Deepwater Horizon Oil Spill (DWHOS)
Water Column Technical Working Group

NRDA Spring 2011 Plankton Imaging Sampling Cruise Plan

Sampling Vessel: R/V *Oceanus*

January 30, 2011
Revised: March 8, 2011

Prepared by:
Deborah French-McCay, Eileen Graham (ASA) and Cabell Davis (WHOI) on behalf of the Trustees
Reviewed by:
Dan Hahn, John Quinlan (NOAA) and Amanda Vincent (LA) on behalf of the Trustees
William Graeber, Jeffery Simms (Cardno ENTRIX), Mark Benfield (LSU) on behalf of BP

Proposed Cruise Dates
March 1 – April 18, 2011

Background/Justification
Conceptual Model – Water Column Organisms

The trustees have developed a preliminary conceptual model of the DWH release, potential pathways and routes of exposure, and potential receptors. This preliminary model has informed the trustees' decision to pursue the studies outlined in the work plan. By signing this work plan and agreeing to fund the work outlined, BP is not endorsing the model articulated in the work plan.

Release and Pathway
Oil released from the broken well head both dispersed at depth and rose through nearly a mile of water column. The composition of the released gas-liquid mixture changed over time and space as the result of dilution, changes in pressure, dissolution, and addition of other constituents such as dispersants, methanol, and anti-foaming additives. Of oil that made it to the water surface, some entrained water forming mousse, was dispersed into the water column naturally and by application of dispersants, and some was removed mechanically or by in situ burning. Floating oil, oil droplets, flocculated and dissolved components were transported large distances at various levels of the water column. Oil also picked up sediments, and other particulate material, some of which became neutrally or slightly negative buoyant, sinking to various depths. The oil dispersed at the wellhead (both via turbulence or by injection of dispersants) was transported by currents that varied in time and space, yielding a complex pathway of subsurface oil contamination that affected abyssal, bathypelagic, and meso-pelagic waters of the offshore Gulf of Mexico.

Routes of Exposure
Fish and invertebrates in the water column are exposed to contaminants by swimming through contaminated water, spending time on/in contaminated sediments, taking up contaminants through body surfaces, passing contaminated water over respiratory structures, and ingesting water, oil droplets, contaminated biota, and particulates contaminated with oil as part of feeding. Additionally, sensitive life stages of pelagic fish and invertebrates come in direct contact with floating oil that covers and is mixed

into the neuston layer (upper ~0.5m) where many embryos and larvae develop. Other neustonic organisms exposed to surface oil include many small invertebrates important to the food web. In the water column, organisms are also exposed to suspended oil droplets, which can foul appendages or other body surfaces. Water column organisms have also been exposed to dispersants dissolved in water, on oil droplets and adsorbed to suspended particulate matter. Water column organisms were also exposed to dissolved and water-borne chemical additives such as methanol and anti-foaming agents.

Plankton in the north-eastern Gulf of Mexico, which include early life history stages of fish and invertebrates, as well as smaller invertebrate holo-plankton and gelatinous zooplankton, are among those biota exposed to the released oil and spill-related chemicals. Planktonic organisms throughout the water column of deep offshore slope areas were potentially exposed, including the deeper depth strata where sub-surface oil has been observed (i.e. 1000-1300m). Figure 1 shows the approximate extent of oil observed on the water surface using radar data, which indicates some areas potentially affected by floating oil. Figure 2 shows a cumulative summary of fluorescence measurements between 1000 and 1500m, indicating a possible southwestward transport of the oil and some locations where plankton may have been exposed in deepwater (laboratory analyses to establish whether or not these measurements are linked to MC252 oil have not yet been conducted).

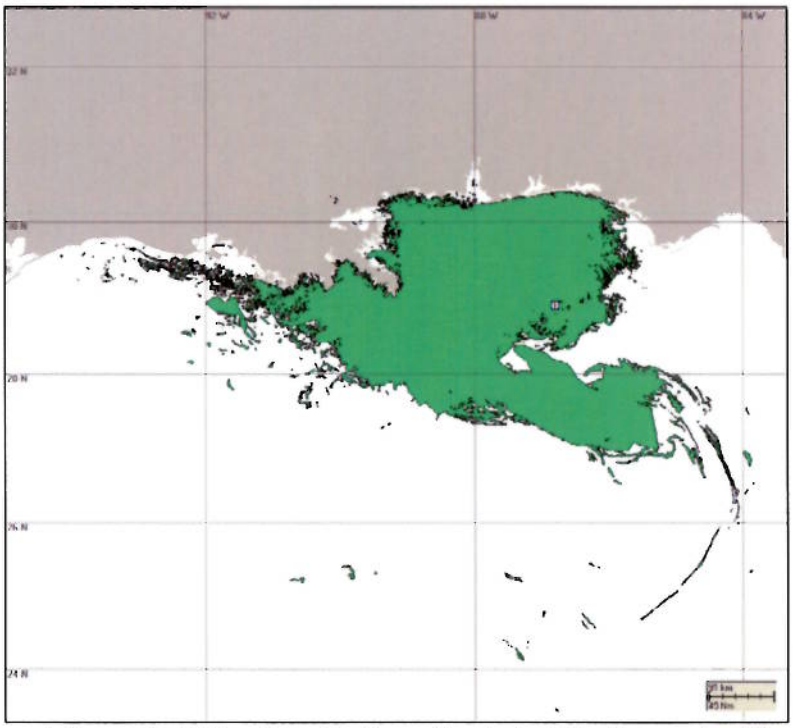

Figure 1. Cumulative potential surface floating oil extent of the Deepwater Horizon oil spill. (Figure derived from compositing April, May, June, and July 2010 radar shape files available on the NOAA ERMA website. Note that radar images with noted anomalies were not included in composite.)

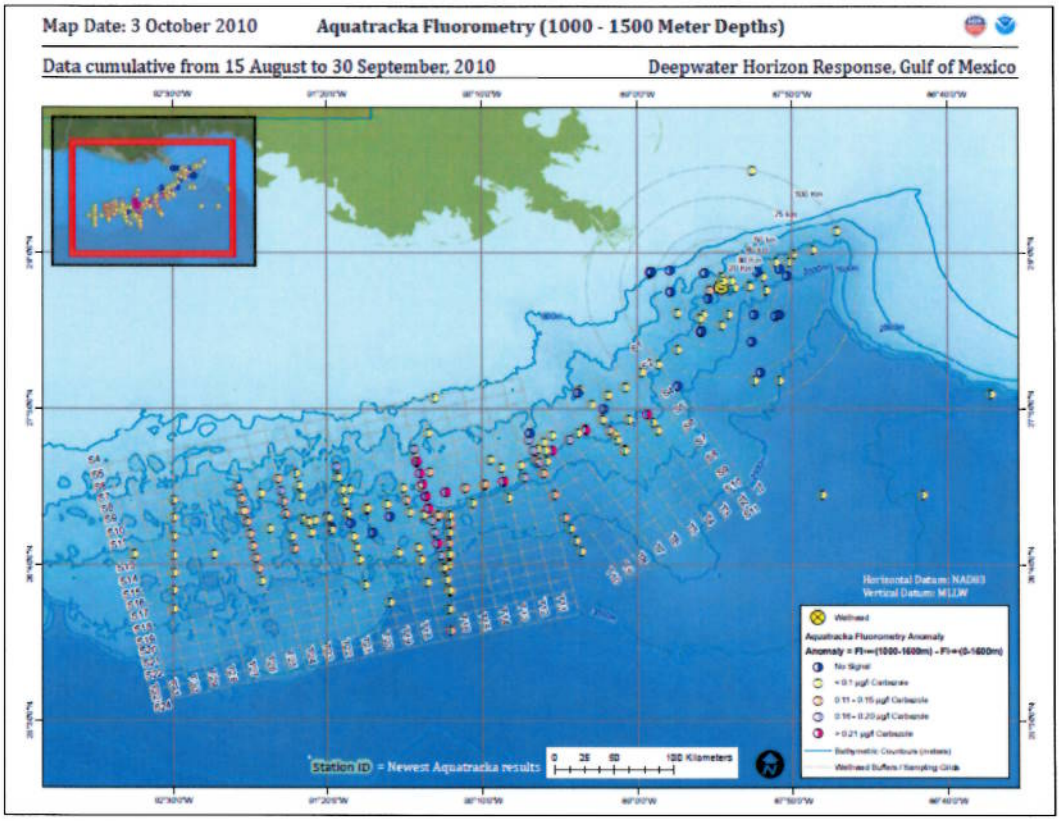

Figure 2. Cumulative summary of Aquatracka fluorescence measurements between 1000 and 1500m, 15 August to 30 September 2010.

Objectives and Approach

This plan is part of a series of cruises scheduled for the spring of 2011 intended to evaluate the distribution and densities of ichthyoplankton, other zooplankton and some phytoplankton (> ~50µm) in Gulf of Mexico waters potentially affected by the Deepwater Horizon Oil Spill (DWHOS) and in surrounding areas. The over-arching plankton plan is to conduct sampling in each season, utilizing several sampling methods (e.g. bongo net, neuston net, Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS), and imaging systems). The duration of the program, with respect to the number of seasons and years, is to be determined. Because plankton are transported over wide areas, and populations are connected across the northern Gulf of Mexico, sampling plans need to be broad in geographic scope.

Plankton in the upper 200m of the water column of the Gulf of Mexico from Texas to Florida have been sampled by the NMFS/NOAA SEAMAP program over the past 25 years (Attachment 9). The overall NRDA plankton sampling plan takes advantage of this historical data set and plans for continuation and extension of the NMFS Southeast Fisheries Science Center (SEFSC) SEAMAP program into deep water areas where the spill took place. The station spacing of the SEAMAP and NRDA sampling grids is extensive, but is sparse compared with the high-resolution sampling capabilities of new optical imaging systems and the high-resolution data needed for initializing and validating coupled biological-physical numerical models of the pelagic ecosystem. The second generation Video Plankton Recorder (VPRII) (Appendix 10) is able to rapidly survey plankton with very high horizontal and vertical spatial resolution, i.e., at the same resolution as the physical and environmental variables (CTD, fluorescence, PAR,

turbidity, dissolved oxygen). This sampling allows direct comparison of plankton and their environment over scales from centimeters to 1,000s of kilometers (Davis et al., 1992; Davis and McGillicuddy, 2006).

A series of cruises in the fall of 2010 (aboard *Walton Smith* and *HOS Davis*) used the digital autonomous video plankton recorder (DAVPR) to sample fragile and other plankton and marine snow in the deeper slope sea from the surface to near bottom. Comparative studies between plankton imaging systems and traditional net-based sampling techniques have been carried out by various investigators (i.e. Broughton and Lough, 2006) and paired MOCNESS-DAVPR sampling was conducted during January 2011 in joint ship operations aboard the *Arctic* and *Nick Skansi*. These two types of sampling systems have been found to be comparable in quantifying hardy plankton that can withstand net sampling. Fragile organisms and particles such as small gelatinous organisms (including many larvae) and marine snow are easily identified and quantified using imaging systems, whereas these delicate groups are destroyed or damaged beyond recognition in net samples.

The primary objective of the proposed Spring 2011 R/V *Oceanus* plankton imaging sampling cruise is to collect high-resolution data on plankton and marine snow together with environmental variables using the VPRII. A high-speed survey of the shelf and slope waters of the northern Gulf of Mexico will be conducted, with the transect lines running through the standard SEAMAP stations and extending beyond them into the slope and offshore areas (Figure 3). It is expected that the proposed sampling will help enable quantification of some characteristics of the plankton communities, such as occurrence, abundance, biomass, and vertical distribution of plankton and marine snow; together with ocean temperature, salinity, chlorophyll fluorescence, PAR, and turbidity in the Gulf of Mexico. This sampling will allow direct comparison of data from traditional samplers used in the SEAMAP surveys and the current NRDA MOCNESS surveys with optical imaging of the VPRII. The VPRII sampling will extend the spatial resolution of the present sampling and will allow quantification of fragile plankton and marine snow in the upper water column. It will also allow for comparison between deeper DAVPR sampling to provide a more complete assessment of the water column (i.e. the VPRII is depth limited and the DAVPR cannot sample the region as efficiently; combined the data sets may be able to provide a complete representation of plankton and marine snow in the water column). The VPRII may be towed at higher tow speeds (i.e. 10-12 knots) than the DAVPR (2-4 knots), and so it was selected to perform semi-synoptic sampling over a wide area. It is expected that the sampling data may be used to help inform estimates of plankton community characteristics including abundance, distribution and biomass input data for the injury assessment. The descriptions of the analyses for those estimates are beyond the scope of this sampling plan.

This plan, the Spring 2011 R/V *Oceanus* plankton imaging sampling plan, describes the sampling effort for March 8 – April 9, 2011. The cruise plan covers March 1 – April 18, 2011 to account for the eight day transit to/from Woods Hole Oceanographic Institute, Massachusetts.

Methodology

Sampling Transects

The VPRII will be towed along continuous transects that run roughly perpendicular to the depth contours of the continental slope and through SEAMAP gridded stations (Figure 3). Specific locations of the transects may be adjusted slightly for logistical or safety reasons

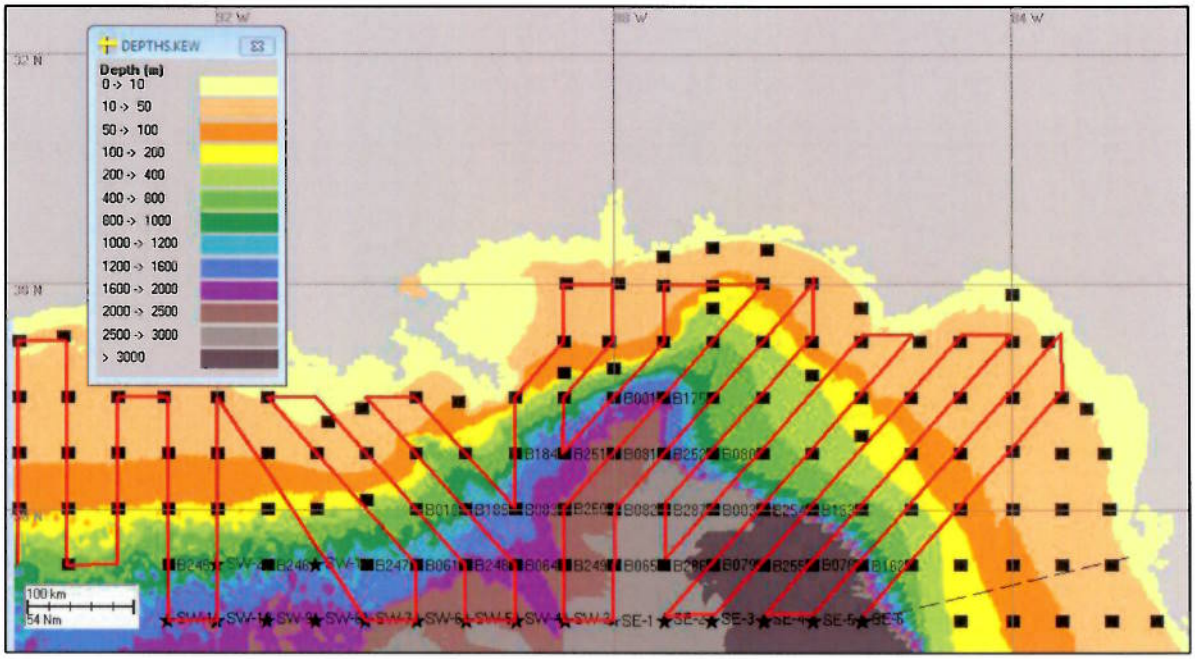

Figure 3. VPRII transect locations (lines), traditional SEAMAP sampling locations (squares), and additional gridded stations (stars). The hashed line (Tampa to start of the transects) is tentative and dependent on engineering test procedures.

Sampling Procedures

VPRII: A video plankton recorder (VPRII) will be used to survey the distribution of plankton and marine snow (Cabell Davis, WHOI). See Attachment 10 for a description of the instrument, specifications, and deployment procedure. The VPRII is towed behind the vessel and undulates through the water column in a tow-yo pattern. On this cruise the VPRII will be deployed to 150m in depth (or to as deep as safety allows) to quantify densities of plankton and particulates in the upper water column in areas potentially exposed to DWHOS contaminants, as well as in unexposed areas. The transects are designed to reduce the number of deployments and retrievals and facilitate continuous (24-hr) sampling.

DAVPR: This instrument (color Digital-Autonomous Video Plankton Recorder (DAVPR), will be used as a backup for the VPRII should mechanical difficulties be encountered with the VPRII during the cruise. As a backup, the DAVPR will be deployed while the VPRII is being repaired and notification of the gear deployment shall be made to BP and the Trustee shore-side team immediately. If it becomes evident that the VPRII will not be able to be repaired in a timely manner, an alternate plan for continued sampling may occur as part of the cooperative cruise after an emergency justification is agreed to by both the Trustees and BP. As a backup instrument, the DAVPR, will be used to survey the distribution of plankton and marine snow (Cabell Davis, WHOI). See Attachment 11 for a description of the instrument, specifications, and deployment procedure. The DAVPR is capable of reaching a depth of 1200m.

Holocam: The holocamera (Holocam, Attachment 11) is an underwater digital holographic imaging camera developed to image plankton and particles ranging in size from a few microns to several centimeters. It may be attached to the CTD package or towed cable to capture *in situ* images continuously. It will be used with the DAVPR to provide comparative data, if the DAVPR is utilized.

CTD: The VPRII has Seabird CTD, fluorometer, optical backscatter, and photosynthetically active radiation (PAR) sensors internally mounted to record environmental characteristic concurrently with the images. The DAVPR does not and therefore will be mounted on the Seabird SBE911+ CTD profiling package to collect high-resolution water characterization data. The following sensors are to be deployed with this package, as logistically feasible: chlorophyll fluorometer, transmissometer, PAR, dissolved oxygen, and salinity, temperature, and depth information.

Retention of Materials: 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 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.

Data Management and Trustee Oversight: All profile, acoustic, and other electronic data will be saved to an on-board computer, and all data shall be migrated to a dedicated hard drive. The data will be controlled and managed by the trustees under project protocols, including Chain-of-Custody tracking of the hard drive. The hard drive will be duplicated in full immediately following the cruise, and the duplicate hard drive will be provided to Cardno ENTRIX on behalf of BP. The original hard drive shall be kept in a secure facility in trustee custody.

Under the direction of the Chief Scientist, a NOAA Data Manager on board each vessel will summarize sampling activities and scientific observations throughout the day and email a daily report to a designated list of recipients and NOAA NRDA (dwhnrdaWC@gmail.com) by midnight each day of the cruise.

In addition, Cardno ENTRIX will use an internal data management system to store, manage and process data from all study elements. This system will accommodate all chemistry and quality assurance data in formats compatible with BP's centralized database. A data management plan will be prepared to document the systems and procedures that will be used to ensure that data quality and data integrity are maintained throughout data management processes (Attachment 7).

Logistics

Vessel:

Operations will be completed on the R/V *Oceanus*. This vessel will be utilized because the VPRII system requires a specialized winch and cable with fairing in order to sample at high speeds. This system has been used on the *Oceanus* many times and the full unit (VPRII, winch, cable) can be transported onboard the *Oceanus* to the sampling locations.

Cruise Schedule:

Table 1. Proposed schedule for R/V *Oceanus* VPR cruise

2/26-2/28/2011	Setup and test sampling systems on R/V *Oceanus*
3/1/2011	R/V *Oceanus* departs WHOI
3/7/2011	R/V *Oceanus* Arrives Tampa, FL
3/8/2011	Final mobilization on *Oceanus* Tampa, FL
3/9/2011	R/V *Oceanus* Departs Tampa, FL
3/19/2011	R/V *Oceanus* Arrives Panama City, FL
3/19/2011	Personnel exchange

3/19/2011	R/V *Oceanus* Departs Panama City, FL
4/8/2011	R/V *Oceanus* Arrives Galveston, TX
4/10/2011	R/V *Oceanus* Departs Galveston, TX
4/18/2011	R/V *Oceanus* arrives WHOI

Personnel for R/V *Oceanus*:
WHOI Contractors:
Dr. Cabell Davis, Chief Scientist
Fredrik Thwaites, VPR Engineer
Phil Alatalo, VPR Technician
TBD, Research Assistant
NRDA Contractors:
VPR Technician (Leg 1: Kate Lingoni, Leg 2: Fred Marin)
Data Manager (Dade Moeller)
Cardno ENTRIX Employees:
2 (Observers, one on each cruise leg)

Budgeting:
The Parties acknowledge that this budget is an estimate, and that actual costs may prove to be higher due to a number of potential factors. As soon as factors are identified that may increase the estimated cost, BP will be notified and a change order provided describing the nature and cause for the increase cost in addition to a revised budget for BP's consideration and review. The field survey costs, miscellaneous costs, and travel costs indicated in Budget Chart # 1 below shall be reimbursed by BP upon receipt of written invoices submitted by the Trustees.

Budget Chart #1.

WHOI Budget	Days	Day Rate	Total
Personnel			
Davis	[redacted]		$90,901
Thwaites			$38,332
Alatalo			$30,681
RAII(TBA)			$19,264
Ship			
Vessel	49	$18,750	$918,750
Shipboard Marine Technician	[redacted]		$71,050
Shipboard VPRII Technician			$71,050
Equipment Fees			
DAVPR	33	$500	$16,500
VPRII	49	$375	$18,375
Holocam	33	$50	$1,650
Travel			$10,000

Equipment			$13,000
		Total	$1,299,553
NRDA Budget			
Personnel			
NRDA Technician	[redacted]	[redacted]	$52,500
Data Manager	[redacted]	[redacted]	$52,500
		Total	$105,000
		Total	$1,404,553

Safety Plans:
BP's full operations and safety plans are attached as appendices. A HASP binder is provided to each vessel. In addition, the NOAA incident site safety plan (which all NOAA employees and contractors must sign prior to the cruise) is attached (Attachment 1). Vessels will call into SIMOPS based on the current regulations (Attachment 5). Vessels will report in daily using the attached situation report (Attachment 6).

Distribution of Laboratory Results
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 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 Quality Assurance Project 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 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. 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).

References:
Broughton EA, Lough RG. 2006. A direct comparison of MOCNESS and Video Plankton Recorder zooplankton abundance estimates: Possible applications for augmenting net sampling with video systems. Deep Sea Research Part II: Topical Studies in Oceanography, 53, 2789–2807.

Davis, CS, SM Gallager, and AR Solow. 1992. Microaggregations of oceanic plankton observed by towed video microscopy. Science, 257, 230–232.

Davis, CS and DJ McGillicuddy. 2006. Transatlantic abundance of the N2-fixing colonial cyanobacterium *Trichodesmium*. Science, 312, 1517–1520.

Attachments:

Attachment 1. NRDA_Ops_Safety_Plan_08DEC2010
Attachment 2. MC252 HSSE Incident Reporting Final 02 May 10 rev 1
Attachment 3. CSA-Davis HSE Plan Rev 005_Final
Attachment 4. Transfer of Personnel and Material at Sea 070510
Attachment 5. NRDA SIMOPS Procedures 111710
Attachment 6. DWH Vessel Daily SitRep
Attachment 7. MC252 Analytical QAP V2.1
Attachment 8. NRDA_Field_Sampler_Data_Management_Protocol_10_23_2010
Attachment 9. Historical Plankton Data_2010Aug17
Attachment 10. CDavis-VPRII-2011Jan30
Attachment 11. CDavis-VPR Holography-2010Dec9

Deepwater Horizon Oil Spill (DWHOS)
Water Column Technical Working Group

NRDA Spring 2011 Plankton Imaging Sampling Cruise Plan

Sampling Vessel: R/V *Oceanus*

Cruise Dates: March 1 – April 18, 2011

Plan Date: January 30, 2011
Revised: March 8, 2011

Approvals

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

BP Approval	Lawrence Malnor Printed Name	Signature	March 9, 2011 Date
Federal Trustee Approval	Jessica White Printed Name	Jessica White Signature	3/09/2011 Date
Louisiana Approval	MAROLINE M DEBUSSCHER Printed Name	FOR ROLAND GUIDRY Signature	7/29/2011 Date