be sent to TDI Brooks Lab.
3. BP agrees that subsamples preserved for analyses proposed here, other than hydrocarbon analyses, will be conducted by separate labs as identified in this proposal. Samples for potential Tier 2 and Tier 3 analyses will be stored in the laboratory of Dr. Erik Cordes at Temple University (Deep coral study samples), or sent to TDI Brooks Laboratory or other appropriate laboratory (Pinnacles samples). Any Tier 2 or Tier 3 analyses are expressly not part of this plan.

F. Data Sharing

Each laboratory shall simultaneously deliver raw data, including all necessary metadata, generated as part of this work plan as a Laboratory Analytical Data Package (LADP) to the trustee Data Management Team (DMT), the Louisiana Oil Spill Coordinator's Office (LOSCO) on behalf of the State of Louisiana and to ENTRIX (on behalf of BP). The electronic data deliverable (EDD) spreadsheet with pre-validated analytical results, which is a component of the complete LADP, will also be delivered to the secure FTP drop box maintained by the trustees' Data Management Team (DMT). Any preliminary data distributed to the DMT shall also be distributed to LOSCO and to ENTRIX. Thereafter, the DMT will validate and perform quality assurance/quality control (QA/QC) procedures on the LADP consistent with the authorized Quality Assurance Project Plan, after which time the validated/QA/QC'd data shall be made available to all trustees and ENTRIX. Any questions raised on the validated/QA/QC results shall be handled per the procedures in the Quality Assurance Project Plan and the issue and results shall be distributed to all parties. In the interest of maintaining one consistent data set for use by all parties, only the validated/QA/QC'd data set released by the DMT shall be considered the consensus data set. The LADP shall not be released by the DMT, LOSCO, BP or ENTRIX prior to validation/QA/QC absent a showing of critical operational need. Should any party show a critical operational need for data prior to validation/QA/QC, any released data will be clearly marked "preliminary/unvalidated" and will be made available equally to all trustees and ENTRIX."

G. Personnel

Lophelia and Chemo Site Component

Leg 1 will be co-led by A. Demopoulos (USGS) and C. Fisher (PSU) as co-chief scientists.

NOTE: All cruise participants are not listed at this time, only the leaders of the different efforts. We will need additional experienced personnel from each team to work together to accomplish all proposed work at sea with limited bunks. Each cruise will include room for an Entrix representative. The cruise will not be rescheduled, however, if no Entrix representative is able to take part.

Jim Brooks	Bryan Texas Project administration Hydrocarbon and dispersant analysis in tissues, sediments and water
Chuck Fisher	Lead on deep habitat component and Photomosaics Pennsylvania State University
Erik Cordes	Oversight of collections and species identifications Assist with site selection and within site navigation Temple University
Chris German	Time series larval/Sediment traps WHOI
Tim Shank	Analysis of species-specific macrofauna associates of corals: WHOI
Peter Etnoyer	NOAA (NCCOS) octocoral assessment
Steve Ross	UNCW Collaboration with USGS, Fish identification

Global Explorer Technical Crew (5 persons, Oceaneering Inc. DSSI, Plymouth, MA)
Additional ROV pilot

Amanda Demopoulos	Co-Lead on deep habitat component, benthic ecology, food webs USGS

MESOPHOTIC SHELF-EDGE SITES LEG-2:

USGS Scientists and Technicians:

Kenneth J. Sulak	Lead on Pinnacle Leg, Pinnacles Fish ID and community structure comparison to previous shelf-edge reef ROV missions.
Amanda Demopoulos	Co-Lead on Pinnacle Leg - benthic ecology, food webs, trophodynamic analyses, and sediment infauna analyses.
Alison Strong	
John Hart	Assisting biologists – benthos, sediments, tissue samples, data collection and compilation, imagery back-up and duplication at sea.

2 Biotechnicians	Assisting with all tasks at sea, and in laboratory, including image analysis, after appropriate training.
Michael Randall	Assisting biologist & oceanic gear specialist, surface-deployed sampling, gear technology, ROV operations assistant, scientific crew safety officer.
Ursula Garfield	GIS specialist (ROV track plotting, data consolidation and mapping, GIS station and cruise mapping).

Pinnacles Study Collaborating Scientists & ROV Team (Bold = personnel sailing on Leg-2):

Scott France	University of Louisiana-Lafayette: Expert in undersea *in situ* and laboratory identification. Assessment of visible sub-lethal condition effects in gorgonians and black corals.
Dennis Opresko	Oak Ridge National Laboratory: Expert in laboratory identification of black corals.
Peter Etnoyer	NOAA (NCCOS) octocoral assessment.

Global Explorer Technical Crew (4 persons, Oceaneering Inc. DSSI, Plymouth, MA) with additional ROV pilot.

G. Safety Plan

Principal investigators will obtain existing safety plans from research vessels chosen for operation and merge with any applicable University or participating organization practices. All well established safety protocols will be followed. MSDS hazardous materials sheets will be posted. USGS will provide formalin dispensing safety gear and spill neutralization kits. USGS will provide work PFDs and hardhats for USGS and academic collaborator personnel.

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H. Budget
Draft summary attached. See Appendix 6.

References

Brooke S. and Schroeder W.W. 2007. State of deep coral ecosystems in the Gulf of Mexico region: Texas to the Florida Straits. In: Lumsden SE, Hourigan TF, Bruckner AW (eds.). The state of deep coral ecosystems of the United States. NOAA Tech Memo NOS-CRCP-3, Silver Spring, MD.

Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group. 2001. Mississippi/Alabama Pinnacle Trend Ecosystem Monitoring, Final Synthesis Report. U.S. Department of the Interior, Geological Survey, Biological Resources Division, USGS BSR 2001-0007 and Minerals Management Service, Gulf of Mexico Regions, New Orleans, LA, OCS Study MMS 2001-080. 415 pp +apps. http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3136.pdf

CSA International, Inc. 2007. Characterization of Northern Gulf of Mexico deepwater hard bottom communities with emphasis on *Lophelia* coral. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-044. 169 pp. + app. http://www.gomr.mms.gov/PI/PDFImages/ESPIS/4/4264.pdf

Fisher, C.R., Roberts, H.H., Cordes, E.E., Bernard, B., 2007. Cold seeps and associated communities of the Gulf of Mexico. *Oceanography* 20, 118-129.

Gallaway, Benny J. (Ed.). 1988. Northern Gulf of Mexico Continental Slope Study, Final Report: Year 4. Volume II: Synthesis Report. Final report submitted to the Minerals Management Service, New Orleans, LA. Contract No. 14-12-0001-30212. OCS Study/M MS 88-0053. 378 pp. http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3696.pdf

Gardner, J.V., K.J. Sulak, P. Dartnell, L. Hellequin, B. Calder, and L.A Mayer. 2000. Cruise Report RV Ocean Surveyor Cruise O1-00-GM. The Bathymetry and acoustic backscatter of the Pinnacles area, northern Gulf of Mexico May 23, through June 10 2000. U.S. Geological Survey Open-File Report 00-350, 36 pp. http://geopubs.wr.usgs.gov/open-file/of00-350.

Gardner, J.V., P. Dartnell, K.J. Sulak, B. Calder, and L. Hellequin. 2001. Physiography and late Quaternary-Holocene processes of the northeastern Gulf of Mexico outer continental shelf off Mississippi and Alabama. Gulf of Mexico Sci. 19(2): 132-157.

Gardner, J.V., P. Dartnell, and K.J. Sulak. 2002a. Multibeam mapping of the Pinnacle region, Gulf of Mexico. U.S. Geological Survey Open-File Report 02-006, http://geopubs.wr.usgs.gov/open-file/of02-006/

Gardner, J. V., P. Dartnell, and K. J. Sulak. 2002b. Multibeam mapping of the West Florida Shelf, Gulf of Mexico. U.S. Geological Survey Open-File Report OF02-5, CD-ROM; online at http://geopubs.wr.usgs.gov/openfile/of02-5.

MacDonald, I .R., W.W. Schroeder, and J.M. Brooks. 1995. Chemosynthetic Ecosystems Studies Final Report. Prepared by Geochemical and Environmental Research Group . U.S . Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0023 . 338 pp. http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3323.pdf

MacDonald, I.R., ed. 2002. Stability and Change in Gulf of Mexico Chemosynthetic Communities. Volume II: Technical Report. Prepared by the Geochemical and Environmental Research Group, Texas A&M University. U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-036. 456 pp. http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3072.pdf

Moore, D.R. and H.R. Bullis, Jr. 1960. A deep-water coral reef in the Gulf of Mexico. Bull. Mar. Sci. 10(1):125-128.

Roark, E., Guilderson, T., Dunbar, R., Fallon, S., & Mucciarone, D. (2009). Extreme longevity in proteinaceous deep-sea corals *Proceedings of the National Academy of Sciences* DOI: 10.1073/pnas.0810875106

Rowe, G.T. and M.C. Kennicutt II, 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.

OCS Study MMS 2009-039. 456 pp.
http://www.gomr.mms.gov/PI/PDFImages/ESPIS/4/4842.pdf

Moore, D.R. and H.R. Bullis, Jr. 1960. A deep-water coral reef in the Gulf of Mexico. Bull. Mar. Sci. 10(1):125-128.

Roark, E., Guilderson, T., Dunbar, R., Fallon, S., & Mucciarone, D. (2009). Extreme longevity in proteinaceous deep-sea corals *Proceedings of the National Academy of Sciences* DOI: 10.1073/pnas.0810875106

Sulak, K. J., M. T. Randall, K. E. Luke, A. D. Norem, and J. M. Miller (Eds.). 2008. Characterization of Northern Gulf of Mexico Deepwater Hard Bottom Communities with Emphasis on *Lophelia* Coral - *Lophelia* Reef Megafaunal Community Structure, Biotopes, Genetics, Microbial Ecology, and Geology. USGS Open-File Report 2008-1148; OCS Study MMS 2008-015, 8 Chapters, pp., 8 Master Appendices (incl. Interactive Dive Track DVD).

Sulak, K. J., J. Berg, M. Randall, G. D. Dennis III, and R. A. Brooks. 2010. Dual-Carbon Sources Fuel the Deep Reef Community, a Stable Isotope Investigation. Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7-11 July 2008, pp 890-894.

Weaver, D.C., G.D. Dennis, and K.J. Sulak. 2002. Community structure and trophic ecology of fishes on the Pinnacles Reef Tract. Biological Sciences Report, USGS BSR 2001-0008, OCS Study MMS 2002-034, 168 pp.

Appendix 1. Additional References Added After ENTRIX/BP Review

Baker, M. C., Ramirez-Llodra, E. Tyler, P. A., German, C. R., Boetius, A., Cordes, E., Dubilier, N., Fisher, C. R., Levin, L., Metaxas, A., Rowden, R., Santos, R. S., Shank, R., Van Dover, C., Young, C., and A. Warén. Biogeography, Ecology and Vulnerability of Chemosynthetic Ecosystems in the Deep Sea. Accepted for publication PLoS One 5/10

Becker, E. L., E. E. Cordes, S. A. Macko and C. R. Fisher. 2009. Importance of seep primary production to *Lophelia pertusa* and associated fauna in the Gulf of Mexico. Deep Sea Res. I 56: 786-800.

Becker, E. L., R. W. Lee, S. A. Macko, and C. R. Fisher. Stable carbon and nitrogen isotopic compositions of hydrocarbon seep bivalves on the lower continental slope of the Gulf of Mexico. Accepted for publication. Deep Sea Res. II 11/09.

Brooks, J. M., M. C. Kennicutt II, R. R. Bidigare, T. L. Wade, E. N. Powell G. J. Denoux, R. R. Fay, J. J. Childress, C. R. Fisher, I. Rossman and G. Boland. 1987. Hydrates, oil seepage, and chemosynthetic ecosystems on the Gulf of Mexico Slope: An update. Eos Trans. AGU, 68: 498-499.

Brooks, J. M., M. C. Kennicutt, C. R. Fisher, S. K. Macko, K. Cole, J. J. Childress, R. R. Bidigare and R. Vetter. 1987. Deep-Sea hydrocarbon seep communities; Evidence of energy and nutritional carbon sources. Science, 238: 1138-1142.

Cary, S. C., C. R. Fisher, and H. Felbeck. 1988. Mussel growth supported by methane as sole carbon and energy source. Science, 240: 78-80.

Childress, J. J., C. R. Fisher, J. M. Brooks, M. C. Kennicutt II, R. Bidigare, and A. E. Anderson. 1986. A methanotrophic marine molluscan symbiosis: Mussels fueled by gas. Science, 233: 1306-1308.

Childress, J. J. and C. R. Fisher. 1988. Energy and carbon sources for endosymbioses between bacteria and marine invertebrates. NOAA Symp. Series for Undersea Research, 6 (2).

Cordes, E. E., D. C. Bergquist, M. L. Redding, and C. R. Fisher. 2007. Growth of *Seepiophila jonesi*: a second species of long-lived tubeworm. Mar. Ecol. 28: 160 – 168.

Cordes, E. E., S. L. Carney, S. Hourdez, R. Carney, J. M. Brooks,and C. R. Fisher. 2007. Cold seeps of the deep Gulf of Mexico: Community structure and biogeographic comparisons to Atlantic and Caribbean seep communities. Deep-Sea Res. I 54: 637-653.

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

Cordes, E. E., D. C. Bergquist, and C. R. Fisher. 2009. Macroecology of Gulf of Mexico cold seeps. Ann. Rev. Mar. Sci. 1: 143-168.

Cordes, E. E., E. L. Becker, S. Hourdez, and C. R. Fisher. Influence of foundation species, depth, and location on biodiversity and structure of cold seep macrofaunal communities on the lower slope of the Gulf of Mexico. Accepted for publication. Deep Sea Res. II 11/09.

Cordes, E. E., E. L. Becker, and C. R. Fisher. Temporal shift in nutrient input to cold-seep food webs revealed by stable-isotope signatures of associated communities. Accepted for publication. Limnol. Ocean. 3/10

Dattaupta, S., M. A. Arthur, G. Telesnicki, and C. R. Fisher. 2008. Modification of sediment geochemistry by the hydrocarbon seep tubeworm *Lamellibrachia luymesi*: A combined empirical and modeling approach. Geochem. Cos. Acta. 72: 2298-2315.

Duperron, S, M. Sibuet, B. J. MacGregor, M. M. Kuypers, C. R. Fisher, and N. Dublier. 2007. Diversity, relative abundance and metabolic potential of bacterial endosymbionts in three *Bathymodiolus* mussel species from cold seeps in the Gulf of Mexico. Environ. Micro. 9; 1423-1438.

Fisher, C R., H. Roberts, E. Cordes, and B. Bernard. 2007. Cold seeps and associated communities of the Gulf of Mexico. Oceanography 20-4: 68 – 79.

Lessard-Pilon, S. A., M. D. Porter, E. E. Cordes, I. MacDonald, and C. R. Fisher. Community composition and temporal change at deep Gulf of Mexico cold seeps. Accepted Deep Sea Research II 12/09.

Roberts, H. H., C. R. Fisher, B. Bernard, J. M. Brooks, M. Bright, R. S. Carney, E. E. Cordes, S. Hourdez, J. L. Hunt, Jr., S. B. Joye, I. R. MacDonald, C. Morrison, K. Nelson, V. Samarkin, W. Shedd, E. Becker, M. Bernier, G. Boland, M. Bowles, L. Goehring, M. Kupehik, S. Lessard-Pilon, H. Niemann, C. Petersen, J. Potter, and G. Telesnicki. 2007. ALVIN Explores the Deep Northern Gulf of Mexico Slope. EOS, Trans. Am. Geophys. U. 88: 341-342.

Appendix 2. Photos and Maps

Photo 1. *Lophelia pertusa* reef at 420 m depth in Viosca Knoll 826.

Photo 2. Chemosynthetic tubeworm communities at 525 m depth in the Green Canyon lease area.

Photo 3. A temperature probe deployed in 2009 on the *Lophelia* reef at 400 m depth in Viosca Knoll 906. Also in the image are two large basket stars, and three different color morphs of black coral growing on the coral rubble.

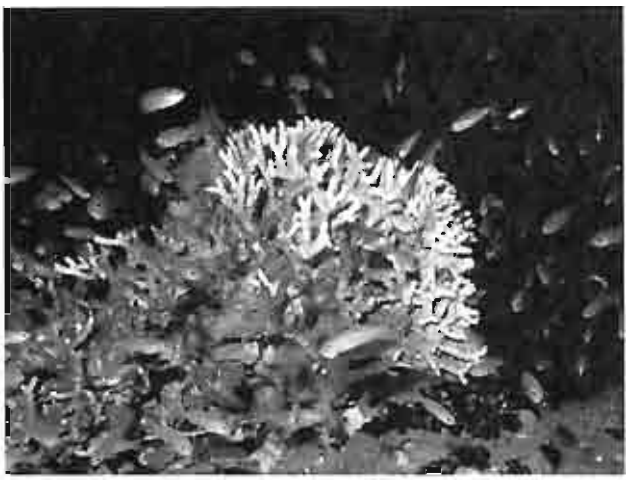


Photo 4. Shelf-edge mesophotic community with optionally hermatypic/ahermatypic hardcoral (cf. *Madracis-Oculina*) and planktivorous serranid fishes - ROV image from USGS shelf-edge cruise, ca 70 m depth.

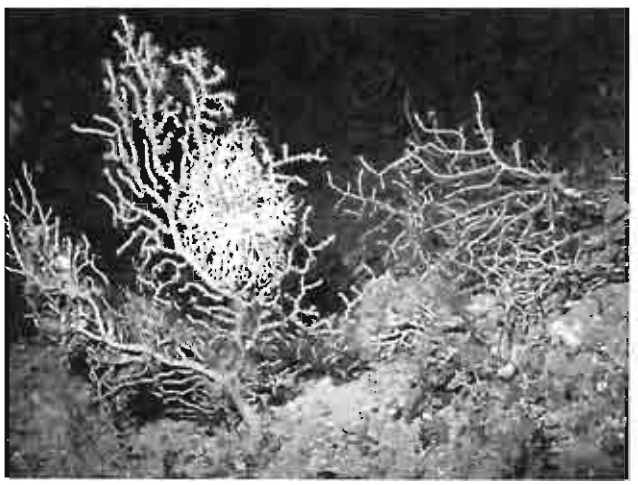
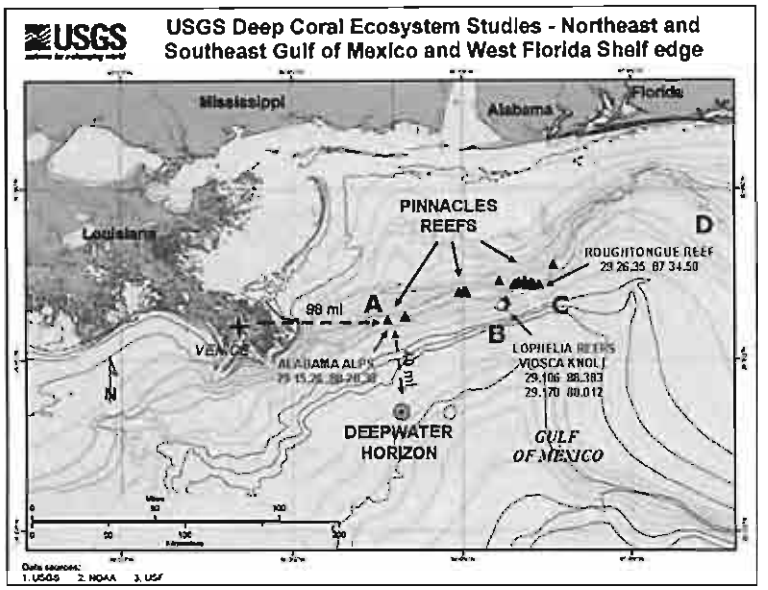
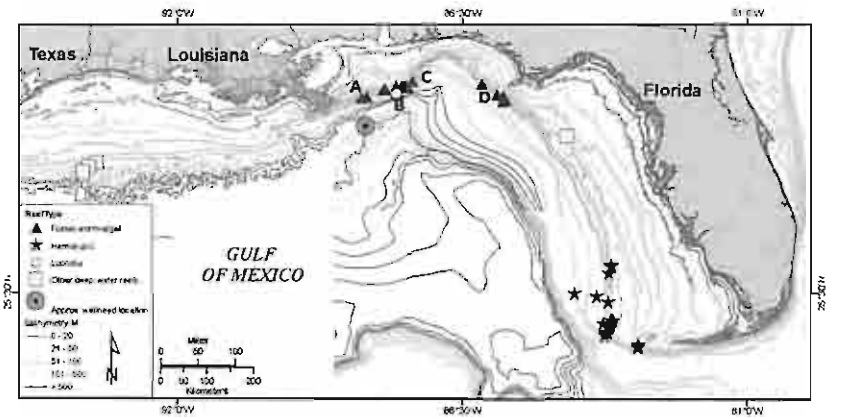


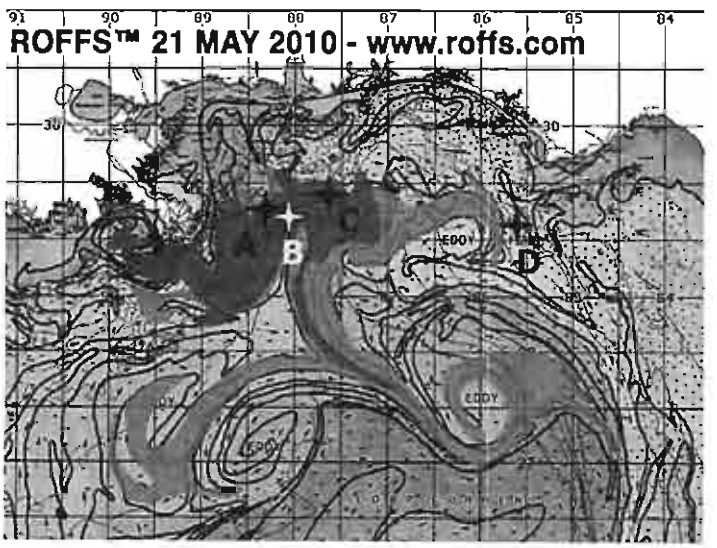
Photo 5. Mesophotic community of soft corals (gorgonians *Madracis-Oculina*) and planktivorous fishes - ROV image from USGS shelf-edge cruise, ca 70 m depth.



Map 1. A portion of the Northeastern Gulf of Mexico showing approximate study site locations for proposed USGS Pinnacles Leg-2 investigation of oil impacts, if any, upon shelf-edge mesophotic reefs. Key: Green dot = location of DWH wellhead site; blue triangles = USGS Pinnacles study reefs, 1997-2005; A, C, D = proposed 2010 Pinnacle study sites and West Florida comparative study site; B = Leg-1 Lophelia reefs; light tan colored area = 29 April to12 May surface distribution of the oil spill from NOAA online reports.

Map. 2. Eastern and Central GOM showing prominent shelf-edge reef features. Blue triangles at 'D' indicate locations of comparative Madison-Swanson and Coral Trees West Florida deep reefs.



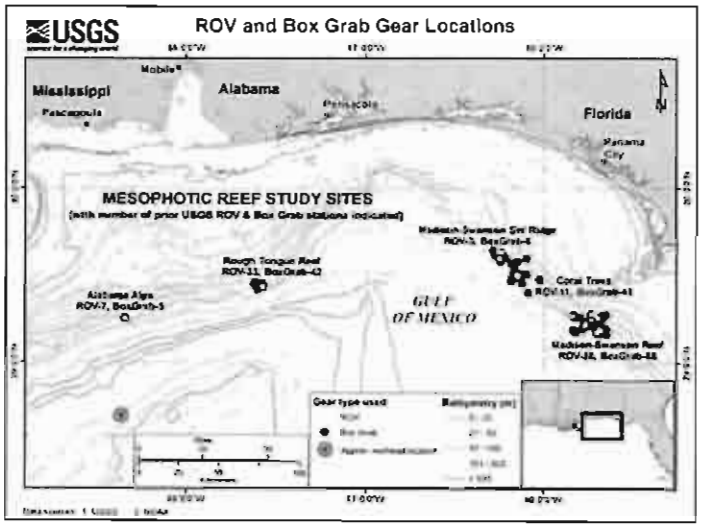


Map. 3. Leg-2 Mesophotic shelf-edge reef study sites (A, C, D) in relation of commercial online interpreted spread of surface oil (dark gray-green color), 21 May satellite interpreted imagery.

Map 4. Deep water sites with significant coral communities recently visited by submersible or ROV in the Gulf of Mexico below 300m depth. The two closest sites to the north of the Deepwater Horizon location are VK906 and VK826.

Map 5. Well surveyed high-density chemosynthetic cold-seep communities in the Gulf of Mexico.

Map 6. Target study reefs along the shelf edge in the northern Gulf of Mexico based on 12 previous USGS Pinnacles and NEGOM cruises. Locations and 'N' for ROV stations and sediment box grabs are indicated.



Appendix 3. NOAA Ship Assets Available for Deepwater Horizon Sampling

N.B. *Fisheries sonars* are designed to detect targets up in the water column (including some capability to detect oil, but much is unknown about this), while *bathymetric sonars* are designed to detect and map bottom features.

Ship	Primary Mission	ETA for DWH work?	Sonar type	Max sampling depth*	Other relevant capabilities	Endurance /Science Bunks
Pisces	Fisheries /ecosystem research	5/24 (Monday) (completing repair period)	Simrad ES-60 Echo Sounder (2): 50/200kHz, Simrad EK-60 (4): 18/38/120/200 kHz Single beam fisheries, Simrad ME-70 multi beam fisheries	2,100m (CTD) 4,300m (oceanographic)	CTD, water sampling rosette, ADCP, midwater and bottom trawl.	33 days/16 bunks Water: 7 days
Nancy Foster	Ecosystem research	Four days from tasking (divert from Grays Reef NMS mission)	Simrad EM 1002, 95kHz and Reson 7125, 200/400 kHz Single and Multi beam bathymetric, Simrad EK60	2,100m (CTD) 900m (towed net/instrument) 5,000m wire	CTD, water sampling rosette, ADCP, extensive small boat and diving cabilities.	14 days/15 bunks Water: 14 days

Cruise Dates		
July 14 - August 3		
$ in thousands		**Nancy Foster**
	DAS	19
Day at Sea Costs		
WM Salaries		35,476
Wage Marine Overtime		60,211
Employer Surcharge - 31%		10,998
NOAA Corps Officer Salaries		15,182
NC Special Pay/Benefits		6,983
Maintenance surcharge		118,750
Food/Supplies/Services		58,824
Fuel ($2.50/gal)		47,500
MOC Shoreside Support (112.3%) of WM and NOAA Corps Labor costs		56,889
Subtotal		**410,813**
	Staging Days	3
Staging/De-staging Costs		
WM Salaries		5,602
Wage Marine Overtime		4,470
Employer Surcharge - 31%		1,736
NOAA Corps Officer Salaries		2,397
NC Special Pay/Benefits		1,103
Maintenance surcharge		-
Food/Supplies/Services		380
Fuel ($2.50/gal)		-
MOC Shoreside Support (112.3%) of WM and NOAA Corps Labor costs		8,983
Subtotal		**24,670**
One Time Costs		
Subtotal One Time Cost		-
Total Costs		**435,483**

Appendix 4. Specifications for ROV Global Explorer

The Max Rover Mk III "**Global Explorer**" is a deep water remotely operated vehicle system for survey, science and recovery operations. The ROV is configured with an extensive array of cameras and lights, oceanographic sensors, marine sampling equipment, navigation and recovery aids, and tools. And it provides the power and agility to precisely maneuver and hover. The entire system, including a winch, operator consoles and all the support equipment, is the most highly mobile system available with this capability and can be rapidly and cost efficiently transported by air carrier.

Cameras

- HDTV camera 720p 12x zoom
- Super dynamic wide angle color TV
- 3-chip wide angle
- DSPL miniature LED color TV
- Digital photo and laser scaler

Lights

- Two to eight 150-watt HID
- Two 150-watt quartz halogen

Sonar

- Digital scanning
- Altimeter

Propulsion and Power

- 2 vertical thrusters
- 4 horizontal thrusters

Manipulator

- 5 function hydraulic
- Soft line cutter
- Wire rope cutter
- Sample basket
- Up to 6 spare hydraulic functions

Science Payload

- 12-position, 2.5-gallon sample carousel
- 55-gpm jet pump, flow or suction

- CTD
- Radiation detector and other sensors

Winch and Cable

- Winch drum 4,500 lb - 60" l x 55" w x 44" h
- Double armored fiber optics cable 7,500 lbs - 11,500'
- Slip ring with 4 power and 7 optical connections
- 25-hp electro hydraulic drive
- Overboard block

Consoles

- Pilot's console
- HDTV console
- Sonar, manipulator and navigation console
- Pilot's joystick control box
- Manipulator control box

Navigation and Relocation Equipment

- Transponder with depth telemetry
- Emergency locator pinger
- Flasher
- Trackpoint navigation system

Per a June 10, 2010 email from C Eban Franks (Deep Sea Systems, International)

We have a 14 foot ROV control console van, empty weight is about 1000 lbs. 7 feet wide and 7 feet high, it fits inside a 20 or 40 footer for shipping. It has 3 consoles inside it for ROV, video and sampling controls. This van is usually put on deck, perhaps up on the 01 level or on the fantail toward the main lab entrance. If there is not sufficient room for the van on deck, we frequently take the consoles out and install them in a lab space that is convenient to the deck.

The dimensions on the 3 consoles are each about 79" high by 26" wide and 74" front to back. We need about 2 feet behind them to crawl around and make connections. I believe these are about 400 lbs each.

One transformer is 26"by 23" by 26" weight about 300 lbs.

There is a high power transformer that can be in the control van or in a dry lab space near the fantail deck. This weighs about 450 lbs, is 26" by 34" by 50" high.

Power requirements:

for the winch: 3 phase, AC 440 volts to 480 volts - 25 Kw

ROV control consoles and transformers:

Single phase AC 240 or 440 to 480 volts - 15 Kw

ROV dimensions:

110" long by 48" wide by 64" tall - about 2200 to 3000 lbs depending on which payload

Winch:

118" long by 65" wide by 72" high, need 3 foot operation area on all sides at least.
Weight, about 12,000 lbs. which includes the wire. Has its own hydraulics, control and level-wind.

Clump weight:

35" by 40" high, weight about 1000 lbs.

There are 6 pallet boxes with spares, tools and equipment, about 600 to 800 lbs each.

So.. the total weight of the entire system is about 20,000 to 22,000 lbs.

Mike Randall of USGS is scaring up the USBL pole, it is 24 feet in length. Some work will be required to adapt it to the Foster. Mike is on it.

Appendix 5. -QAP

Data Quality Objectives

The MC252 incident has the potential to injure deep coral reefs, and associated natural resources and services. The sampling program described in this document addresses the collection of the data and information relevant to characterize deep coral reefs physically, chemically, and biologically: (a) with previously-collected data, prior to potential contamination by MC252-related oil, (b) post-impact (if any), and (c) in reference areas.

The exact timing and locations of potential impacts from oiling or related activities remain uncertain. The geographical scope for sampling activities therefore also remains uncertain, but will be as comprehensive as possible. Specific sampling objectives include:

- Rapid SPMD deployment: deploy sampling gear to allow determination of presence/absence of oil
- ROV Cruise: Characterization, quantification, and determination of any oil related impacts

Data Quality Indicators

Data developed in this study must meet acceptable standards of precision, accuracy, completeness, representativeness, comparability and sensitivity. Each of these data quality indicators, some of which are not readily quantifiable, is discussed below with specific reference to the current study.

Precision is defined as the level of agreement among repeated independent measurements of the same characteristics. Precision for this study is assessed in several ways: first, by the use of field duplicates for those data types that are amenable to duplicate measurements (e.g., samples collected for chemical analysis, and core samples collected for hydrocarbon analysis, and infaunal species diversity and abundance information). Precision in the context of laboratory analysis will be addressed in the Analytical Quality Assurance Plan (under development by NRDA; not as part of this Working Group).

Accuracy is defined as the agreement of a measure with its true value. Accuracy in the context of laboratory chemical analyses will be addressed in the Analytical Quality Assurance Plan (under development). Accuracy in species identification and in abundance measurements will be estimated by subjecting a proportion of samples (5%) to re-analysis by a second reviewer. Accuracy may also be evaluated, although more qualitatively, via comparison with results from prior studies in similar locations, if available.

Completeness is defined as the percentage of the planned samples actually evaluated and processed. Completeness can be evaluated for all components of this study. In particular, for all sites visited, it can be determined whether all specified measurements were recorded, and whether samples were acquired from all sites for which sampling was planned. Completeness can also be evaluated with respect to the proposed sampling strategy—e.g., taking three cores per site, or running a 3 minute transect. Note, however, that since the condition of the deep coral reefs is unknown, the conditions encountered may require changes in the sampling design. Also, work at depth is complex; equipment is prone to failure, and all sampling is subject to weather restrictions; thus not completing an ambitious sampling plan is not likely to be a sign of failure. Completeness in the context of the analytical chemistry measurements is addressed in the Analytical Quality Assurance Plan (under development).

Representativeness refers to the degree to which the data accurately reflect the broader community represented by the sampling effort. The careful selection of sites for

evaluation, among all possible sites, and the positioning of specific sampling locations within sites, has been designed using statistical considerations intended to allow results to be representative. Representativeness also will be ensured by proper handling and storage of samples and analysis within accepted holding times so that the material analyzed reflects the material collected as accurately as possible.

Comparability expresses the confidence with which one data set can be compared to another. Comparability for this project will not be quantified, but will be addressed through the use of consistent field and laboratory methods.

Sensitivity, the ability of a measurement technique or instrument to operate at a level sufficient to measure the parameter of interest, is largely not applicable to the biological parameters. The detection limits for chemistry parameters are addressed in the Analytical Quality Assurance Plan (under development). These, in conjunction with the measured biological parameters, is expected to provide sufficient sensitivity for the purpose of providing insight into the potential for the measured contaminants to impact the deep coral reef community.

Project Management

Project organization, roles, and responsibilities help ensure that individuals are aware of specific areas of responsibility as well as internal lines of communication and authority. Overall authority for project management rests with the Trustee Council. The Trustee Council has divided its staff into a number of technical work groups (TWGs), which are overseeing the development of specific plans for the evaluation and generation of information of relevance for the ongoing natural resource damage assessment. The Trustees are currently engaged in a cooperative effort with BP, whose representatives are also participating in the TWGs.

Under the auspices of the TWGs, field teams are being organized to implement the plans developed by the TWGs. Field team members have partially overlapping and partially distinct areas of responsibility. All field team members are responsible for ensuring that they are adequately trained with respect to health and safety requirements, requirements relating to the implementation of study-specific data generation activities, and adherence to case-wide protocols on topics including (but not necessarily limited to) chain-of-custody documentation, sample collection documentation, use of camera and GPS equipment, sample handling, packaging, and shipping requirements.

Designated field team leaders (Chief Scientists) have additional responsibilities, including overall responsibility for the activities of the field teams while they are deployed. Field team leaders have responsibility for communication with designated contacts on the status and safety of their teams. They are also responsible for ensuring the accuracy of information and the integrity of samples collected during field activities, and to make sure samples are appropriately handled and delivered, under chain-of-custody, to designated locations where they will be temporarily stored prior to shipment to an appropriate laboratory. Field team leaders are also responsible for ensuring complete collection of all information, data, and samples. They have responsibility for

ensuring that electronic data (e.g., from cameras and GPS units) are appropriately archived and uploaded into Trustee databases, and that hard copy data are transcribed into case-wide databases.

The Trustees have also been assembling a quality assurance team, comprised of individuals who will have responsibility for various aspects of quality assurance for this NRDA including the effort described in this plan. Individuals from the QA team have been and will continue to serve in roles including but not necessarily limited to: development of the Analytical Quality Assurance Plan; reviewing/assisting TWGs with the development of project-specific QA plans; conducting audits and ensuring implementation of QA plans; archiving samples, data, and all documentation supporting the data in a secure and accessible form; and reporting to the Trustee Council. Members of the QA team include Ms. Ann Bailey of EcoChem, Inc. and Mr. Charles Ramsey of EnviroStat, Inc.; the team may be expanded in the future.

Data Generation and Acquisition

The SOPs included in this document, and included by reference, provide full details about how data will be generated, including sampling methods, sample handling, and chain-of-custody requirements. All data generated will be compiled in a GIS-compatible electronic database.

Assessment and Oversight

All field-collected information is recorded in forms kept in loose leaf notebooks and will be signed and dated. The Chief Scientist supervises day-to-day field investigations, including sample collection, field observations, and field measurements and generally is responsible for all field quality assurance procedures. The Data Manager, designated by the Chief Scientists, shall review all forms for accuracy prior to their submittal at the end of the field day. The field forms will be scanned and archived, and data from the forms will be entered into the case-wide database (in development).

If technically and logistically feasible[1], during the course of the field work, an external audit will be conducted by a Trustee-designated member of the QA team to evaluate adherence to relevant protocols and ensure that procedures are in place for proper sample handling, processing, and documentation of results. Laboratory audits are also anticipated.

If, during the course of any field or laboratory audits, the QA auditor identifies deficiencies and other non-conforming conditions, the QA auditor or designee shall document these issues and shall formulate recommendations for corrective actions, which shall be communicated to the responsible team members, designated TWG representatives, and/or Trustee Council representatives.

Data Validation and Usability

[1] Feasibility may be limited by boat availability and capacity limits, response activity restrictions, or other factors.

All of the chemistry data will be subjected to formal data validation prior to use. The other data will also be evaluated to determine if they meet the performance criteria for measurement data that are described in this document. Any data that do not meet the performance criteria for measurement data will be flagged appropriately

The data generated in this study will be compiled in a GIS-compatible electronic database. The accuracy of data transcriptions will be evaluated by conducting checks of the data. This evaluation level will be increased if any errors are encountered during the initial evaluation of the data.

Appendix 6.

This budget excludes Trustee labor and contract employee labor costs. This budget also excludes costs for all laboratory analyses that are not specifically included in this budget. All costs that are not reflected in this budget will be documented and accounted for at a later time as part of the Trustees' assessment costs.

Budget Summary for Tier 1 NRDA deep coral assessment (from detailed budgets, in $K, rounded up)					
		Lophelia/Chemo	**Lophelia/Chemo**	**Pinnacles**	**Pinnacles**
Institution	**P.I.s**	**Tasks**	**Costs ($K)**	**Tasks**	**Costs ($K)**
USGS	Demopoulos	Co-chief Scientist sediment infauna	148	Co-chief Scientist benthic ecology	148
USGS	Sulak			Co-Chief Sci. community struct, fishes	220
U of LA	France			coral ID	21
Penn State	Fisher	Co-chief Scientist habitat, photomosaics	254		
Temple	Cordes	collections, species ID	25		
WHOI	German	sed time series, larvae	136		
WHOI	German	moorings	165		
WHOI	Shank	macrofauna assoc	93		
UNCW	Ross	fishes	50		
NOAA	Etnoyer	octocoral assmnt	8.67	octocoral assmnt	25
TDI Brooks		chemistry	tbd	chemistry	tbd
*ROV Global Explorer**	Franks	fundamental asset	227	fundamental asset	227
(w/o oil cleaning chrg)		for sampling		for sampling	
RV Nancy Foster	NOAA	fundamental asset	453.483	fundamental asset	(prior cost is for both legs)
		for sampling		for sampling	
Contract Oversight	IEc		7		3
Totals			**1567.15**		**644**
Total all projects	**2211.15**				
*additional cleaning costs may apply					