Mississippi Canyon 252 Incident

NRDA Sampling Plan

Offshore and Deepwater Softbottom Sediment and Benthic Community Structure Survey

Deepwater Benthic Communities Technical Working Group

April 6, 2011

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:

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April 6, 2011
Date

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Tentative Cruise Dates: Sediment Profile Imaging Survey: 04/06/11 – 04/22/11

1.0 Background and Objectives

1.1 Background

The seafloor environment in the vicinity of the MC252 spill site may have been impacted by a variety of oil transport pathways associated with the Deepwater Horizon (DWH) spill. To investigate potential impacts of the spill on the deepwater benthic environment, the Deepwater Benthic Communities Technical Working Group (TWG) has proposed a study to collect sediment chemistry, benthic infauna and potentially sediment toxicity data in the region around the wellhead and to the southwest of the spill area ("Deepwater Sediment Sampling Study") in the spring of 2011. A second study ("ROV Sediment Sampling Study") will collect sediment, floccular material and near bottom water samples for hydrocarbon and fingerprinting analyses in the area around the Deepwater Horizon (DWH) incident site. The Unified Area Command Operational Science Advisory Team (OSAT) report (OSAT 2010) on the sub-sea and sub-surface oil and dispersant monitoring describes the findings of sediment sampling in the offshore, deepwater environment.

This *Offshore and Deepwater Softbottom Sediment and Benthic Community Structure Survey* is designed to map surface sediment structures and the type and geographic extent of surficial seafloor sediment deposits (upper 20 cm) in the area surrounding the MC252 wellhead that may have been deposited from drilling, the MC252 incident and well control activities. These sediments are of interest because there may be oil-impacted sediment deposits, drilling mud deposits, and other allocthonous sedimentary layers in soft-bottom surficial sediments. Because this study will utilize imaging technology rather than physical sampling to collect information on seafloor sediments, it will complement the *Deepwater Sediment Sampling Study* and the *ROV Sediment Sampling Study*. While the two studies do not depend on one another, each offers the opportunity to provide additional insight for the interpretation of data collected by the other and providing a fuller context and geographical coverage for the injury assessment.

The sediment imaging survey will be conducted using a Sediment Profiling Imaging/Plane View camera (SPI/PV) system. The system and associated image analysis protocol allow benthic conditions over broad seafloor areas to be relatively quickly characterized in a systematic, comprehensive, and semi-quantitative manner. SPI/PV technology has been used as an effective sampling tool to delineate gradients in near-surface depositional layers, sediment textures, and benthic infaunal community function and structure (Germano et al. 2011). The images and parameters measured from them can be used to support interpretation of physically collected samples, as well as to guide and optimize the design of more time-consuming and spatially limited sediment sampling activities to be conducted in the future. Germano et al. (2011) provides a full review of the history and application of SPI technology in marine environmental monitoring studies, including the Drilling Effects Study (CSA 2006). Appendix A includes a detailed description of the SPI camera equipment, use and safety.

Two MMS surveys provide reference data on the sediment chemistry, characteristics, toxicity and benthic infaunal communities in the northern Gulf of Mexico (GOM). The first, commonly referred to as the "Rowe and Kennicutt Study" (2009), offers several sampling locations within the region of interest. The second study, commonly referred to as the "Drilling Effects Study" (CSA 2006) studied the effects of oil drilling operations on the sediment chemistry and benthic communities in four general areas the northern GOM. Of these, the Mississippi Canyon Block 292 (MC292) and Viosca Knoll sites are within the region of interest. The *Drilling Effects Study* collected Sediment Profile Image (SPI) photos related to oil exploration drilling activities at 14 locations (seven in each of the two areas) and included SPI photos before and after drilling activities.

1.2 Objectives

1.2.1 SPI Survey Objectives

This SPI survey will complement the proposed *Deepwater Sediment Sampling Study* and any other planned benthic studies by: (1) obtaining much greater sample density than is feasible with sediment coring techniques; (2) providing additional information on bottom habitat conditions that may aid in the interpretation of benthic data collected during sediment coring efforts; and (3) helping to inform future sediment sampling designs by identifying areas or strata that show potential impact.

SPI/PV images will be collected on a systematic grid of radial transects extending outward from the MC252 wellhead (as close as possible as allowed by SIMOPS, and outside of the 750-foot Court-Ordered Exclusion Zone around the DWH wreckage). SPI/PV images also will be collected at the 35 locations planned for sediment sampling as part of the *Deepwater Sediment Sampling Study* and the *ROV Sediment Sampling Study*, as well as at some locations where sediments have been previously sampled following the MC252 spill (e.g. surveys led by Dr. Samantha Joye of the University of Georgia and Dr. Kevin Yeager of the University of Southern Mississippi). The study area overlaps the area where sediment samples were collected as part of the Response effort and the area intended for sediment and near bottom water sampling as part of the *ROV Sediment Sampling Study*. This will allow comparison of the SPI/PV results with other sediment data types (e.g., sediment chemistry) when those data become available. Finally, locations sampled with the SPI/PV system as part of the *Drilling Effects Study* will be re-occupied during this survey to allow temporal changes in benthic conditions at those locations to be evaluated.

1.2.2 Water Sampling Objectives

During this survey, the chemical and physical conditions of the overlying water column along SPI transects will be documented using full-depth oceanographic profiling instruments (CTD, dissolved oxygen sensor, CDOM fluorometer, and Aquatracka fluorometer) at selected areas, primarily in the nearfield within 10 km of the wellhead. A water sampling rosette will also be on board the vessel to enable opportunistic water sampling,at the discretion of the scientific party, if water column features, i.e., fluorescence peaks or dissolved oxygen (DO) sags, are observed. The objectives of this portion of the study are to: 1) provide measurements of the general water column structure at the time of SPI survey, and 2) if features suggestive of the presence of hydrocarbons in the water column are detected, then to characterize water chemistry near those features and the sediment bed.. Cast locations will be widely spaced so as to not hinder SPI sampling but to provide information on overall conditions near-bed and in the overlying water column during the SPI survey period. These samples will be collected opportunistically as described below and are considered supplemental to the primary mission of the study, which is to collect SPI photos. No water sampling will be conducted unless peaks or sags are observed and then only in and immediately above and below those sags and near-bottom at the same location. No sampling of the upper water column is anticipated unless such features are observed there. The Trustees see only minimal utility in this water sampling component of the plan. While sampling of fluorescence peaks or dissolved oxygen sags would be interesting if they are found, sampling in the upper water column in the manner anticipated is unlikely to provide useful information.

2.0 Study Design

A principal objective of this *Offshore and Deepwater Sediment and Benthic Community Structure Survey* using SPI/PV techniques is to map the geographic extent of potentially oil-impacted sediment, drilling mud deposits and other deposits on the sea floor in the area surrounding MC252.

The SPI/PV camera frame is designed to collect undisturbed cross-sections of seafloor sediments from the sediment-water interface down to approximately 20 cm (Figure 1). The sediment profile camera works like an inverted periscope, giving the viewer the same perspective as looking through the side of an aquarium half-filled with sediment. The knife-sharp cutting edge of the prism penetrates the bottom and a strobe is discharged to obtain a cross-sectional image. The camera is then raised 2-3 m off the seafloor to recharge the strobe (within 5 seconds), and the camera is ready to be lowered again for another image. The resulting photographs (Figure 2) illustrate benthic characteristics in a visual manner that offers utility to both non-technical and technical audiences.

Of particular importance for this survey, the camera is designed to allow very low shear strength or floccular layers of deposited material at the sediment-water interface to be imaged. Depending on sea state (i.e., vessel movement), and near-bottom wire out speed, disturbance of floccular layers at the sediment-water interface, or the sediment-water interface itself, is possible. All efforts will be made to minimize potential disturbance factors associated with setting the camera frame on the bottom (the camera's optical prism drop rate is controlled by a passive piston which greatly minimizes its impact). In addition, such sampling artifacts are often discernable upon review of the images, particularly replicate images from a single location or between closely spaced locations. Target locations will be re-occupied if the level of disturbance affects image quality and interpretability. When effectively deployed, the SPI system successfully captures (and allows measurement of) surface deposits such as drilling muds (see Figure 2) and any other optically discernible layers in the upper sediment column or settled on the sea bed. The presence and thickness of these sedimentary layers will be mapped in conjunction with other SPI parameters to provide a measure of general benthic environmental conditions as a function of the distribution and extent of these mapped depositional layers. Table 1 lists the sediment parameters that will be measured using the SPI/PV system.

2.1 Sampling Design

Three (3) replicate images will be collected at each target SPI location. Approximately 50 stations can be sampled with the SPI/PV instrument during each 24-hour sampling day. Periodic review of the images collected during the SPI cruise by on-board senior SPI scientists will allow a nearly-real-time base map of sediment deposits, drilling muds and overall benthic habitat conditions across the surveyed area.

The SPI sampling plan is divided into five sets of sampling locations: (1) systematic radial transects; (2) existing sediment sampling locations (collected and planned); (3) previously sampled (i.e. reference) SPI survey locations; (4) previously surveyed ROV/video locations; and (5) opportunistically selected locations. These are summarized below and detailed in Tables 2 through 4 and Figures 3 and 4.

1. Radial Transects — Eight regularly spaced radial transects at 45° intervals around the wellhead will be sampled to systematically map sediment conditions in the area immediately surrounding MC252 wellhead out to at least 10 km in all directions (Figure 3, Table 2, Appendix B). Three additional transects "downhill" from the well will be sampled to explore possible transport of potentially oiled sediments along bathymetric contours; these are labeled GD1 (Gloria Dome 1), GD2, and GD3 in Table 2, Figure 4, and Appendix B. As time allows, samples will continue to be collected beyond 10 km along any transect where depositional layers potentially associated with the *Deepwater Horizon* spill are observed based on initial examination of SPI images and data (Table 2, Appendix B, Figures 3-4).
2. Existing sediment sampling stations — SPI images and data will be collected at stations within 50 km of the wellhead at which sediments have previously been collected (or are planned for collection) for chemical, benthic infauna, or toxicity testing as part of previous *Deepwater Horizon* spill assessment activities (e.g. OSAT 2010 and *Deepwater Sediment Sampling Study* to be conducted in spring 2011), by other researchers (e.g. Dr. Samantha Joye of University of Georgia and Dr. Kevin Yeager of University of Southern Mississippi), or as part of pre-2010 survey efforts (e.g. Rowe and Kennicutt 2009), so that inferences on benthic conditions based on SPI evaluation can be compared on a station-by-station basis with these other data types (Table 3, Figure 4). All 35 stations planned as part of the *Deepwater Sediment Sampling Study* will be included in the SPI study locations.
3. Previously-occupied stations from pre-spill SPI studies — A subset of stations where SPI images were collected as part of the Drilling Effects Study (CSA 2006) in 2001 and 2002 in the vicinity of MC252 will be re-sampled to allow direct comparisons to be made of temporal changes in benthic conditions at these locations as determined by SPI (Table 4, Figure 4).
4. Previously-characterized locations from post-spill ROV video surveys — SPI data may be collected (as time allows) at locations at which ROV bottom video was collected on

water column studies in 2010 to compare video and SPI/PV data sets (Appendix C, Figure 4).

5. Adaptive sampling — Additional samples may be collected in an adaptive manner in order to characterize unique communities, geographic features and presumed impacts, if observed. Such sampling locations will be at the discretion of the scientific party, in communication with land-based advisory teams, and with respect for the timing and stated objectives of the SPI survey.

2.1.1 Radial Transects

Table 2 lists the radial transects that will be sampled and the spacing of sampling locations along these transects. Eleven (11) transects are identified in Table 2 and Figure 3: eight (8) transects every 45 degrees starting from 0 degrees plus three (3) additional transects that follow bathymetric contours away from the well (Gloria Dome transects GD1, GD2, and GD3; Figure 4). Latitude and longitude positions are provided for these locations in Appendix B. Stations are spaced every 100 m close to the wellhead and gradually step out to 500 m spacing at 10 km distance from the wellhead.

This approach targets 330 locations within 10 km of the wellhead (listed in Table 2) and additional adaptive sampling stations may be added on the basis of observations. These efforts will likely occupy six to eight (6-8) total survey days.

Key features observed in the SPI images collected along radial transects will be reviewed, mapped, and discussed with shore-based project scientists. The subsequent target sampling grid may be modified to: (1) add stations where steep gradients in notable features (e.g. drilling muds or potentially oiled sediment layers) are observed within the 10 km radius circle; (2) continue sampling outward at 1 km intervals along transects where notable features are still being observed at 10 km; or (3) discontinue sampling along these transects where ambient conditions are apparent. Specific features that, if observed, may extend adaptive sampling beyond 10 km include layers of contrasting sediment properties (e.g. color or texture) and evidence of physical disturbance at the sediment-water interface. Beyond 10 km, two consecutive stations (including all three replicate images) should display presumably ambient conditions before stopping the transect. If any replicate image from a station is equivocal, the transect will be continued. Bottom topography will be considered in decisions made regarding items (2) and (3). For example, regardless of observed gradients in depositional features or benthic conditions, sampling may be continued beyond a large-scale topographic feature (such as a salt dome) to assess conditions on both sides of the feature.

2.1.2 Existing sediment collection study locations

Table 3 lists locations within 50 km of the wellhead at which sediments were collected as part of the *Deepwater Horizon* spill response or assessment activities, at the 35 sample locations planned for collection by the *Deepwater Sediment Sampling Study* in spring 2011, as well as at locations where sediments were collected in previous studies. According to OSAT (2010), stations where qualitative observations of oil in sediments were observed were extended to a distance of 37 km of the wellhead, although none of the available quantitative results of sediment samples exceeded the EPA chronic aquatic life benchmarks outside of 3 km from the wellhead. To further investigate sediment conditions within 50 km of the wellhead, SPI/PV data (three replicates per station) will be collected at each of the locations listed in Table 3 to allow comparisons with the laboratory sediment data and to identify any qualitative observations that may persist. Sampling the locations listed in Table 3 is expected to take a total of three to four (3-4) survey days. Because the direction of transport was primarily to the southwest, adaptive sampling will occur beyond 10 km along transect 225 (at a heading of 225 degrees from the wellhead). Additional adaptive sampling transects will be added if necessary (e.g. 240 degree and/or 210 degree radials) to discern spatial extent of observed sediment features.

2.1.3 Previously-occupied SPI study locations

Table 4 lists the center coordinates of 500-meter diameter circles within which SPI images and data were collected along one or more transects during the Drilling Effects Study (CSA 2006). In October and November 2000, a pre-drilling SPI survey was conducted in Viosca Knoll Block 916 (VK916) at depths of ~1100-1200 m (Figure 4). The "before" nearfield survey at VK916 provides baseline data because it had not experienced exploratory nor development drilling. The "after" nearfield station provides baseline conditions related to drilling (but not a spill event). In July 2001, an SPI survey was conducted in MC292 at a depth of ~1050 m. These locations were post-development sites surveyed once after several exploration and development wells had been drilled.

Images and data from these surveys are available for comparison with images data to be collected in this proposed study, in which several near-field and far-field areas occupied around MC292 and VK916 from 2000 to 2002 will be re-sampled with the SPI/PV system. Two transects (offset by approximately 90 degrees) that run through the previous coordinates will be sampled to characterize overall bottom conditions in the area. It is anticipated that 100-150 stations will be sampled with the SPI system along these transects to allow evaluation of potential changes in benthic conditions at these locations since the early 2000s. The MC292 and VK916 SPI transects are expected to take two (2) survey days to complete (one day at each location).

2.1.4 Previously-occupied ROV locations

Seafloor observations from previous ROV studies associated with NRDA Water Column sampling efforts may warrant investigation with the SPI/PV system, if time permits (Figure 4). For example, OSAT (2010) reported that chronic aquatic life exceedances were observed in sediments within 3 km of the wellhead, therefore locations with video of the seafloor collected by an ROV in this area (e.g. around the 2 km ring) may be targeted for sampling during the SPI survey, if time and logistics permit. In addition, because the direction of transport was primarily to the southwest, locations with ROV observations along transects 210, 225, and 240 will be prioritized.

2.1.5 Adaptive sampling locations

Additional samples beyond the 10 km transects may also be collected in an adaptive manner in order to characterize unique communities, geographic features, and presumed impacts, if observed. Such sampling locations will be at the discretion of the Chief Scientist, in communication with land-based advisory teams, and with respect for cruise timing and the stated objectives of the SPI survey.

3.0 Field Methods and Equipment

3.1 SPI Camera Survey

3.1.1 Survey Methods

A dynamically-positioned (DP) vessel will be required to control vessel position during SPI field operations. This is especially important for holding station while replicate images are collected. Three replicates bottom images will be collected at each target location. The field sampling effort will be conducted as a 24-hr operation to maximize the number of stations sampled during the 16-day cruise. Meeting Environmental, Health and Safety (EHS) requirements for operating at this level of effort will require a four-person field operations crew with seven (7) people on each 12-hour shift. Each shift will include at minimum a lead scientist responsible for the daily sampling plan, quality assurance, oversight on positioning, communications of technical findings to shore-based team, and drafting the daily cruise reports; two experienced SPI scientists (one predominately on deck to operate the cameras and one predominantly in the CONEX maintaining the SPI field log, managing and periodically reviewing downloaded SPI/PV images, and conducting preliminary evaluations of the bottom features imaged). The four other personnel on each shift will include an operations chief/navigator, two deckhands to handle SPI camera deployment and retrieval and other on-deck activities, and a winch operator.

An SPI QAPP, prepared by Germano & Associates, Inc., is provided as Appendix A to this sampling plan. Appendix A includes a detailed description of the SPI camera equipment, its set-up and operation, safety and health considerations associated with SPI field operations, and a detailed description of the SPI image analysis procedures. Appendix A also describes the standard operating procedure for a SPI survey and associated profile image analysis. For this deepwater survey, a plan view camera will be attached to the SPI camera frame to obtain plan view images of the seafloor immediately before profile image acquisition. Figure 1 illustrates the equipment configuration and bottom image acquisition sequence.

The plan view images provide a much larger field of view than the sediment profile images and can provide valuable information about the landscape ecology and sediment topography in the area where the pinpoint “optical core” of the sediment profile is taken. Unusual surface sediment layers/textures or structures detected in any of the sediment profile images can be interpreted in light of the larger context of surface seafloor features, i.e. whether or not a surface layer or topographic feature is a regularly occurring feature and typical of the seafloor in this general vicinity or just an isolated feature. Scale information is provided by underwater laser points in the plan view image that allow accurate density counts (number per square meter) of imaged epifauna, sediment burrow openings, or larger macrofauna (such as anemones or epifaunal foragers) which may be missed in the sediment profile cross-section. The analysis of the plan view images is less formalized than the profile image analysis protocol described in Appendix A. But a systemic review of the plan view images will be conducted as complimentary information to the SPI image interpretation as described above.

In addition to the SPI/PV cameras, an acoustic pinger will be attached to the camera frame and wired to double its ping rate whenever the SPI camera strobe discharges. The ping rate is monitored on deck by the vessel’s Odom 12 kHz fathometer so that image acquisition is confirmed in real-time. This information will allow the winch wire-out rate to be slowed as the array approaches the sea floor to minimize any “bow-wave” disturbance of potentially floccular, high-water content, or thin-surface sediment layers prior to image acquisition. In addition to utilizing multibeam bathymetry data collected prior to the survey, water depth will be continuously monitored while the camera is towed at depth between stations to ensure that the camera is safely above the bottom. The camera also will be equipped with an ultra-short baseline (USBL) positioning system to identify the latitude and longitude where the images are collected thereby facilitating analysis with sediment samples previously collected or planned for the future.

3.1.2 SPI Camera Operations

Details on the SPI camera operation are provided in Appendix A. Once the camera is deployed and near the bottom, the system can be "pogo-sticked" along to occupy multiple stations on each deployment. The camera prism is mounted on an assembly that moves up and down by producing tension or slack on the winch wire (Figure 1). As the camera is lowered, tension on the wire keeps the prism in the "up" position. Once the camera frame contacts the bottom, slack on the wire allows the prism to vertically descend into the seafloor. The rate at which the optical prism penetrates into the sediments is controlled by a passive hydraulic piston. This allows the optical prism to descend at approximately 6 cm per second and minimizes disturbance to the sediment column. As the camera is raised off the bottom, a wiper blade automatically cleans any sediment off of the prism faceplate. The film is automatically advanced by a motor drive, the strobes are recharged and the camera can be lowered for another replicate image.

3.1.3 Field Collections and Field Logs

At the beginning of each survey day, the time on the data logger mounted on the SPI camera is synchronized with the navigation system clock. A Nikon digital SLR camera and a charged battery are loaded in the camera housing. Test shots are fired on deck at the beginning of each day to verify all internal electronics systems are working according to specifications.

Each SPI station replicate will be identified by the time recorded in the image file and the corresponding time and position recorded by the navigation system. A position will be recorded for each of the three replicate images taken at each SPI station. Redundant sample logs will be kept by the field crew.

Information recorded in the field log includes:

- Time
- Date
- Station Location
- Replicate ID
- Frame Count
- Water Depth
- Penetration
- Observations on weather conditions, environmental conditions, or other pertinent observations
- Sampling Crew

Three replicate images will be taken at each SPI station. At regular intervals during each survey day, the camera will be brought to the surface and the frame counter checked to make sure that the desired number of replicates has been taken. If images have been missed or the penetration depth is insufficient, then proper adjustments will be made (e.g., weight is added to the frame) and additional replicates are taken.

The target production rate during the survey is 50 stations per 24-hr day, with three replicates per station. The rate of data acquisition will be affected by several variables including but not limited to: winch speed, efficiency of vessel positioning, weather conditions, water depth and transit times.

3.2 Navigation and Hazard Avoidance

Methods for accurate positioning will be used during the collection of all cruise data. The survey team will employ a modular computer software and hardware package based on Coastal Oceanographics' Hypack software that will interface various data collection sensors with a differential Global Positioning System (DGPS) receiver. A DGPS receiver will be used to navigate the survey vessel along sample transects. The DGPS and vessel fathometer will be connected to an on-board computer equipped with Hypack Max (Version 9.9.1.0.0) navigation and data acquisition software (Coastal Oceanographics, Inc., 2009). An ultra short baseline (USBL) Sonardyne transponder will be attached to the SPI camera frame to record its position relative to the vessel position recorded with DGPS. While in the field, the actual on-bottom positions of all collected images will be recorded and stored by the navigational software program.

The latitude and longitude of seafloor obstacles and hazards identified in post-spill AUV and ROV surveys conducted by BP have been mapped using GIS software and will be provided in advance to the navigation team on the sampling vessel. Maps and locations of known hazards are provided in Appendix D. Hazards are not shown to scale (vertically or horizontally), and hazards may exist that have not been mapped. Additional data on the location of potential hazards locations will be obtained from the BP "Abandonment AUV" survey that is currently underway. All efforts will be made to identify and avoid potential bottom hazards. If there remain areas where significant uncertainty regarding bottom hazards could result in safety concerns to either the equipment or the crew, then those areas will be excluded from the survey area and will be clearly identified on maps.

3.3 Water Column Profiling and Sampling

During this sediment reconnaissance survey, the chemical and physical conditions of the overlying water column along SPI transects will be documented using full-depth oceanographic profiling instruments to provide synoptic measurements of water column and near-bed characteristics at the time of the SPI survey. Cast locations will be spaced so as to not hinder the principal objectives of the SPI survey. A water sampling rosette will be on board the vessel to enable opportunistic water sampling at the discretion of the scientific party if fluorescence peaks or DO sags are observed in the water column.

A second A-frame and winch will be required to deploy the profiling instruments (CTD, dissolved oxygen sensor, CDOM fluorometer and Aquatracka fluorometer). Time permitting (collection of SPI images from all target locations will take priority), casts will be conducted at the start, middle, and end of each SPI radial transect.

If CTD/DO and *in situ* fluorescence profiles reveal a fluorescence peak or DO sag in the water column, then water column samples for chemistry analyses may be collected at the discretion of the scientific party. If either a distinct depth-zone fluorescence peak is observed and/or a distinct decrease in DO is observed (relative to background), then water samples may be collected as follows:

- above the indicator depth zone (fluorescence peak and/or DO minimum);
- at the maximum deflection or mid-point of the indicator depth zone (peak or minimum);
- at other locations within the indicator depth zone (e.g. if the indicator is particularly thick or if there is more than one peak);
- below the indicator depth zone;
- near-bottom at this location.

Samples collected above and below the indicator shall be collected immediately adjacent to the observed indicator (fluorescence peak or DO minimum) but at a vertical location that is clearly outside the feature (i.e. on the background or ambient trend line of the parameter outside the influence of the perturbation). The actual depths of sample collection are at the discretion of the scientific leads on each vessel based on the real-time assessment of the CTD/DO/CDOM/ Aquatracka profiles and in accordance with the above criteria. Near-bed water samples will be collected as close to the seafloor as operationally safe, facilitated by an altimeter mounted to the instrument platform.

If water samples are collected, operating procedures for water sampling and handling established during previous NRDA water sampling studies (see list of attached appendices) will be followed, and care will be taken to preserve sample integrity for hydrocarbon analyses. Field duplicates will be collected for 10% of samples. Equipment blanks will be collected once per day (or after sampling in a particularly strong indicator layer) from different pieces of equipment. Trip blanks and temperature blanks will be included in samples for at-sea transfer and shipping.

For each sample, sufficient volumes will be collected to satisfy all analytical procedures in accordance with the NOAA MC252 Analytical QAP V2.2: Table 1.1a (extended PAH); Table 1.1b (alkane/isoprenoid and TEH); Table 1.1c (volatile aromatic hydrocarbons); Table 1.1e and f (quantitative and qualitative petroleum biomarkers); and dispersant concentrations (by LC/MS/MS). Biomarker analyses will be conducted only if there are detectable hydrocarbons.

Water sampling volumes, jar requirements and handling procedures for each of the primary analytes are summarized in Table 5. Whole water samples for PAH and TPH analyses will be placed in 1-L I-Chem Certified Clean amber glass jars. Whole water samples for total suspended solids (TSS) and organic carbon, hydrogen, and nitrogen (CHN) analyses will be placed in 1-L non-acidified amber glass jars, clearly labeled for this dual intent. The CHN analysis will be conducted after the non-destructive TSS analysis using an elemental analyzer (micro-Dumas method). Water samples for volatile aromatic hydrocarbons (Standard List of VOCs given in AQAP v2.2 Table 1.1c) will be collected in duplicate (in 40 mL pre-acidified and unacidified VOA vials with septa). VOA samples may or may not be analyzed, pending agreement among the parties on the need for continued volatile analyses.

All water samples will be sent to Columbia Analytical Services Laboratory, in Kelso, WA. Sample extracts for hydrocarbon analysis will be split into two sub-samples, one of which will be transferred to Alpha Analytical for archive. If warranted, these extracts will be used for analysis of biomarkers indicated in Table 1.1e and 1.1f of the NOAA MC252 Analytical QAP V2.2 only.

4.0 Image Processing and Analysis Methods

The SPI/PV images will be analyzed based on a suite of standardized, quantified measures (Table 1). These quantified measures can be correlated with sediment chemistry (e.g. hydrocarbon, barium and sulfide concentrations), grain size and infaunal community measures where co-located sediment samples are collected. Following completion of the field operations, the raw NEF image files are converted to high-resolution Joint Photographic Experts Group (jpeg) format files using the minimal amount of image file compression. Once converted to jpeg format, the intensity histogram (RGB channel) for each image is adjusted in Adobe Photoshop® to maximize contrast without distortion. The jpeg images are then imported to Sigmascan Pro® (Aspire Software International) for image calibration and analysis. Calibration information is determined by measuring 1-cm gradations from the Kodak® Color Separation Guide. This calibration information is applied to all SPI images analyzed. Linear and area measurements are recorded as number of pixels and converted to scientific units using the calibration information. All raw and converted images are saved as part of the survey data set and will be archived digitally.

4.1 Analysis of Sediment Profile Images

A detailed description of image analysis methods is included in Appendix A. Table 1 lists the key features to be measured and brief summary of the interpretive rationale. A summary of the image analysis process and a brief discussion of the key parameters to be quantified in this survey are provided below.

Thorough measurements of all physical parameters and some biological parameters are measured directly from the digital image files using a computer-image analysis system. The full color image analysis system can discriminate up to 16.7 million different shades of color, so subtle features can be accurately digitized and measured. The customized software allows the measurement and storage of data on 21 different variables for each SPI image obtained.

All measured parameters undergo an independent quality assurance/quality control review by Germano & Associates' senior scientist (Dr. J. Germano) before final mapping and data interpretation is performed.

Appendix A and Table 1 describe a number of parameters that will be measured in each SPI image, however, it is anticipated that the mapped distribution of the following three key SPI measured parameters will provide the most significant value to an understanding of the benthic impacts associated with the Deepwater Horizon Incident.

Depositional Layers: First, the very detailed mapped horizontal and vertical distribution of drilling mud, oiled sediment, and/or atypical surface floccular layers based on hundreds of sampled locations will complement all other benthic sampling effort by defining the areal extent of variously impacted areas or strata. Because of the camera's unique profile design and its ability to cover broad seafloor areas, SPI has proven invaluable in detecting depositional layers ranging from 20 cm (the height of the SPI optical window) to 1 mm in thickness. During image analysis, the thickness of surficial and any shallow subsurface deposited layers is directly determined by measuring the vertical extent of the observed feature. Deposited material or layers are evident whenever they contrast in optical reflectance and/or color relative to the ambient bottom laterally or vertical (i.e., the underlying pre-disposal surface).

Apparent Redox Potential Discontinuity (RPD) Depth: Aerobic near-surface fine-grained marine sediments typically have higher reflectance values relative to underlying hypoxic or anoxic sediments. This difference in optical reflectance is readily apparent in SPI images; the oxidized surface sediment contains particles coated with ferric hydroxide (an olive color when associated with particles), while reduced and muddy sediments below this oxygenated layer are darker, generally grey to black. The boundary between the colored ferric hydroxide surface sediment and underlying grey to black sediment is called the apparent redox potential discontinuity (abbreviated as the RPD).

The depth of the apparent RPD in the sediment column is an important time-integrator of dissolved oxygen conditions within sediment pore waters. In the absence of bioturbating organisms, this high reflectance layer (in muds) will typically reach a thickness of 2 mm (Rhoads, 1974). This depth is related to the supply rate of molecular oxygen by diffusion into the bottom and the consumption of that oxygen by the sediment and associated microflora. In sediments that have very high sediment-oxygen demand, the sediment may lack a high reflectance layer even when the overlying water column is aerobic. The relationship between the thickness of this high reflectance layer and the presence or absence of free molecular oxygen in the associated pore waters must be considered with caution. The actual RPD is the boundary or horizon that separates the positive Eh region of the sediment column from the underlying negative Eh region. The exact location of this Eh = 0 boundary can be determined accurately only with microelectrodes; hence, the relationship between the change in optical reflectance, as imaged with the SPI camera, and the actual RPD can be determined only by making the appropriate *in situ* Eh measurements. For this reason, the optical reflectance boundary, as imaged, will be described in this study as the “apparent” RPD and will be mapped as a mean value. In general, the depth of the actual Eh = 0 horizon will be either equal to or slightly shallower than the depth of the optical reflectance boundary (Rosenberg et al., 2001). This is because bioturbating organisms can mix ferric hydroxide-coated particles downward into the bottom below the Eh = 0 horizon. As a result, the apparent mean RPD depth can be used as an estimate of the depth of pore water exchange, usually through pore water irrigation (bioturbation).

In the presence of bioturbating macrofauna, the thickness of the high reflectance layer may be several centimeters. As a result, the apparent mean RPD depth can be used as an estimate of the depth of pore water exchange, usually through pore water irrigation (bioturbation). The depression of the apparent RPD within the sediment is relatively slow in organic-rich muds (on the order of 200 to 300 micrometers per day); therefore this parameter has a long time constant (Germano and Rhoads, 1984). The rebound in the apparent RPD is also slow (Germano, 1983). Measurable gradients in the apparent RPD depth using the SPI optical technique over time or space can be used to effectively to document changes (or gradients) which develop as a function of changes in the benthic community structure and function. For example in nearshore marine settings, seasonal variations in biogenic sediment reworking and the apparent RPD depths due to water temperature effects on bioturbation rates, seasonal hypoxia, sediment oxygen demand, and infaunal recruitment are observed in SPI surveys. In sediment-profile surveys of ocean disposal sites sampled seasonally or on an annual basis throughout the New England region performed under the DAMOS program for the U.S. Army Corps of Engineers, New England Division, SPI results have repeatedly documented a drastic reduction in apparent RPD depths at disposal sites immediately after dredged material disposal, followed by a progressive post-disposal apparent RPD deepening (barring further physical disturbance). Consequently, spatial gradients (or time series) in RPD measurements can be a critical diagnostic element in determining the relative impact on biogenic sediment reworking in an area by the ambient benthos and so reflect the relative impact of a disturbance in an area if all other major factors (e.g., water depth, grain-size) are comparable.

Infaunal Successional Stage: The mapping of successional stages is possible with SPI technology and is based on the theory that organism-sediment interactions follow a predictable sequence after a major seafloor perturbation. This theory states that primary succession results in "the predictable appearance of macrobenthic invertebrates belonging to specific functional types following a benthic disturbance." (Rhoads and Germano 1986). This continuum of change in animal communities after a disturbance (primary succession) has been divided arbitrarily into three stages: Stage I is the initial community of tiny, densely-populated polychaetes assemblages, Stage II is the start of the transition to head-down deposit feeders, and Stage III is the mature, equilibrium community of deep-dwelling, head-down deposit feeders. Infaunal successional stages are recognized in SPI images by the presence of dense assemblages of near-surface polychaetes and/or the presence of subsurface feeding voids; both types of assemblages may be present in the same image. However, this infaunal successional model was developed from data for soft-bottom, shallow water (coastal and shelf) ecosystems. While SPI has been used for deep-sea investigations in the past (Diaz et al. 1994; Diaz 2004), the application of the standard Pearson-Rosenberg/McCall-Rhoads successional model to results from SPI investigations in sandy shelf sediments or deep sea environments is questionable; the most that can be done with any degree of confidence is to document the type of animal-sediment structures present and measure apparent biological mixing depth. While there is the possibility of doing field colonization experiments (à la McCall 1977) in shallow sandy sediments with the frequency necessary to document the successional sequence, there is little chance of this ever happening in a deep sea environment given the cost of performing such a study.

The mapped distribution of oiled sediment, drilling mud, surface floc layers, in conjunction with the measured gradients in RPD depths and biological mixing depths should allow areas of varying degrees of benthic community impact to be delineated throughout the broad area to be surveyed as part of this sampling plan. This SPI information will serve as a backdrop to and should inform the interpretation of the less dense physical, chemical, and biological sediment data to be collected in the vicinity of the MC 252 wellhead as part of the other sediment studies already conducted or planned with an acknowledgment of the timing and duration of the release relative to all studies, the ephemeral nature of these processes, and limitations on the positional accuracy of the various data types.

5.0 Data Handling/Data Sharing Process

5.1 Digital and Shipboard Data

All data and imagery (including navigation, SPI/PV raw data files, instrument data, field logs and documentation), acoustic, and other electronic data will be saved to an on-board computer, and all data shall be migrated to a dedicated external hard drive. The data will be controlled and managed under project protocols, including Chain-of-Custody tracking of the external hard-drive. Upon return to port, the Data Manager shall produce identical copies of the raw and processed electronic media generated during the cruise and deliver one of those copies each to NOAA (or its contractor), Louisiana Oil Spill Coordinator's Office (LOSCO) on behalf of the State of Louisiana, and to Cardno ENTRIX.

5.2 Laboratory Data

Each laboratory shall 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 BP (or Cardno 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 BP (or Cardno ENTRIX on behalf of BP). Thereafter, the DMT will validate and perform quality assurance/quality control (QA/QC) procedures on the LADP consistent with the authorized Analytical Quality Assurance Plan, after which time the validated/QA/QC'd data shall be made available simultaneously to all trustees and BP (or Cardno ENTRIX on behalf of BP). Any questions raised on the validated/QA/QC results shall be handled per the procedures in the Analytical Quality Assurance 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. In order to assure reliability of the consensus data and full review by the parties, no party shall publish consensus data until 7 days after such data has been made available to the parties. The LADP shall not be released by the DMT, LOSCO, BP or Cardno 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 to BP (or Cardno ENTRIX on behalf of BP).

All materials associated with the collection or analysis of samples under these protocols or pursuant to any approved work plan, except those consumed as a consequence of the applicable sampling or analytical process, must be retained unless and until approval is given for their disposal in accordance with the retention requirements set forth in paragraph 14 of Pretrial Order # 1 (issued August 10, 2010) and any other applicable Court Orders governing tangible items that are or may be issued in MDL No. 2179 IN RE: Oil Spill by the Oil Rig "DEEPWATER HORIZON" (E.D. LA 2010). Such approval to dispose must be given in writing and by a person authorized to direct such action on behalf of the state or federal agency whose employees or contractors are in possession or control of such materials. This plan will be implemented consistent with existing trustee regulations and policies. All applicable state and federal permits must be obtained prior to conducting work.

5.3 Reporting

Preliminary results of the SPI survey, including SPI/PV images and field observations, will be provided within a week of cruise completion so as to provide insight to the *Deepwater Sediment Sampling Study*. The preliminary report will consist of brief narrative and a base map (or series of base maps) of the stations sampled with annotations that indicate the preliminary distribution (based on visual assessment of the images during and immediately following the cruise) of imaged features presumed to represent potentially oiled-sediment layers, drilling muds, atypical floccular deposits or other near-surface sediment features/that are inconsistent with “ambient” benthic conditions in the surveyed area.

A full interpretative SPI/PV image analysis report, based on the quantitative image analysis process described in Appendix A, will be drafted within 150 days of cruise completion.

6.0 Logistics

6.1 Cruise Schedule

The SPI survey is tentatively proposed for April 6-22, 2011. The survey will require 2 days of mobilization, 16 days of surveying, and 1 day of demobilization.

Logistics and schedule are based on use of the M/V *Sarah Bordelon*. Exact schedules will be determined following review by Trustees, staff availability, and assignment of a vessel by the Vessel Coordination Committee.

6.2 Personnel

8 CSA Personnel (2 operations leads, 2 winch operators, 4 deck hands); included in vessel costs
1 Cardno ENTRIX/Integral senior scientist
1 Cardno ENTRIX project scientist
1 Cardno ENTRIX data manager / field technician
4 SPI Scientists
Cardno ENTRIX onshore sample management team (1 coordinator, 3 technicians)
Trustee scientists/representatives

6.3 Vessels

The M/V Sarah *Bordelon* is a vessel in the NRDA fleet that is available and is equipped to conduct the proposed sampling. Costs herein are based on use of that vessel. The M/V *Emily Bordelon* will provide at-sea transfer of samples and supplies. Actual vessel assignments and associated costs and schedules may be revised following review by Trustees and the Vessel Coordination Committee.

6.4 At-Sea Transfer of Samples

Multiple at-sea transfers of supplies and samples will be necessary to maintain the integrity of the samples and to meet laboratory hold times. Assuming samples have a maximum hold time of seven (7) days from the time of collection, at-sea transfers will be scheduled to occur after two days of sampling. A Chain of Custody (COC) will be maintained by ensuring that both a NOAA representative and a Cardno ENTRIX representative are present on all transfers. Protocols for at-sea transfers and COC procedures are attached as NOAA and Cardno ENTRIX appendices to this cruise plan ("Transfer of Material at Sea"). At-sea transfers will be performed by the M/V *Emily Bordelon* (140') (or similar vessel) operated by Bordelon Marine, Houma, LA. Samples under COC will be unloaded at the Houma yard for sample processing and shipment to CAS laboratory, Kelso, Washington (Table 5).

<u>Sampling deployment gear:</u>
To sample at full depths (to 2500 m) to be provided and mobilized by CSA:
Seabird CTD with dissolved oxygen sensor and CDOM fluorometer
Chelsea Labs AquaTracka *in situ* fluorometer
ECO-FL *in situ* fluorometer
Sediment-Profile Camera/Plan View Camera System with pinger and USBL to be provided and mobilized by Germano and Associates
Go-Flo bottle samplers
Water sampling rosette

<u>Sample Containers (per collection depth):</u>
1-L wide-mouth amber glass jars for unfiltered PAH analysis and unfiltered TSS/CHN analysis
1-L polycarbonate (or plastic Nalgene) wide-mouth bottles for dispersant analysis
2-40 ml pre-acidified vials with septa for VOC analysis
4-15 ml centrifuge tubes for dispersant analysis
Coolers

7.0 Safety Plans

BP's full operations and safety plans are attached as appendices. A HASP binder containing all health and safety protocols is provided to each vessel.

8.0 Costs

Costs are based on use of the M/V *Sarah Bordelon* pending availability through the Vessel Coordination Committee. Costs are representative of vessels in the NRDA Fleet. Mobilization and demobilization of the M/V *Sarah Bordelon* (or similar vessel) will be conducted by CSA at the Bordelon Yard in Houma, LA. CSA will also provide acoustic instrumentation (USBL and Odom 12 kHz fathometer), appropriate winches, wires, A-frames, water sampling rosette, and full-depth oceanographic profiling instruments (CTD, dissolved oxygen sensor, CDOM fluorometer, and Aquatracka fluorometer). Vessel costs are inclusive of CSA personnel. Cardno ENTRIX will provide scientists and data managers for both surveys, including scientists from Integral Consulting (Cardno ENTRIX costs provided separately). Costs of CSA mobilization, participation in the surveys, interpretation, and reporting are included below. SPI/PV implementation and associated oceanographic profiling will occur on a 24-hour basis for 16 days.

The Parties acknowledge that this budget is an estimate, and that actual costs may prove to be higher. BP's commitment to fund the costs of this work includes any additional reasonable costs within the approved scope of this work plan that may arise. The trustees will make a good faith effort to notify BP in advance of any such increased costs.

Budget Charts

Vessel Costs: SPI Survey (SPI)	**Cost**
Mobilization Costs	$ 105,000
Vessel Costs	$ 808,227
CSA Fleet Mgmt / Shore Support	$ 131,250
SPI Costs	$ 371,000
Subtotal	**$ 1,415,477**

Vessel Costs: Stand-by*	**Cost**
69 days	$ 849,331

Total Estimated Costs (SPI, Stand-by)	**$ 2,264,808**

Costs are based on use of M/V *Sarah Bordelon*. Costs are typical of NRDA Fleet. Costs include Fuel and Lube. Operational Days for SPI are based on Mob (2 days), Survey (16 days) and Demob (1 day), for a total of 19 days (2011 1st Quarter Schedule). *Stand-by charges for the M/V *Wes Bordelon* of 69 days represent days between Jan. 1 and Mar. 11. Costs may be adjusted pending potential changes to the cruise schedule.

9.0 References

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Rowe, G.T., and M.C. Kennicutt III. 2009. Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study. Final Report. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-039. 417 pp.

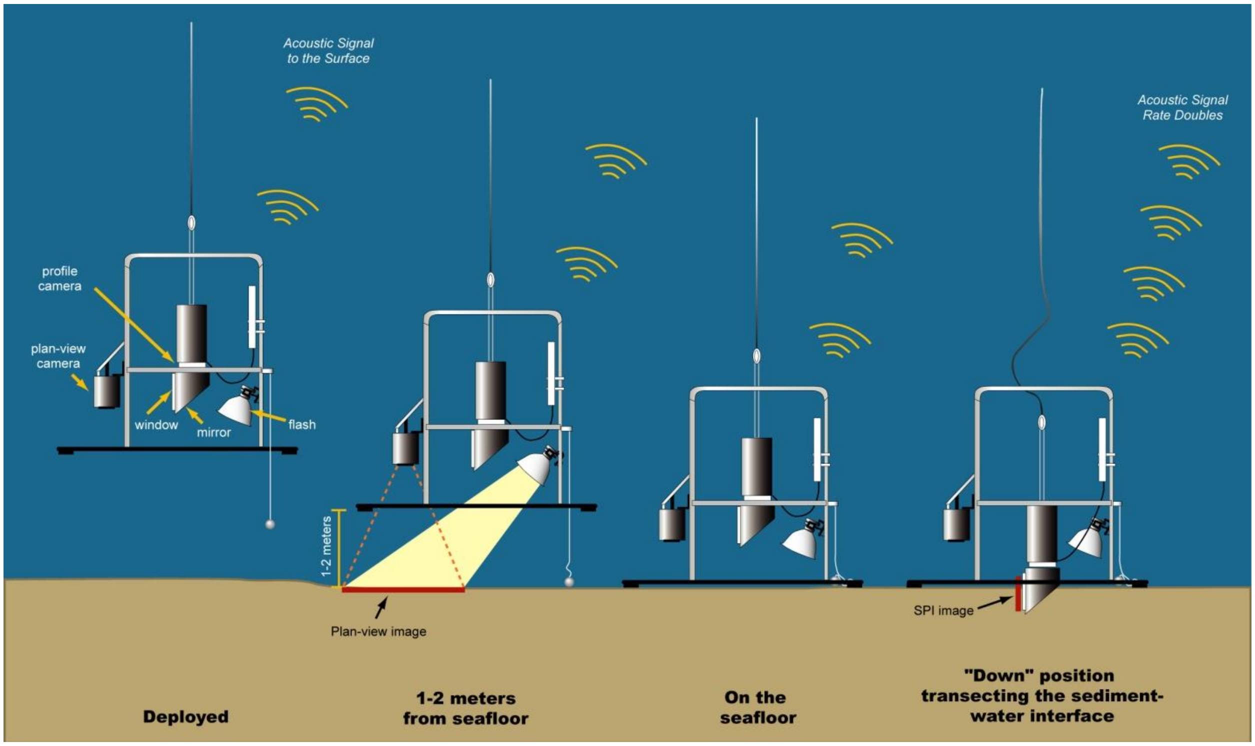

Figure 1. Schematic showing the operation of the SPI camera system with associated digital plan-view camera and acoustic pinger that signals when images are successfully acquired.

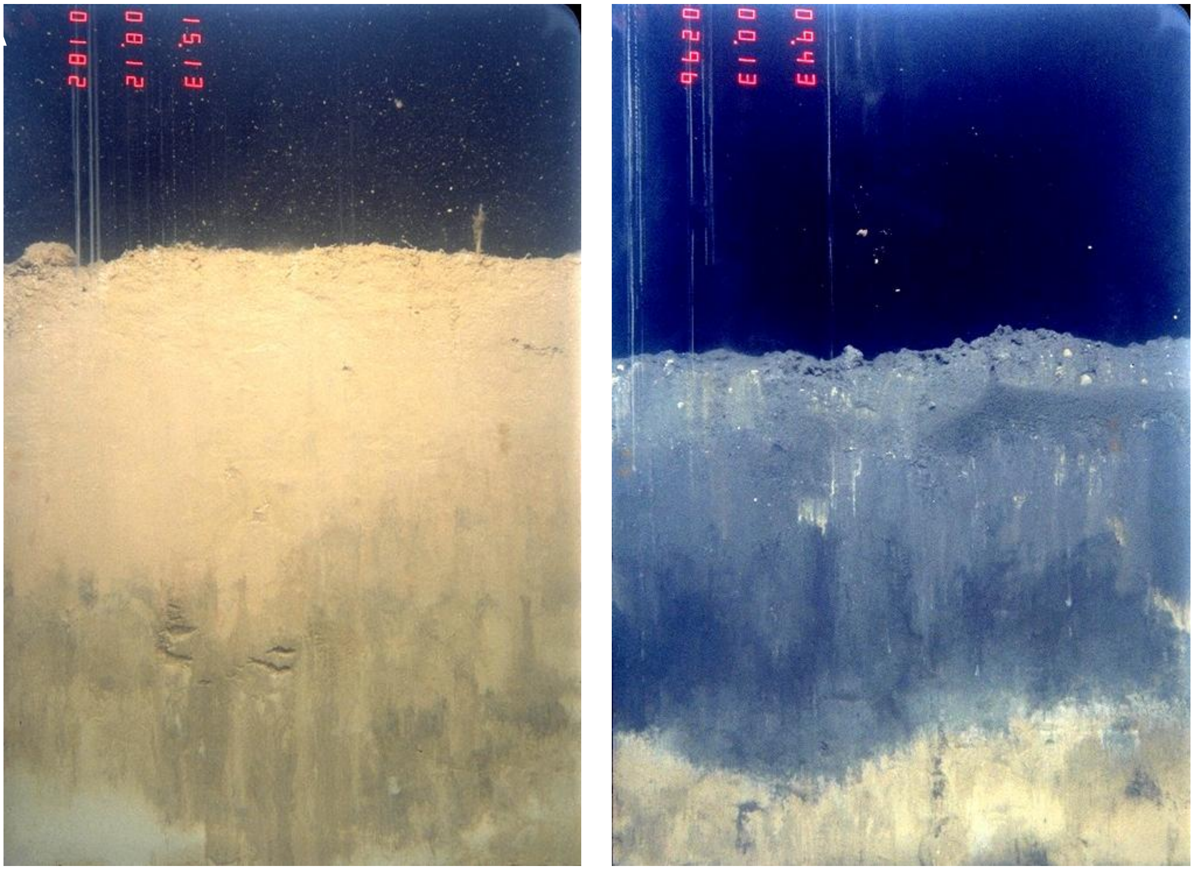

Figure 2. Sediment profile images collected during the 2000-2002 Drilling Effects Study (CSA 2006). A) Shows an undisturbed reference site with a relatively deep, biogenically-mixed surface layer and the presence infaunal feeding voids at a depth of approximately 12 cm. B) Shows a station near a well site at which the seafloor is overlain by dark sediments presumed to be drilling muds, extending from the sediment-water interface to the about 12 cm depth. Image width is 15 cm.

Figure 3. Map of locations to be sampled along 8 radial transects using the SPI/PV camera system within a 10 km radius of the wellhead. Rings are labeled with the distance from the MC252 well site at which SPI data will be collected (Table 2). Sampling beyond the 10 km ring may occur if observations of potential impact are made. Latitude and longitude positions for sampling locations shown with green circles below are listed in Appendix B.

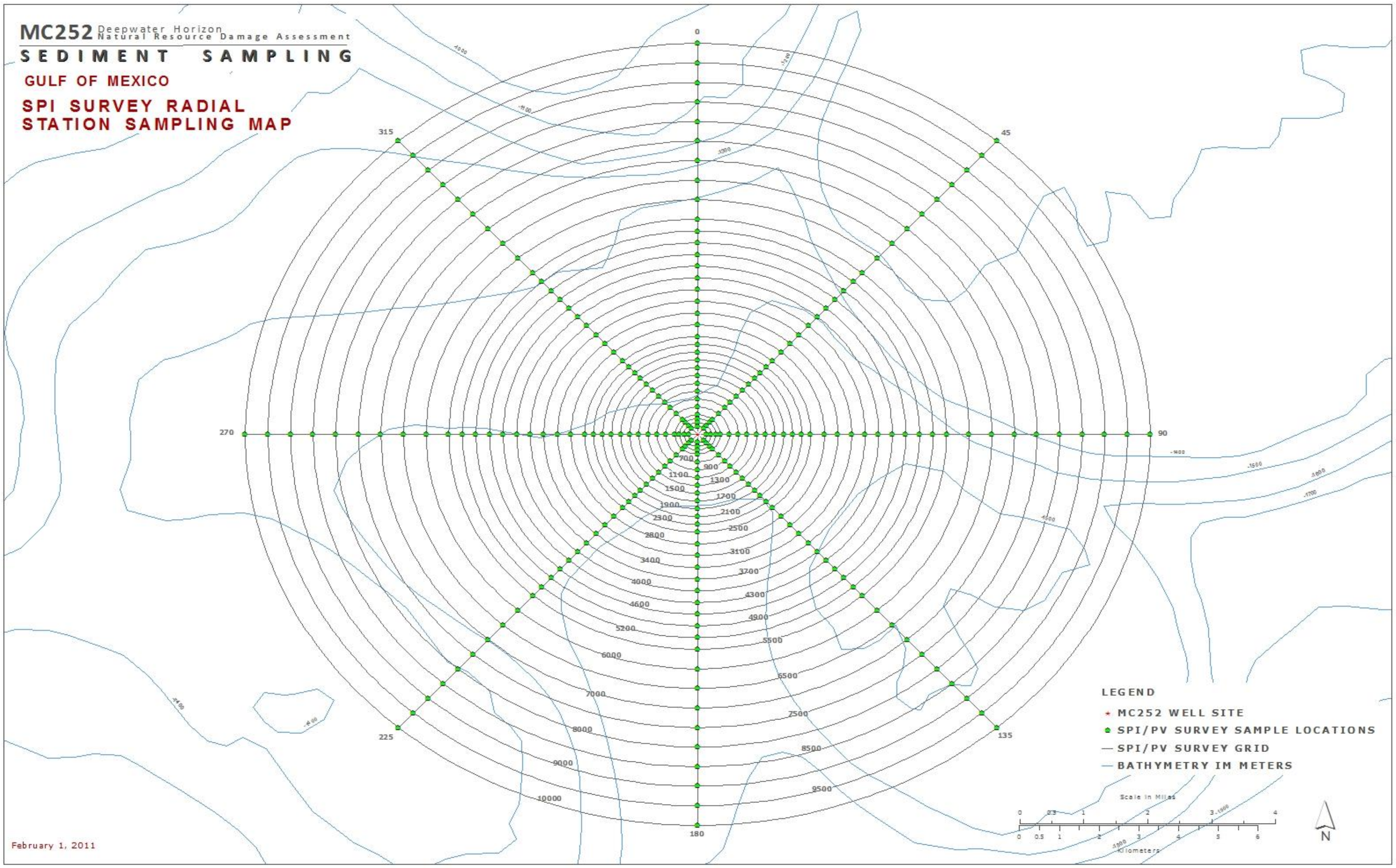

Figure 4. Map of additional SPI sampling locations outside of the radial grid. Details are provided in text and tables.

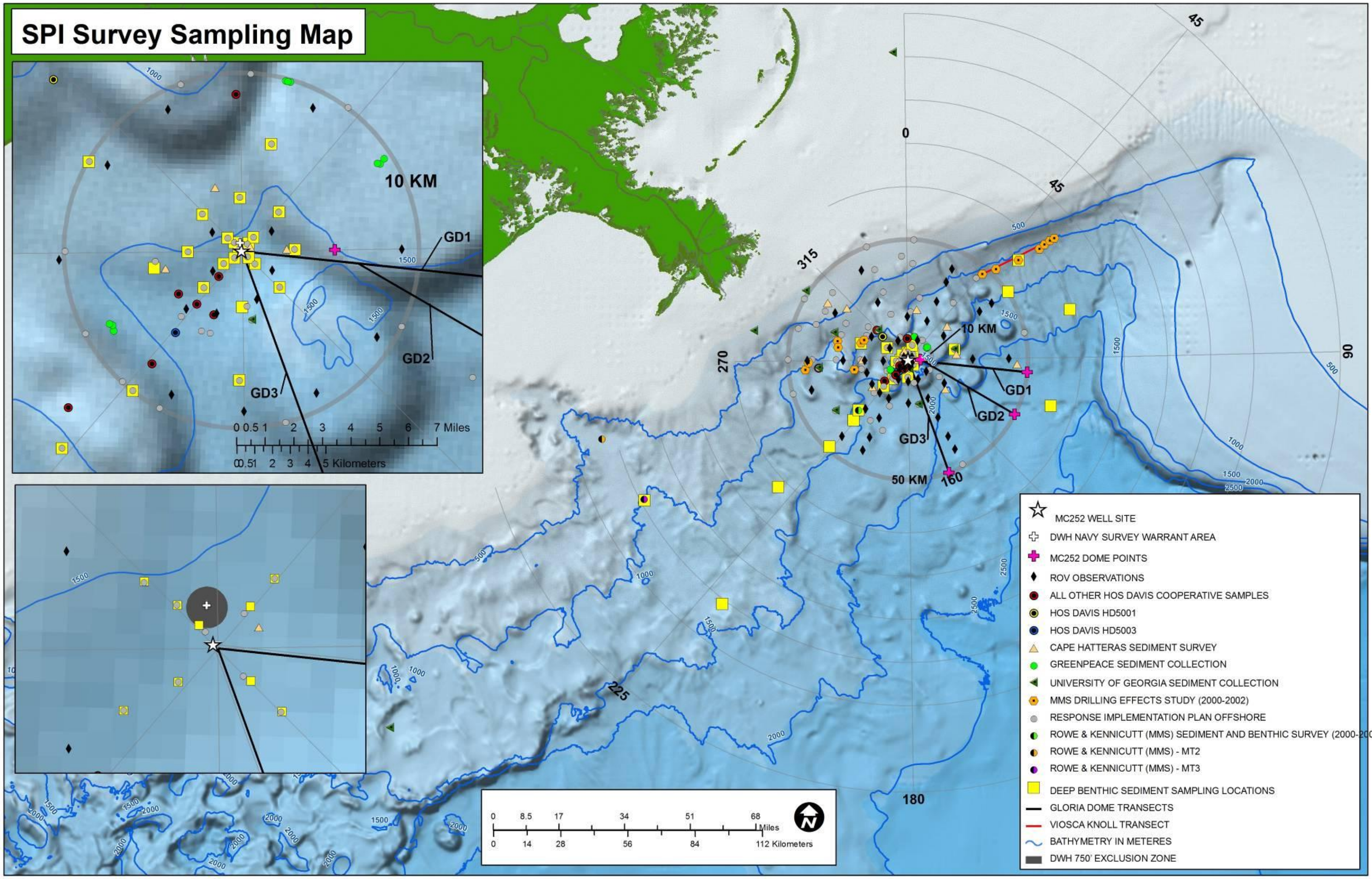

Table 1. Sediment parameters measured using the SPI/PV system.

Sediment Profile Imaging (SPI) Camera	
Depositional layers, drilling muds, oiled-sediment layers	These depositional layers are often distinct due to textural or color differences with underlying/ambient bottom sediments. The thickness any optically-distinct strata or layers will be measured.
Grain size major mode and range (phi units, resolution limit of 62 microns)	Visually estimated by overlaying a grain-size comparator.
Prism penetration depth (cm)	Distance from mudline to bottom of prism. Comparative measurements can be indicative of relative sediment water content and consolidation.
Mud Clasts	The abundance, oxidation state, and shape of mud clasts can be used to make inferences about recent patterns of seafloor disturbance .
Average boundary roughness (cm)	Vertical distance between highest and lowest point at the sediment-water interface may reflect biogenic and/or physical disturbance factors
Apparent Redox Potential Discontinuity (aRPD) depth (cm)	Thickness of high-reflectance, near-surface sediments is a measure of oxygen penetration into the sediment. The depth of the apparent Redox Potential Discontinuity (aRPD) layer between oxidized (sub-oxic) and reduced chemical conditions in the sediment column is an important time-integrator of dissolved oxygen conditions within sediment pore waters and can be indication of the intensity of biogenic sediment reworking of surface sediments.
Sedimentary Methane	If present, the number and size of gas bubbles in the sediment column are measured; their presence suggests high levels of organic loading, pore-water sulfate depletion, and/or methanogenesis.
Infaunal Successional Stage	Based on the benthic successional paradigm described in Rhoads and Germano (1982), the degree of infaunalization (type of benthic infaunal assemblages present and extent of sediment reworking) is indicative of disturbance history of an area.
Sediment Plane View (PV) Camera	
Mega and Epifaunal Species	Fish, Crabs, Holothuroidae
Lebensspuren	A measure of tracks, trails, burrows, and mounds.

Table 2. Radial transect sampling design for SPI/PV survey. Columns are bearing in degrees from MC252 well site; rows are distance in meters. Gloria Dome transects 1 and 3 (GD1, GD3) are on the radial grid, originating at the wellhead. GD2 begins 5 km from the wellhead on the 90° transect and is oriented southeastward between Mitchell and Gloria Domes. Latitude and longitude sampling locations along transects (including start and end points for GD transects) are provided in Appendix B.

0°	45°	90°	GD1 (96°)	135°	GD3 (160°)	180°	225°	270°	315°
200	200	200	200	200	200	200	200	200	200
300	300	300	300	300	300	300	300	300	300
400	400	400	400	400	400	400	400	400	400
500	500	500	500	500	500	500	500	500	500
700	700	700	700	700	700	700	700	700	700
900	900	900	900	900	900	900	900	900	900
1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
2300	2300	2300	2300	2300	2300	2300	2300	2300	2300
2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
3400	3400	3400	3400	3400	3400	3400	3400	3400	3400
3700	3700	3700	3700	3700	3700	3700	3700	3700	3700
4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
4300	4300	4300	4300	4300	4300	4300	4300	4300	4300
4600	4600	4600	4600	4600	4600	4600	4600	4600	4600
4900	4900	4900	4900	4900	4900	4900	4900	4900	4900
5200	5200	5200	5200	5200	5200	5200	5200	5200	5200
5500	5500	5500	5500	5500	5500	5500	5500	5500	5500
6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
6500	6500	6500	6500	6500	6500	6500	6500	6500	6500
7000	7000	7000	7000	7000	7000	7000	7000	7000	7000
7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
8500	8500	8500	8500	8500	8500	8500	8500	8500	8500
9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
9500	9500	9500	9500	9500	9500	9500	9500	9500	9500
10000	10000	10000	10000	10000	10000	10000	10000	10000	10000

Table 3. Existing sample (pre-spill, post-spill, and planned) at which SPI data will be collected during this study. Locations are shown in Figure 4. Preliminary results (*, **) have not been confirmed by quantitative fingerprinting data at this time. Studies are listed by number at the bottom of the table (next page).

Study	Site	Latitude	Longitude	Depth
1	ALTNF001	[redacted]	[redacted]	1543
	D031S	[redacted]	[redacted]	1508
	D038SW	[redacted]	[redacted]	1509
	D040S	[redacted]	[redacted]	1517
	D042S	[redacted]	[redacted]	1502
	D044S	[redacted]	[redacted]	1493
	NF006MOD	[redacted]	[redacted]	1517
	ALTNF015	[redacted]	[redacted]	1607
	D034S	[redacted]	[redacted]	1544
	LBNL1	[redacted]	[redacted]	1578
	NF008	[redacted]	[redacted]	1585
	NF013	[redacted]	[redacted]	1567
	NF014	[redacted]	[redacted]	1579
	NF009	[redacted]	[redacted]	1489
	NF010	[redacted]	[redacted]	1439
	NF011	[redacted]	[redacted]	1449
	NF012	[redacted]	[redacted]	1520
	FF010	[redacted]	[redacted]	1356
	2.21	[redacted]	[redacted]	1367
	D019S	[redacted]	[redacted]	1656
	D024S	[redacted]	[redacted]	1697
	LBNL14	[redacted]	[redacted]	1535
	LBNL7	[redacted]	[redacted]	1577
	D050S	[redacted]	[redacted]	1432
	LBNL9	[redacted]	[redacted]	1516
	LBNL10	[redacted]	[redacted]	1402
	D043S	[redacted]	[redacted]	1492
	D062S	[redacted]	[redacted]	1303
	FFMT3	[redacted]	[redacted]	1002
	FFMT4	[redacted]	[redacted]	1405
	D002S	[redacted]	[redacted]	2389
	HiPro	[redacted]	[redacted]	1574
	S36	[redacted]	[redacted]	1826
	MC292/FF005	[redacted]	[redacted]	1003
	VK916	[redacted]	[redacted]	1125
2	15-1	[redacted]	[redacted]	1372
	15-2	[redacted]	[redacted]	1397
	15-3	[redacted]	[redacted]	1381
	17-1	[redacted]	[redacted]	1189
	17-2	[redacted]	[redacted]	1250
	17-3	[redacted]	[redacted]	1220
	18-1	[redacted]	[redacted]	1318
	18-2	[redacted]	[redacted]	1303
	18-3*	[redacted]	[redacted]	1318

[continued]

Table 3. [continued]

Study	Site	Latitude	Longitude	Depth
3**	HD5001A	[redacted]	[redacted]	1100
	HD5003	[redacted]	[redacted]	1600
4	Joye014	[redacted]	[redacted]	1200
	Joye015	[redacted]	[redacted]	20
	Joye016	[redacted]	[redacted]	1700
	Joye017	[redacted]	[redacted]	900
	Joye018	[redacted]	[redacted]	800
	Joye020	[redacted]	[redacted]	200
	Joye022	[redacted]	[redacted]	200
	Joye024	[redacted]	[redacted]	1200
	Joye025	[redacted]	[redacted]	1400
	Joye026	[redacted]	[redacted]	1600
	Joye027	[redacted]	[redacted]	1900
5	Well	[redacted]	[redacted]	1500
	GIP 4	[redacted]	[redacted]	300
	GIP 18	[redacted]	[redacted]	1500
	GIP 16	[redacted]	[redacted]	1500
	GIP 24	[redacted]	[redacted]	1400
	GIP 23	[redacted]	[redacted]	1400
	GIP 14	[redacted]	[redacted]	500
	GIP 15	[redacted]	[redacted]	1200
	GIP 17	[redacted]	[redacted]	1600
	GIP 19	[redacted]	[redacted]	2000
	GIP 20	[redacted]	[redacted]	1800
	GIP 25	[redacted]	[redacted]	1100
	GIP 21	[redacted]	[redacted]	2200
6	HIPRO	[redacted]	[redacted]	1565
	MT1	[redacted]	[redacted]	482
	MT2	[redacted]	[redacted]	677
	MT3	[redacted]	[redacted]	990

Studies:
(1) *Deepwater Sediment Sampling Study* (Benthic TWG, planned for May 2011)
(2) Greenpeace (9/25/10 - 9/26/10)
(3) HOS Davis Cruise 5 (samples verbally reported to contain MC252 oil)
(4) Univ. of Georgia, Dr. Samantha Joye (Sept. 2010)
(5) Univ. of S. Mississippi, Dr. Kevin Yeager (June 2010)
(6) Rowe & Kennicutt (MMS 2009; samples collected in 2000 - 2002)

Table 4. Selected stations previously sampled with SPI techniques (MMS Drilling Effects Study; CSA 2006) that will be sampled in this study. Locations are shown in Figure 4.

Block	Site	Depth (m)	Latitude (dec deg)	Longitude (dec deg)	Latitude (dms)	Longitude (dms)
Viosca Knoll (VK916)	NF1	1,125	[redacted]	[redacted]	[redacted]	[redacted]
	FF1	1,120	[redacted]	[redacted]	[redacted]	[redacted]
	FF2	1,110	[redacted]	[redacted]	[redacted]	[redacted]
	FF3	1,100	[redacted]	[redacted]	[redacted]	[redacted]
	FF4	1,035	[redacted]	[redacted]	[redacted]	[redacted]
	FF5	1,020	[redacted]	[redacted]	[redacted]	[redacted]
	FF6	1,015	[redacted]	[redacted]	[redacted]	[redacted]
Mississippi Canyon (MC292)	NF1	1,034	[redacted]	[redacted]	[redacted]	[redacted]
	FF1	1,120	[redacted]	[redacted]	[redacted]	[redacted]
	FF2	1,030	[redacted]	[redacted]	[redacted]	[redacted]
	FF3	1,025	[redacted]	[redacted]	[redacted]	[redacted]
	FF4	1,050	[redacted]	[redacted]	[redacted]	[redacted]
	FF5	1,025	[redacted]	[redacted]	[redacted]	[redacted]
	FF6	1,035	[redacted]	[redacted]	[redacted]	[redacted]

Table 5. Summary of water sample volumes, containers, and handling procedures required for primary analytes. Details are provided in the Water Sampling Protocol Attachments.

Analyte	Sample Volume	Sample Container	Sample Handling	Holding Time	Lab
PAH (extended) TEH, Dispersant indicators (DPnB)	2x 1 L	Amber Glass, Chem Certified Clean	4° C (refrigerate)	7 days	CAS (Kelso, WA)
PAH (extended) TEH, Dispersant indicators (DPnB) (acidified)	2x 1 L	Amber Glass, Chem Certified Clean	4° C (refrigerate)	14 days	CAS (Kelso, WA)
TSS CHN	1 L	Amber Glass, Chem Certified Clean	4° C (refrigerate)	7 days	CAS (Kelso, WA)
Dispersant (DOSS)	4 x 15 mL	Centrifuge tubes	0° C (freeze)	N/A	CAS (Kelso, WA)
VOA (non-acidified)	80 mL	2 x 40 mL non-acidified vials w/ septa	4° C (refrigerate)	14 days	CAS (Kelso, WA)
VOA	80 mL	2 x 40 mL pre-acidified (HCl) vials w/ septa	4° C (refrigerate)	14 days	CAS (Kelso, WA)

10.0 List of Appendices

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Cardno ENTRIX MC252 NRDA Water Column Electronic Photo Description
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MC252 NRDA Cruise Appendices: Sediment Profile Imaging (SPI) Survey (continued)
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ENTX_SOP_002_-_Preservation,_Handling,_Shipping,_and_Tracking
ENTX_SOP_003_-_Standard_Operating_Procedure_for_Photo_GPS
ENTX_SOP_004_-_Decontamination_Procedures
ENTX_SOP_005_-_SOP_Water_Quality_Monitoring_and_Deployment_10.29.10
ENTX_SOP_006_-_Surface_Water_Sampling
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MC252 CSA BP NRDA Transfer of Material at Sea
Contact With Questions
Jodi Harney, [redacted] (updated 03/07/11)