DEEPWATER HORIZON MC 252 RESPONSE

UNIFIED AREA COMMAND

STRATEGIC PLAN FOR SUB-SEA AND SUB-SURFACE OIL AND DISPERSANT DETECTION, SAMPLING, AND MONITORING

November 13, 2010

STRATEGIC PLAN FOR ENHANCED SUB-SEA AND SUB-SURFACE OIL AND DISPERSANT DETECTION, SAMPLING AND MONITORING

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EXECUTIVE SUMMARY

Response to the Deepwater Horizon event has required an unprecedented amount of sampling in Gulf of Mexico waters to determine the location, fate, transport and threat of oil and dispersants. To transition from the response to other phases of the oil spill, the National Incident Commander (NIC) directed that the Unified Area Command (UAC) develop an enhanced sampling plan with the primary objective of assessing the presence of oil that could be removed to prevent, minimize or mitigate damage to the public health or welfare (hereinafter referred to as "actionable oil"). Per the National Contingency Plan (NCP), Clean Water Act (CWA) and Oil Pollution Act of 1990 (OPA 90), "removal" is defined as containment and removal of the oil or hazardous substance from the water and shorelines or the taking of other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare, including, but not limited to, fish, shellfish, wildlife, and public and private property, shorelines and beaches. Oil may be present but not be appropriate for removal action (e.g., if the environmental costs of taking action exceed those of leaving the oil in place). Thus, for purposes of this document, we refer to oil that is both present and appropriate for removal as "actionable oil."

This Strategic Plan provides the guiding framework to execute the 13-step Unified Area Command (UAC) Strategy promulgated on 18 August 2010 and focuses upon the removal phase of the Deepwater Horizon (DWH) Spill of National Significance in accordance with the National Contingency Plan (NCP). To achieve the stated objective, this plan: (1) describes an initial environmental sampling plan, (2) enables additional sampling on an adaptive basis, with specific plans to be based upon initial findings, based on the recommendation of the Operational Science Advisory Team (OSAT) and approval of the FOSC, (3) supports timely sharing of data and knowledge among federal, state, local and tribal stakeholders, members of the scientific and academic communities, and the public, and (4) wherever possible, involves the government, academic and private research community in monitoring and data interpretation activities to build on the broad set of information now available from agency, academic and private research institution sampling.

As stated in the National Incident Commander's Directive of 13 August, 2010 and the Sub-Sea and Sub-Surface Monitoring Strategy dated 18 August, 2010, the goals of this Plan are to:

a. Monitor and assess the distribution, concentration, and degradation of the portion of the oil that remains in the water column and/or bottom sediments.

b. Evaluate the distribution of indicators of dispersant or break-down products of dispersants used in oil spill response activities.

c. Identify any additional response requirements that may be necessary to address remaining sub-surface oil.

This Plan describes enhanced sampling in three spatial domains: (a) the *nearshore* from the marshes and beaches (including bays and behind barrier islands) to 3nm offshore[1] (b) the *offshore*, from 3 nm to the shelf break (the 200 meter depth contour) and (c) the *deep water,* from 200 meters to about 2,000 meters water depth (the well is in 1,500 meters of water). The spatial extent of the sampling of shallow waters was guided by previous observations of the extent of oil at the surface (from ships, aircraft, satellites and *in situ* sampling) and by knowledge of the nearshore physical oceanography, i.e., movement of water and sediments. Sampling in offshore and deep waters was guided by monitoring results obtained to date, trajectory models for the deep water layer where hydrocarbons had previously been observed, and a set of hypotheses for likely locations of remaining oil. This effort emphasized enhanced sediment sampling on the continental shelf and in deep waters. Evaluation of degradation rates will help assess attenuation of remaining oil.

Since May, 2010, substantial data have been collected through agency, academic, and private scientific efforts regarding the distribution and magnitude of oil (hydrocarbons), dispersants and other water chemistry attributes (e.g., dissolved oxygen) in the nearshore, offshore and deep water zones. A coalition of state and federal agencies has collected environmental information and media samples immediately following the DWH rig explosion. Additionally, other data have been collected by independent scientists. This plan outlines steps taken to better unify and integrate all efforts in sampling, detection, analysis and reporting of results.

The approaches to the enhanced monitoring varied with the sampling domain. In the nearshore, an array of approximately 200 locations encompassing the Louisiana, Mississippi, and Alabama coasts, and the Florida panhandle were sampled. These locations were designed to provide a high level of confidence for the detection of oil and dispersants, should they exist. In the offshore and deep water environments, sampling efforts were targeted based on observed oil distributions, hydrodynamic model results, and oceanographic considerations, in the areas *most likely* to have oil and/or dispersants on the seabed or in the water column. Sampling of offshore and deep water sediments included a broad array of surveillance stations in areas where oil may have migrated.

Water and sediment sampling results have been, and will continue to be, coordinated with the seafood safety sampling plan to assure appropriate concurrent sampling of the water column, sediments and fish/shrimp tissues. Results indicating oil presence are shared with NMFS and FDA. Decision points for determining when sampling under this response Directive was stopped and transition to long-term monitoring started were based on:

1. Whether oil or dispersant was present that is attributable to the DWH

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[1] With the exception that the nearshore area off of the Florida Panhandle is defined as 9 nautical miles instead of 3 nautical miles.

2. Whether oil or dispersant was "actionable" (that is, were there any actions that could be undertaken to address detected levels of oil and dispersants from the environment under OPA definitions of removal actions)
3. Whether actions were feasible and consistent with the principle of net environmental benefit (the actions would not create additional environmental issues of greater concern than allowing the oil/dispersants to remain in the environment)[2].

These are sequential decision points (e.g., if the answer to oil presence was "no," then the following two decision points would not apply, if the answer to oil presence was "yes," then the following questions were asked.)

In evaluating the presence of oil, the plan applied "indicators." Indicators assisted in determining the presence of actionable oil. These indicators included the presence and measured concentrations of oil and/or dispersants in relation to public health and environmental benchmarks. These benchmarks included levels of concern for the presence of polycyclic aromatic hydrocarbons (PAH) in relation to human health and aquatic life toxicology. It must be noted that these benchmarks were used here to screen analytical results and were not used as regulatory standards, site-specific cleanup levels, or remediation goals.

Indicators for the presence of oil or dispersants were applied for each of the sampling domains. In nearshore waters, indicators included comparisons to acute and chronic aquatic life benchmarks, human health benchmarks and fishery closures. In nearshore sediments, indicators included results of toxicity testing, comparisons to acute and chronic aquatic life benchmarks and comparisons to reference locations and pre-impact conditions. In the offshore environment, water concentrations were again evaluated using human health and acute and chronic aquatic life benchmarks and fishery closures as indicators of oil/dispersant presence. Offshore sediment were evaluated using aquatic life benchmarks and comparisons to results at reference locations. In the deep water environments, the indicators included dissolved oxygen concentrations, comparisons to acute and chronic aquatic life benchmarks, and fishery closures. In deep water sediments, indicators included comparisons to acute and chronic aquatic life benchmarks and comparisons to results at reference locations.

While this plan is primarily intended to provide information for removal (as defined by CWA and OPA90), it is recognized that the data collected may be helpful for other purposes beyond removal. Thus, to the extent possible, sampling was coordinated with scientists supporting these other phases to leverage efforts, eliminate redundancies, and preserve the sampling data for subsequent use.

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[2] The FOSC reserves, and nothing herein constrains, the FOSC's full authority to make decisions on removal actions, including decisions based on later-discovered information,

The adaptive approach to sampling employed the use of empirical evidence to guide the need for future sampling. This adaptive approach also included a formal review process to determine the need for continued sampling once indicators had been evaluated.

This plan incorporated additional steps to improve communication of information about the program, data collected, and analytical results among all stakeholders and to the public regarding the process used to determine the presence and fate of the DWH oil and dispersants in the environment. Sampling results are posted on publicly accessible web sites, along with maps and other data and syntheses showing results of sampling in comparison to indicators (e.g., PAH levels in water in relation to human health levels of concern). These results will also be available on the website of the Environmental Response Management Application (ERMA): GeoPlatform.gov.

The plan was developed with input from a number of academic and private science sources. For example, four public meetings were held in various parts of the Gulf of Mexico (GOM) ranging from Tampa, FL to Biloxi, MS to New Orleans, LA. Comments from the academic and private research community were received and considered in the final plan development. The plan further enables ongoing collaborations with academic and private scientific institutions and provides the flexibility and adaptability to incorporate all scientific findings as the plan unfolds.

The Operational Annex to this plan provides more detailed guidance for operations on specific activities referenced in this plan.

1 INTRODUCTION

Response to the Deepwater Horizon event has required an unprecedented amount of sampling in Gulf of Mexico waters to determine the location, fate, transport, and threat of oil and dispersants. To transition from the response to other phases of the oil spill, the National Incident Commander (NIC) directed that the Unified Area Command (UAC) develop an enhanced sampling plan with the primary objective of assessing the presence of actionable oil. This plan has been developed through a series of iterations that were drafted even while the sampling was in progress. An iterative approach was necessary due to the ephemeral nature of the data being collected and the need to make timely response decisions. The iterative nature of the planning is also consistent with the adaptive nature of the sampling process, which is described later in this document. This version of the Strategic Plan is being finalized at the point in time between completion of the planned sampling effort and analysis of the final set of analytical and observational results by the Operational Science Advisory Team (OSAT).

The goals of this Plan are to:

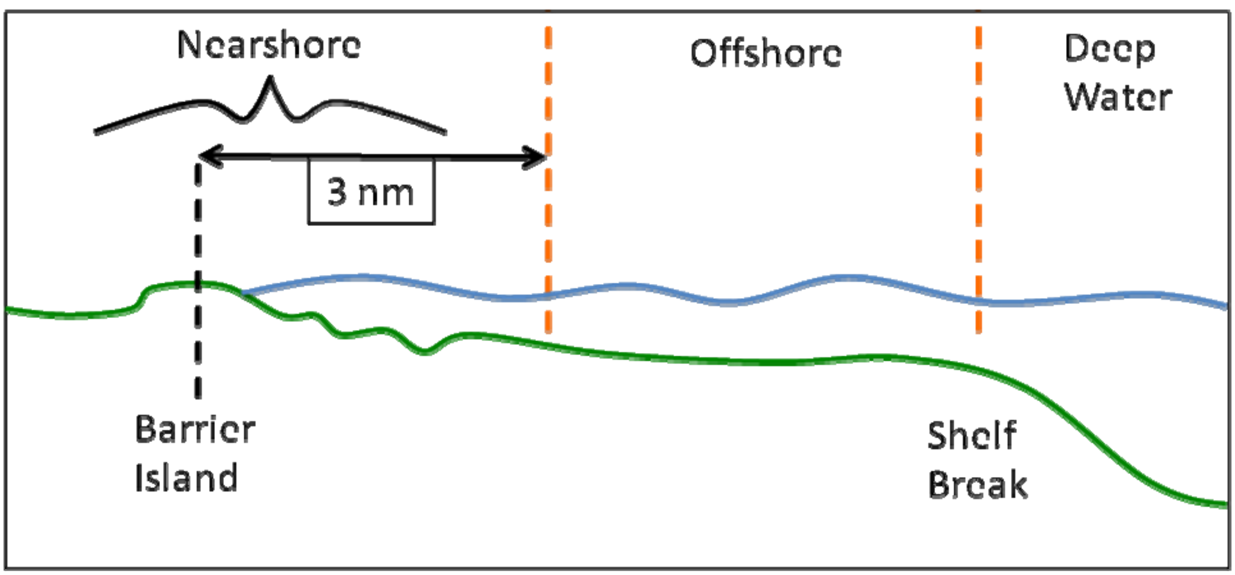
a. Monitor and assess the distribution, concentration, and degradation of the portion of the oil that remains in the water column and/or bottom sediments.

b. Evaluate the distribution of indicators of dispersant or break-down products of dispersants used in oil spill response activities.

c. Identify any additional response requirements that may be necessary to address remaining sub-surface oil.

Removal activities are authorized under the Federal Clean Water Pollution Control Act (FWPCA) as amended by the Oil Pollution Act of 1990 (OPA 90) if they meet certain criteria. Removal action funding provisions under OPA 90 specifically prohibit funding for “response actions other than removal, such as scientific investigations not in support of removal.” Thus, in order to comply with OPA 90’s funding provisions, any sampling efforts must be limited to removal activities. This Plan provides the guiding framework to execute the 13-step Unified Area Command (UAC) Strategy promulgated on 18 August 2010 and focuses upon the response phase of the Deepwater Horizon (DWH) spill of national significance in accordance with the National Contingency Plan (NCP). The intent of this Plan is to: (1) describe an initial environmental sampling plan, (2) enable additional sampling on an adaptive basis, with specific plans to be based upon initial findings based on recommendations of the OSAT and approval of the FOSC, (3) support timely sharing of data and knowledge among federal, state, local and tribal stakeholders, members of the scientific and academic communities, and the public[3], and (4) wherever possible, involve the government, academic and private research community in monitoring and data interpretation activities to build on the broad set of information now available from agency, academic and private research institution sampling.

This plan describes enhanced sampling in three spatial domains: (a) the *nearshore* from the marshes and beaches (including bays and behind barrier islands) to 3 nautical miles (nm) offshore[4] (b) *offshore*, from 3 nm to the shelf break (the 200 meter depth contour) and (c) the *deep water,* from 200 meters to about 2,000 meters water depth, where oil and dispersants are likely to have migrated (the well is in 1,500 meters of water) (Figure 1.1). The spatial extent of the sampling of shallow waters was guided by previous measurements of the extent of oil at the surface (from ships, aircraft, satellites and *in situ* sampling) and by knowledge of the nearshore physical oceanography, i.e., movement of water and sediments. Sampling in deep waters was guided by monitoring results obtained to date as well as sub-surface trajectory models. In particular, this effort emphasized enhanced sediment sampling on the continental shelf and in deep waters where there are preliminary observations of oil on sediments. Evaluations of degradation rates would help assess attenuation of remaining oil.



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[3] A detailed description of the data management process will be provided in a Data Management Technical Addendum. The details of how this will be developed and implemented are presently under discussion.

[4] With the exception that the nearshore area off of the Florida Panhandle is defined as 9 nautical miles instead of 3 nautical miles.

Figure 1.1 Sampling zones from behind the barrier islands to deep water environments (nm=nautical miles). Note that the nearshore area off the Florida Panhandle is an exception and extends to 9 nm. This figure is not to scale.

Relationship to Previous Sampling

The plan outlined herein builds upon and fills gaps identified in the substantial sampling efforts conducted to date. Vessels under the control of the Unified Command had previously collected over 20,000 water and sediment samples at about 5,500 unique locations. The strategy that was developed in this plan built upon what was learned from these samples.

Both quantitative (analytical) and qualitative (presence/absence) sampling and observation activities have been conducted in the nearshore domain. Approximately 5,000 nearshore water and sediment samples have been collected as of September 11, 2010. For example, over 400 passive snare sentinels, a technique used to indicate the presence of mobile sub-surface oil, were placed in nearshore waters and were typically inspected every 48 hours.

The deep water column has been extensively sampled within about 75 km of the well using fluorometry, particle size analyzers, oxygen probes, hydrocarbon analyses, and standard conductivity, temperature, and depth (CTD) sensor casts. Formal documentation of a subset of these data and subsequent analysis exists in publicly accessible reports posted at: (http://ecowatch.ncddc.noaa.gov/JAG/reports.html) authored by the Joint Analysis Group (JAG) of the National Incident Command.

The offshore and some deep water areas have received the least attention in terms of water and sediment sampling, which are an emphasis area of this plan (Figure 1.2).

In the deep water environment (beyond the continental shelf break), observations have defined a diffuse layer of hydrocarbons in the water column, primarily in the 1,000 – 1,300 meters depth range, that has been independently confirmed by a number of sampling teams (http://www.noaa.gov/sciencemissions/PDFs/JAG_Oxygen_Report%20%28FINAL%20090410%29.pdf). These signals were predicted and observed primarily southwest of the DWH well site, although at certain times, some locations in other directions also showed the presence of this oil. Following the capping of the well, the deep water hydrocarbon signature became attenuated, possibly through diffusion and/or biodegradation, resulting in the expansion of water sampling and the use of more sensitive detection instruments to follow the decreased signal.

Figure 1.2 shows the location of 28,767 water and/or sediment samples or measurements collected between 28 April, 2010 and 19 September, 2010. Chemical analysis has been completed and validated on more than 5,000 samples; a summary of the numbers of samples are shown in Table 1.1. These data have been compared to standard benchmarks for human health and aquatic life. Few samples to date out of 7,231 have exceeded benchmarks for either oil or chemicals associated with dispersants (Table 1.1). In addition to quantitative samples taken for chemical analysis, a number of qualitative observations have been made. These observational programs are designed to search for subsurface oil in nearshore areas. A “hit” indicates that oil was encountered during the sampling process. If oil was encountered, a sample was taken and sent to a laboratory for further chemical analysis. Some programs provide observations at discrete points and others by towing oil snares through the water. If the observation is from a program that tows through the water, the number is reported as nautical miles. A summary of observations is shown in Table 1.2. A short description of each of these qualitative observation programs is given in Appendix A. For these qualitative data, of over 7,000 observations, 154 had positive indications of oil observed as of September 11, 2010. Samplers were dragged through 430 nautical miles of water resulting in six oil “hits” through the same date.

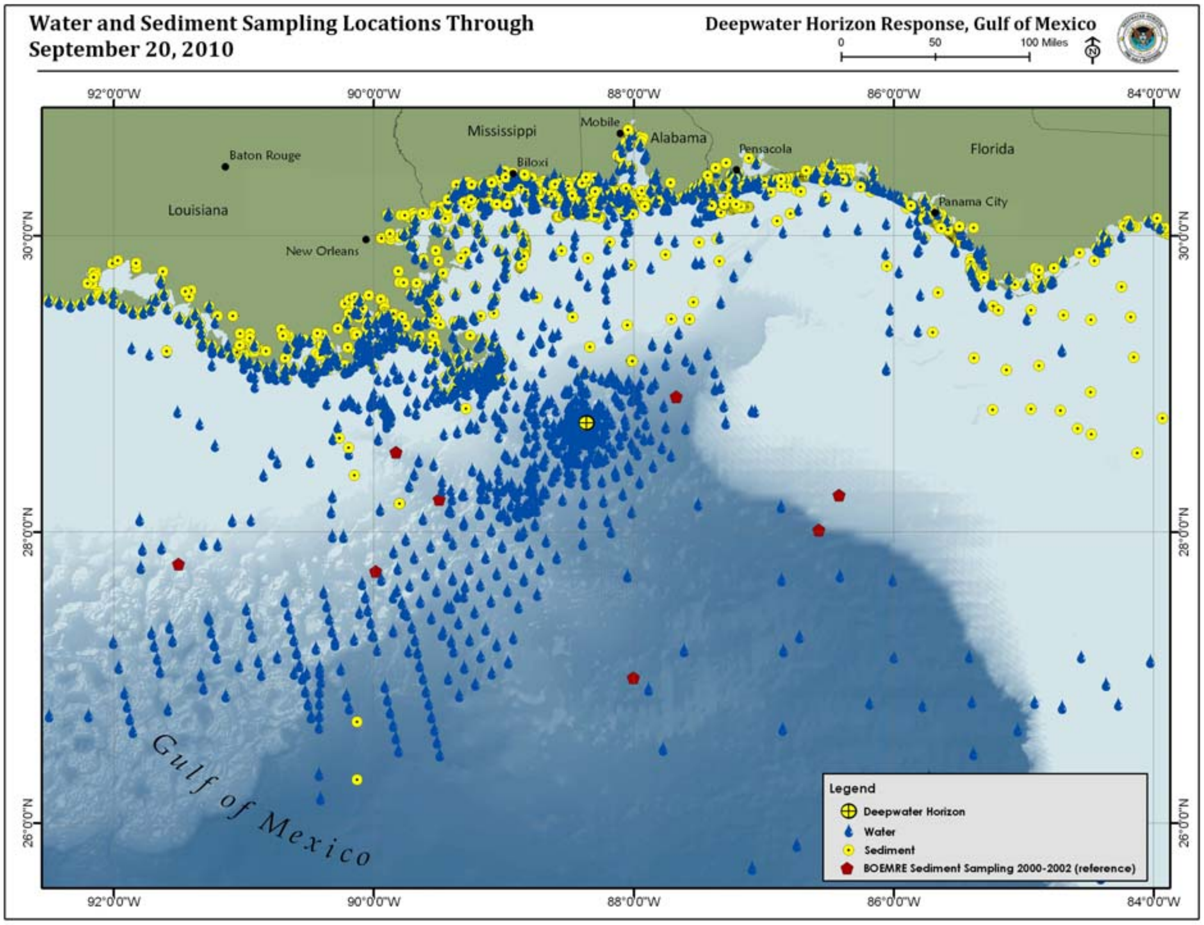

Figure 1.2 Map of sampling and observation locations through 20 September, 2010.

28 April–19 September, 2010	Water	Sediment
Number of Samples Collected [1]	28,914	876
Number Exceeding Human Health Indicator (number analyzed)[2]	0 (6,564)*	Not Available
Number Exceeding Aquatic Life Indicator (chronic)[3]	20 (6,564)*	12 (667)
Number Exceeding Aquatic Life Indicator (acute)[3]	4 (6,564)*	2 (667)
Number Exceeding Aquatic Life Dispersant Indicators[3]	1 (1,678)*	Not Available

Notes:

1. These numbers reflect all samples collected. Not all of these samples have been evaluated for all indicators.
2. The Public Health Task Force Human Health Benchmark for Child Swimmer (http://www.epa.gov/bpspill/health-benchmarks.html)
3. EPA Aquatic Life Acute and Chronic Benchmarks for PAH (http://www.epa.gov/bpspill/water-benchmarks.html).

*** Numbers in parenthesis are samples analyzed to date for that specific indicator.**

Table 1.1. Preliminary sample analysis 28 April-19 September, 2010. Discussion on application of Human Health and Aquatic Life Criteria can be found in Section 3 of this document.

06/03/10 thru 9/11/10	Snare Sentinals[1]	VIPERS[2]	Snare Drag Trawl[3]	Ponar Sediment Samples[4]
Number of Samples Completed	5,644	266 nm	164 nm	1682
Number of “hits”	116	2	4	32
Percentage Un-oiled	98%	N/A	N/A	98%

Table 1.2. Results from qualitative observations.

1 This indicates an observation from a string of snare placed on a line from the bottom to near surface.
2 Vessels with petroleum ensnaring and recovery systems (VIPERS) were only conducted in the Mobile AOR.
3 Snare drag trawls were only conducted in the Houma AOR.
4 Ponar operations were only conducted in the Mobile AOR.

The remainder of this plan describes sampling conducted to fill gaps and approaches for evaluating indicators to evaluate whether detectable oil remains. The Operational Annex to the Sub-sea and Sub-surface Strategic Sampling Plan provides the details on execution of specific projects.

Importantly, there was no fixed time frame for the completion of this plan. However, given that time is of the essence for response efforts, every effort was made to expeditiously implement this plan, including analysis and interpretation of the data and recommendations. The program was considered complete when the three sampling domains have been sufficiently sampled to characterize any remaining oil and/or dispersants to determine whether any actionable oil remained.

2 SAMPLING PLAN

This section outlines a comprehensive sampling plan derived using a requirements-driven, statistically robust, or targeted approach that may be modified as recommended by OSAT and authorized by the FOSC. It addresses steps (i), (iv), and (vi) of the 18 August, 2010 UAC Strategy. In the context of the previous and ongoing sub-surface sampling efforts, a gap analysis was conducted in order to identify sampling programs that would continue orbe augmented, or modified. This involved a comprehensive review of the existing data sets, identification of suspected locations of sub-surface oil (from empirical data and models), and identification of locations for further exploration based on a number of hypotheses on potential for oil to deposit onto bottom sediments. These hypotheses were informed by an understanding of the fate of oil in the environment, and oceanographic conditions in the GOM.

2.1 Oil Fate and Behavior and Oceanographic Considerations

Deepwater Horizon oil is lighter than water. DWH oil released from the bottom of the GOM would be expected to rise to the surface. How fast it rises depends on how large the oil droplet is. Larger droplets rise faster; small droplets may take months to rise and very small droplets may never reach the surface. Oil will be carried with sub-surface currents as it rises. The GOM water is warmer on the surface than at the bottom. The water is also fresher at the surface, especially in the area where the Mississippi River water enters the Gulf. The DWH well-head is at approximately 5,000 feet deep. Pressures at this depth are 150 times greater than at the surface. In general, currents are stronger near the surface and decrease with depth. The direction of currents on the bottom is not necessarily the same as on the surface. These differences between surface and bottom water conditions create stratified layers that influence the behavior and transport of oil. Oil in deep water would not be expected to reach the bottom unless it was altered by suspended particles. Oil released along the bottom that became entrained with particles would be transported with bottom currents until it settled out. Bottom currents are primarily southwest along bathymetry lines, with temporary excursions in other directions (the second most common direction being to the northeast). The bathymetry in the area of the well includes a number of "salt domes" (Figure 2.1). Eddies and mixing could move material over into deeper water to the south and around the salt domes, where oil and suspended particles could settle out. Oil entrained with drilling mud would not move far from the well head, since drilling mud is very dense.

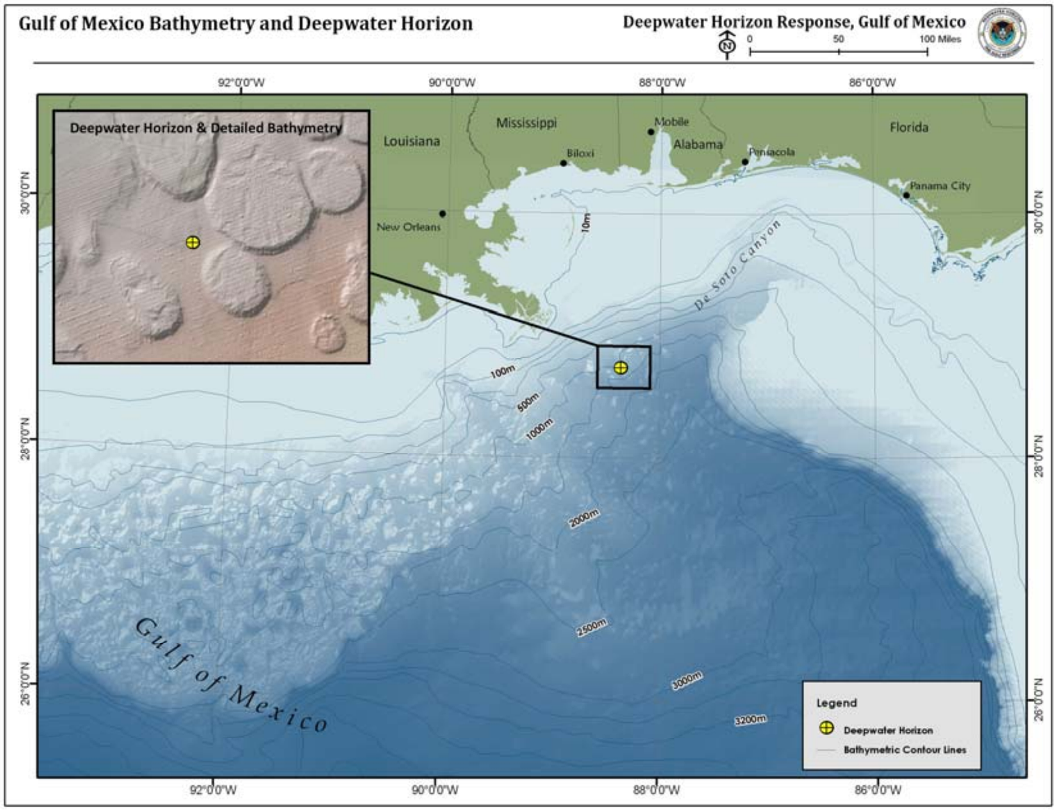

Figure 2.1 Gulf of Mexico Bathymetry with inset showing high resolution bathymetry in area of DWH well head.

DWH oil was found as a diffuse plume of small droplets (estimated at 60 microns or less) in a layer of water between 1,000 m and 1,300 m deep. This deep, cold water layer generally moves counterclockwise through the GOM and water from this depth does not get mixed up onto the shelf.

Oil arriving at the surface of the water would not be likely to go into the sub-surface again unless it was driven into sub-surface layers by wind and wave action (in which case it would refloat when the turbulence subsides, much like leaves fly until the wind stops blowing), or unless it was altered by encounters with suspended particles (including nearshore sediment or sediment from the Mississippi River, marine detritus, and copepods and other zooplankton). Surface oil would be carried by surface currents, which are affected by winds, as well as the larger circulation patterns in the Gulf. These surface circulation patterns vary, but generally the net current is to the west in the area south of the Mississippi Delta. Oil was stranded on beaches, barrier islands, and in wetlands when it reached shorelines, and some of it could be carried back offshore on subsequently higher tides where it could mix with sediment in the surf zone. During the DWH oil spill, surface trajectory models were used to predict where surface oil would most likely be observed and where it might encounter shorelines. Observations from aircraft, boats, and shoreline teams were used to confirm and improve these predictions.

When dispersants were added to oil (either at the surface or at depth) the surface tension of the oil was reduced and it formed droplets that mixed into the water. Dispersants work using the same principles as kitchen detergents. Dispersed oil is not “dissolved,” but the increased surface area to volume ratio allowed naturally occurring bacteria greater access to the oil molecules so that they could be degraded. As with un-dispersed oil, dispersed oil would not sink unless it was altered by suspended particles. In the deep ocean, dispersed oil could encounter “marine snow,” a continuous shower of mostly organic detritus falling from the upper layers of the water column.

2.2 Existing Data

Numerous sources of data from both Federal and State Agencies were evaluated during the sampling design process. This included data and information from EPA Regions 4 and 6, USGS, NOAA, the States of Louisiana, Alabama, Mississippi, and Florida, and the Responsible Party (RP), BP. In addition, numerous academic institutions and investigators have collected data during the response activities. Numerous samples and measurements have been taken since the beginning of the oil spill including, but not limited to: CTD casts, fluorometry, particle size analysis, dissolved oxygen, surface water and sediment samples in nearshore areas for chemical analysis and toxicity assessment, deep water samples for chemistry, finfish and shellfish tissue sampling for seafood safety, and qualitative measurements using methods such as sorbent probes and sentinel snare sampling to detect presence or absence of oil. Chemical analyses have included an extensive suite of contaminant classes such as Volatile Organic Carbons (VOC), Semi Volatile Organic Carbons (SVOC), dispersants, Polycyclic Aromatic Hydrocarbons (PAH), Total Petroleum Hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylene (BTEX), and metals.

Figure 2.2 shows where water and sediment samples or observations have been taken through September 20, 2010, including 8 historical sample locations taken by BOEMRE in prior years that may be used as reference stations.

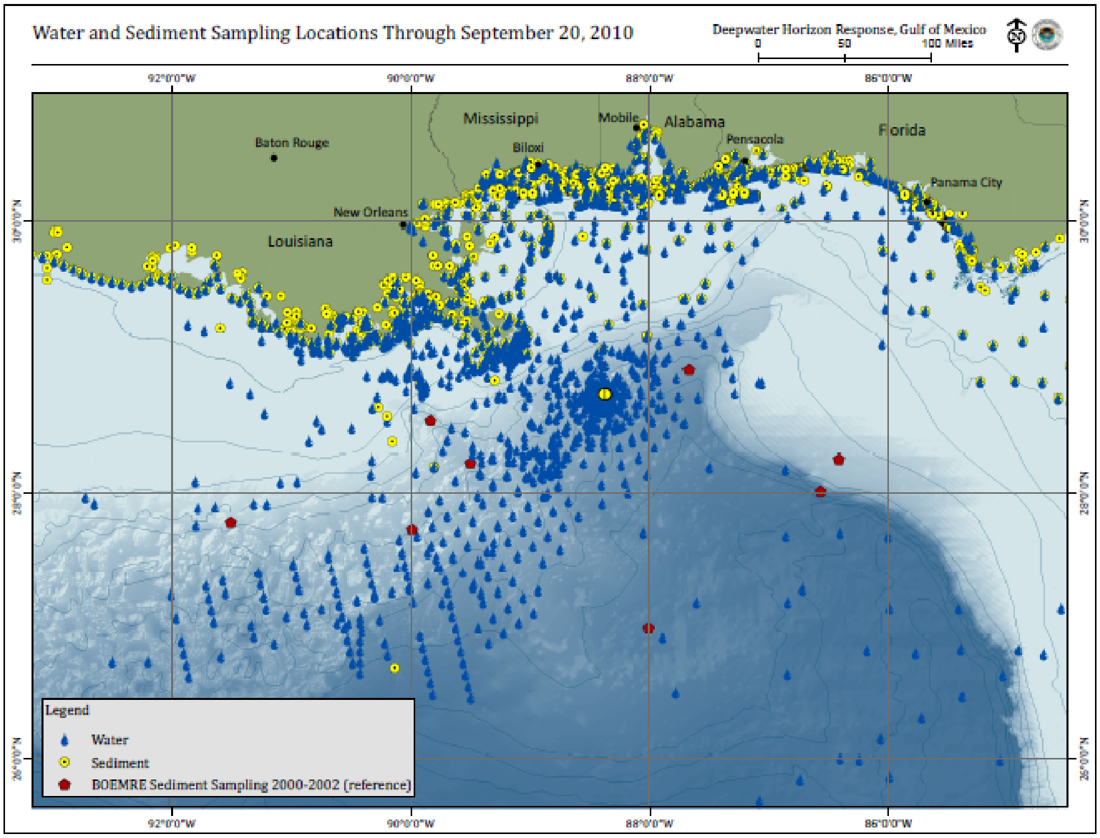

Figure 2.2 Map showing where sediment and water samples have been taken or observations have been made through 20 September, 2010.

Lastly, sediment traps to capture falling debris (marine snow) and semi-permeable membrane devices (SPMDs) to evaluate dissolved PAHs have been deployed as part of NRDA activities. Results from these efforts may further inform evaluation of oil distribution and characterization.

2.3 Sampling Plan Design

The overall strategy used to develop the sampling plan for the GOM Removal Action was to apply a hybrid approach that was robust and science-driven. In brief, this approach combined statistically based placement of locations with targeted sampling. Statistical power analyses were conducted to determine sample sizes needed for the evaluation of pre-impact to post-impact periods in the nearshore where pre-impact data were available. Targeted sampling in specific locations and areas of interest and consideration of both quantitative and qualitative sampling were also incorporated into the design. All analyses will be conducted in accordance with a Quality Assurance Project Plan (QAPP), developed by EPA. This QAPP will be posted on Restorethegulf.gov, along with sampling protocols and analyte lists.

In addition to augmentation of ongoing nearshore sediment and water sampling, additional water and sediment sampling in the offshore and deep water zones was carried out. Given the dynamic nature of the water, the shut off of continued oil into the environment on 15 July, and the identified sediment sampling gap, a major emphasis in this plan is on the sediment sampling.

Historic sediment and water sample data from NOAA, USGS, BOEMRE (formerly MMS), and several regional universities (e.g., TAMU, LSU) helped to provide context for evaluating the extent of hydrocarbons in the water column and sediments. In addition, basic oceanographic conditions such as continuous temperature and salinity, and discrete measurements of dissolved oxygen, nutrients, POC, pigments, and total suspended material are available from these previous studies.

Mississippi Canyon (MC) 252 oil has an average density of 0.849 (API 35.2). Therefore, the oil would be expected to eventually surface and move with the surface currents and winds. However, there are a number of pathways in the nearshore, offshore and deep water zones that may lead to oil being found in the sediments. These pathways are illustrated in Figure 2.3. In particular:

1. Small droplets of oil in the deep water subsurface plume could have encountered and absorbed onto organic debris (marine snow) that falls from the upper layers of the ocean and accumulates on the seafloor.
2. Dispersants applied at the surface creates smaller droplets of oil in the upper part of the water column. These droplets could possibly have sorbed onto sediments or organic debris (marine snow) and subsequently been deposited on the bottom, or these droplets may have become a source of food for copepods, eventually being excreted in fecal matter that subsequently sinks (copepods have a limited ability to metabolize oil).
3. Oil that encountered sediment or other particles may have adsorbed onto the particles and sunk in the offshore area (oil encountering detritus or sediment laden waters, e.g., the Mississippi River plume).
4. During the injection of drilling mud as part of the top kill operation, oil and mud may have been mixed and could have created an oily mud complex that could settle on the bottom.
5. Burning of oil may have resulted in by-products that were heavier than the surrounding water and, therefore, sank – moving with subsurface currents as they deposit.
6. Oil that encountered sediment or other particles may have adsorbed onto the particles and sunk in the nearshore area. Particles may have been encountered on the shore (oil stranding and getting mixed with sand and carried off by a subsequently higher tide) or in the surf zone (oil getting mixed with sediment where waves are breaking on shore).

Each of these potential scenarios was considered in selecting the sediment sampling locations for offshore and deep water zones.

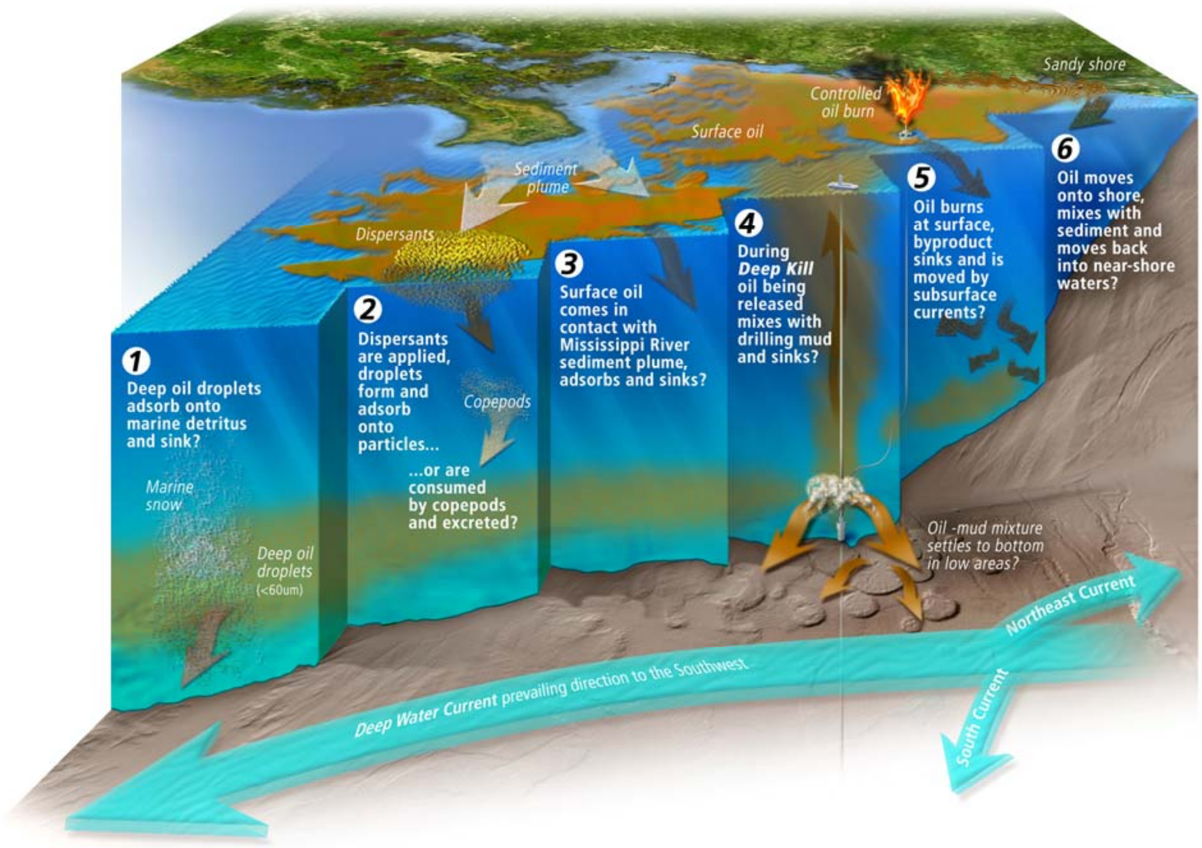

Figure 2.3. Potential pathways for oil to reach bottom sediments.

2.3.1 Nearshore

The primary objective of the sediment and surface water sampling in the nearshore area is to describe the distribution and concentration of any remaining oil, dispersants or by-products. Both qualitative and quantitative data are available in this nearshore region. A significant body of qualitative data has been collected using methods such as snare sentinels, sorbent pad drops, vessels with petroleum ensnaring and recovery systems (VIPERS) and snare drag trawls (Appendix A). When oil was indicated in a qualitative sample (water or sediment), samples were taken for chemical analysis. Samples are analyzed for volatile organic compounds (VOCs), propylene glycol, 2-butoxy ethanol, 2-ethylhexanol, semi-volatile organic compounds (SVOCs), gasoline range organic compounds (GRO), diesel range organic compounds (DRO) and oil range organic compounds (ORO). The need and locations for qualitative sampling has been identified by the Incident Commands based on observations, models, and community concerns.

Quantitative sampling in nearshore areas was initiated shortly after the spill began, and focused on sediments, water, and biota. In addition to quantitative and qualitative data collection, hotlines have been established to receive reports from the public regarding observed oil. The UAC will continue to monitor and investigate any credible reports of observable oil related to the DWH oil spill.

In order to calculate the number of samples needed to determine if the spill has significantly enriched the sediments and surface waters with petroleum-related products and dispersants, an initial review of quantitative sampling already undertaken in this zone was performed. The overall objective of this review was to determine how many samples would be required to evaluate whether concentrations of oil-related contaminants were higher in sediment and surface water after the spill compared to conditions pre-impact. This work was undertaken to develop a statistically rigorous geospatial design that could be augmented with targeted sampling to achieve the objectives of this plan.

A total of 658 sediment samples and 4,291 water samples were available for statistical analysis. The data encompassed analytical results of the response-related sampling conducted along the GOM coastline prior to impact, during impact, and post-impact. From these data sets, sixty-seven analytes were considered to determine an appropriate sample size. Source oil composition from the MC Block 252 (DWH) is shown in Appendix D.

The development of sampling design options began with nearshore pre- and post-impact sediment data. Visual Sample Plan (VSP) software was used to determine geographic locations projected in a non-biased grid in the nearshore zone. Approximately 150 locations in the nearshore area from the LA/TX border to Apalachicola Bay in the Florida Panhandle were identified based on the VSP results. The lack of detected PAHs in the water samples analyzed to date meant this same rigor could not be applied to locating future nearshore water samples. Therefore, nearshore water sampling was co-located with sediment sampling, and, to take advantage of adaptive sampling, VSP recommendations were modified to coincide with National Coastal Conditions Assessment (NCCA) locations (which have been repeatedly sampled in the past) where appropriate. The details of the analysis (software, analytes considered, and rationale) are given in Appendix B.

In addition to the approximately 150 sites identified during the statistical analysis, USGS resampled additional sites between the LA/TX border and Apalachicola Bay where water and benthic invertebrates were collected in May and June, 2010. Therefore, a total of approximately 200 nearshore locations were sampled for water, sediment chemistry, and sediment toxicity using benthic invertebrates. Water, sediment chemistry, and samples for toxicity testing were collected at three reference sites. All sampling followed standard protocols and included all necessary environmental, historic and archaeological consultations. This subsurface plan does not include shoreline sampling work being conducted at a number of the more heavily oiled shorelines throughout the region. One of the goals of these shoreline sampling efforts is to better characterize weathering and shoreline degradation of the oil and/or dispersants.

Nearshore sediment and water sampling sites are shown in Figure 2.4.

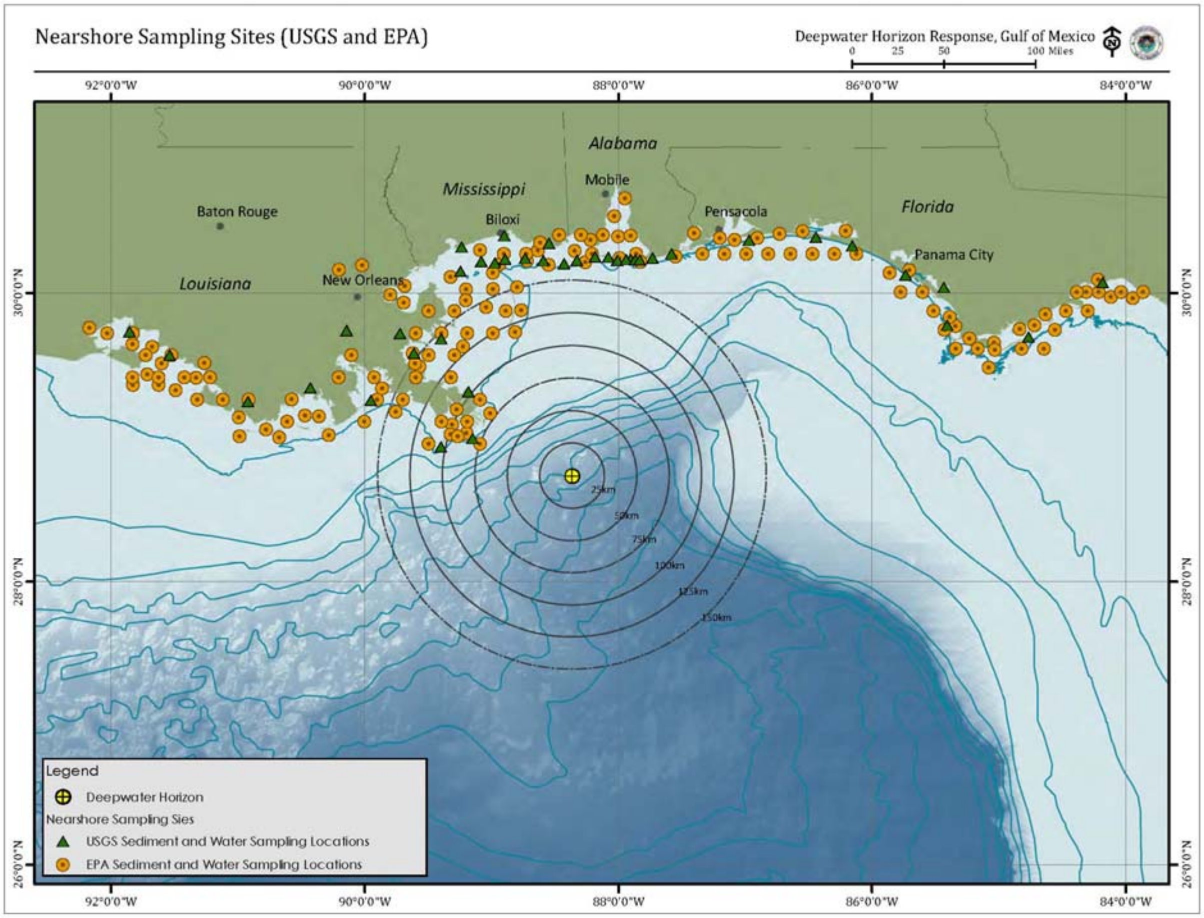

Figure 2.4 Nearshore sampling sites (EPA and USGS).

2.3.2 Offshore

Review of existing water column and sediment sampling in this zone (3 nm to the continental shelf break) indicated a significant gap in sediment sampling. This gap was filled using a targeted sampling approach combined with a statistically placed grid to detect “hot spots.” Targeted sediment sampling in the offshore zone considers locations where oil may have settled into sediment as a result of adsorption to suspended sediment discharged from the Mississippi River or other suspended particles or burn by-products settling into the sediment. In addition, a statistical analysis was conducted to evaluate the number of sampling stations on the shelf needed to locate “hot spots” with 95% certainty. This number of stations would provide a high probability that any individual sampling point would be located within an elliptically-shaped hot spot smaller than 2% of the total area.VSP was used to explore sampling design options that would meet this requirement (Appendix B.) Final station locations represent a combination of targeted stations located to evaluate hypotheses, and additional stations to address statistical concerns.

Figure 2.5 shows cumulative observations of surface oil between 22 April and 21 August based on imagery analyzed by the National Environmental Satellite, Data, & Information Service (NESDIS). The satellite analysis can only detect where surface capillary waves are depressed, so it can't differentiate between thick oil and transparent sheens. Based on over-flights with trained observers, only thin sheens were observed in the areas to the southeast and towards the farthest west shown in this figure. Oil on the surface moves under the influence of surface winds and currents, providing significantly more cross-shelf movement of oil than the currents alone would suggest. Combining the distributions shown in Figure 2.5 with the shoreline areas where some of the heaviest oiling occurred, potential surface movement pathways are suggested. One hypothesis is that oil may have been scavenged along these pathways by sediment-laden water or through other processes (Figure 2.6).

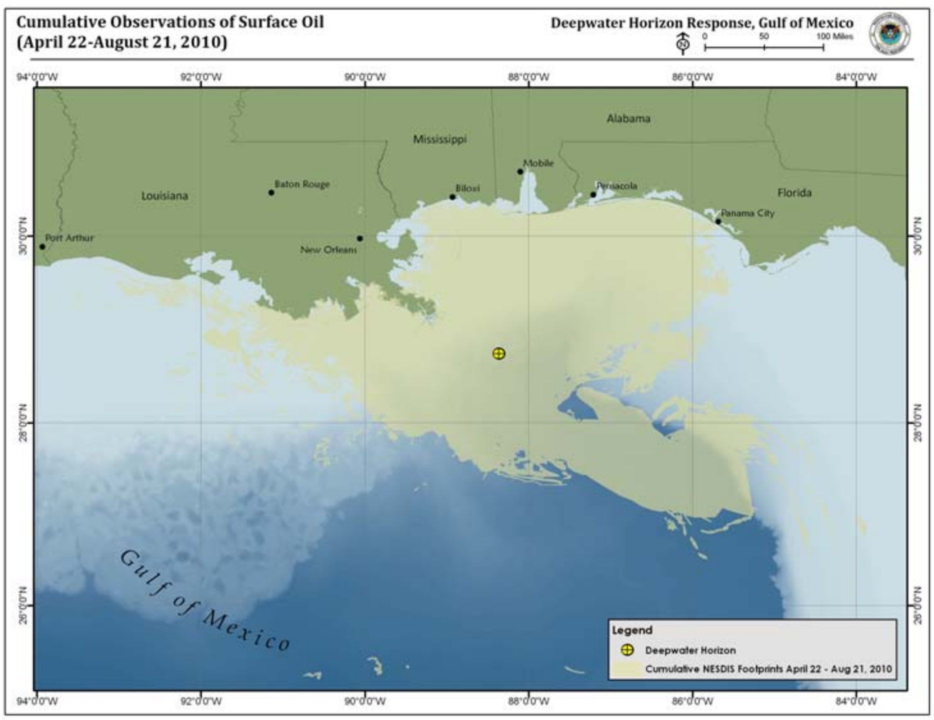

Figure 2.5. Cumulative surface oil observations from NESDIS satellite analysis. Note that thickness was not uniform, satellite analysis does not differentiate between heavy oil and transparent sheens.

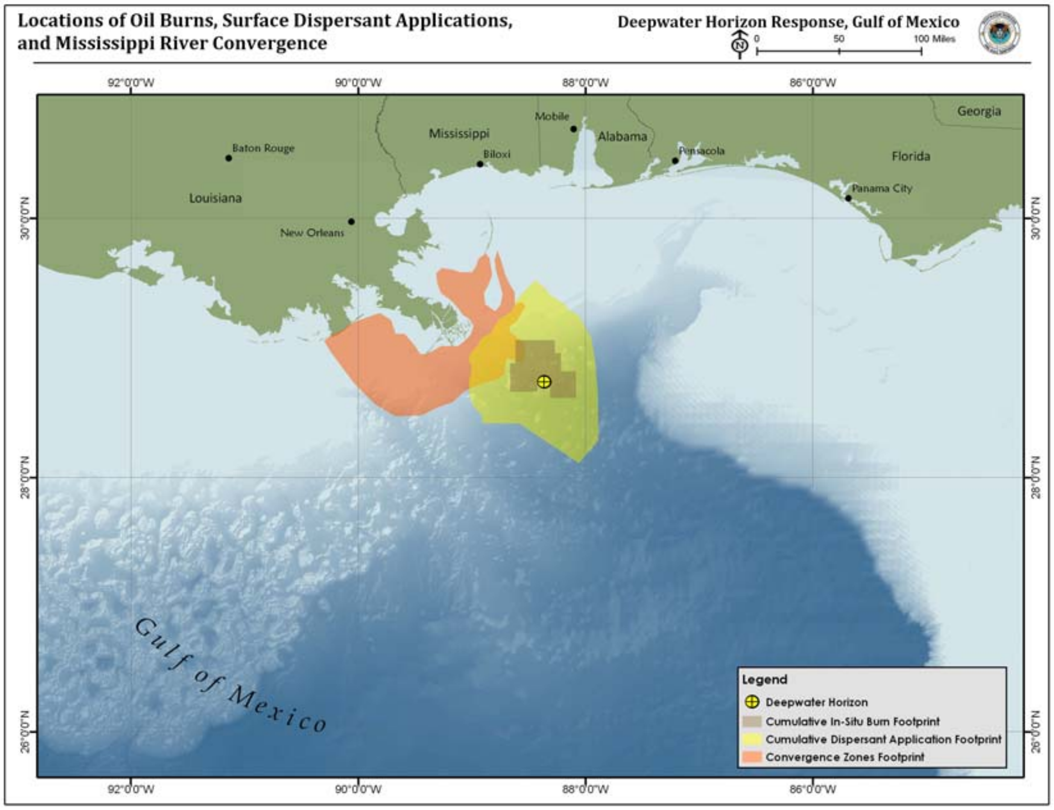

Figure 2.6 Polygons that correspond to 1) convergence areas observed off the Mississippi River Delta during times when oil was observed in the area[5]; 2) a representation of in-situ burn areas; and 3) the area where surface dispersants were applied.

In developing the final locations for sediment sampling (Figure 2.7) these factors were taken into account, in addition to considering areas of concern identified by academic researchers (e.g., Dr. Joye, University of Georgia and Dr. Holland, University of South Florida), and including locations sampled during recent cruises. In addition, circular buffers were drawn around the well spaced at 25 km intervals to allow evaluations of any possible gradient in concentrations away from the well. Offshore sampling locations were selected by considering pathways to both offshore and deep water areas of sediment.

[5] A convergence area is where surface waters come together, generally forming a line of organic scum, debris or other floating material.

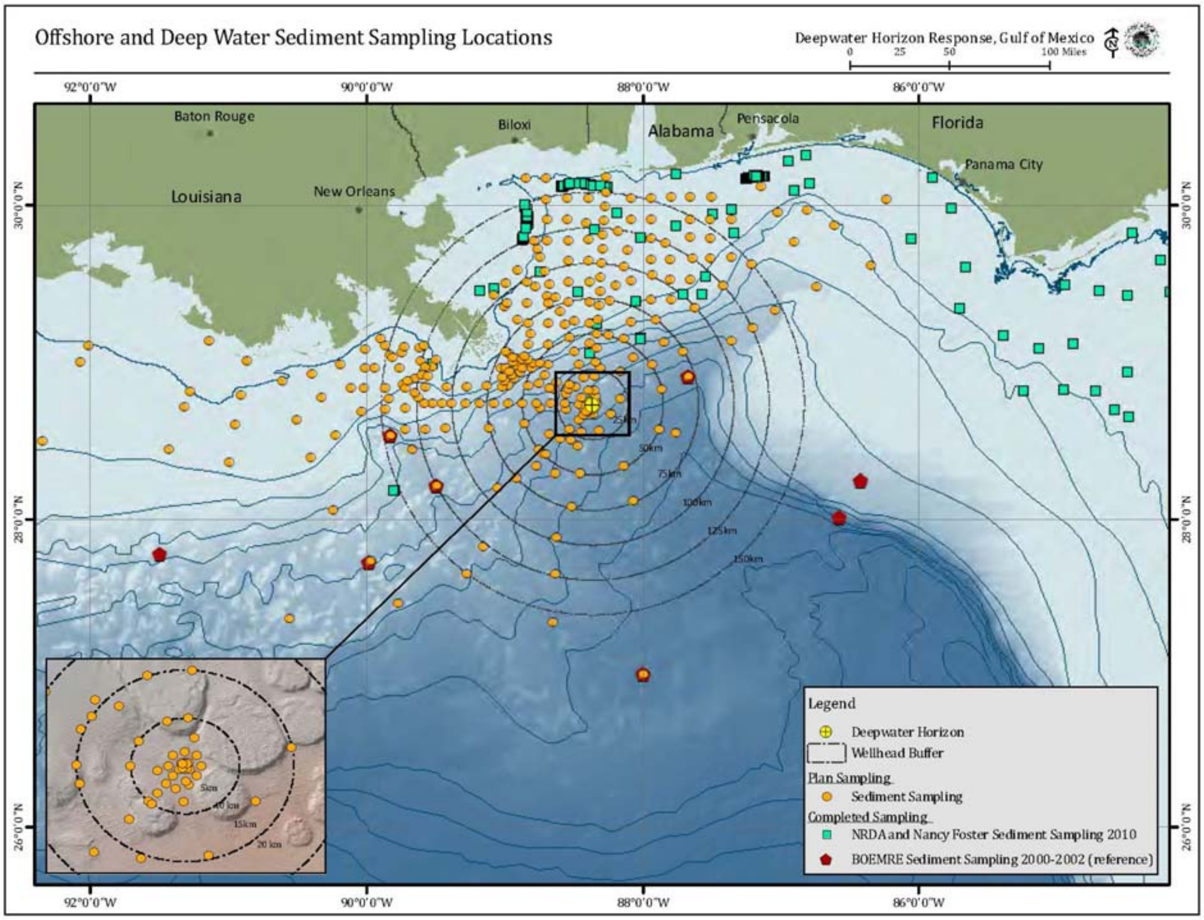

Figure 2.7 Sediment sampling locations for offshore and deep water zones.

All offshore sediment samples were analyzed for PAHs and other oil components as well as grain size, total organic carbon and dispersants. Samples in water shallower than 75m were collected using grab samplers. Samples in water depths greater than 50m were collected using multi-corers. Samples collected in depths between 50 and 75 m were sampled using both grab and multi-coring methods. Reference samples for comparison will be determined after analysis, and will likely include more than 20 locations sampled on the Eastern shelf.

In addition to sediment samples placed in the offshore area using pathway analysis and "hot spot" statistical analysis, additional sediment samples were placed on the shelf in the eastern portion of the area. These sample locations were placed along radials from the well-head and correspond to areas where oil was known to be on the surface several times between May and July, 2010.

Shipwrecks are important cultural, fishery and eco-tourism structures. The results of sediment sampling was used to evaluate the need for additional sampling or surveys of wreck sites. If there was no indication of oil in sediments in the vicinity of wrecks, further assessment would not be necessary as part of this plan. However, if additional wreck activity were undertaken, Section 106 consultation procedures for sea floor sampling to ensure protection of historic and cultural resources would be completed. If oil were detected at recreational sites, this information will also be useful for NRDA.

The offshore waters in the northern Gulf of Mexico are very dynamic, therefore sediment, rather than water column, sampling is a focus for this zone. However, for a subset of the sediment sampling locations, water samples were taken concurrently. These water sampling locations help fill in gaps from previous water sampling efforts. These offshore water samples were collected at one meter below the surface, at mid-depth, and at the sediment-water interface (bottom). Locations for these additional water samples are shown in figure 2.8.

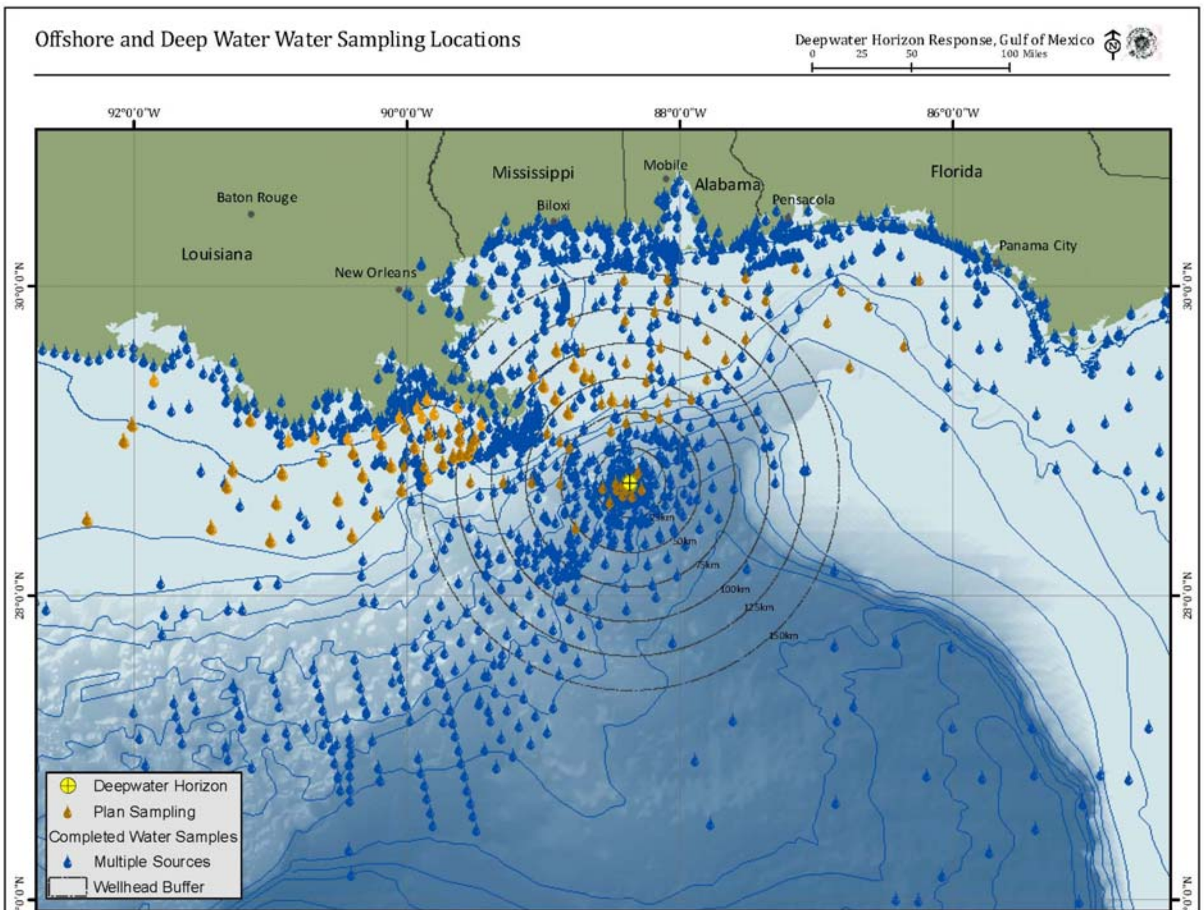

Figure 2.8. Water sampling locations in the offshore and deep water areas. Blue drops indicate areas where samples were taken prior to this Plan. Orange drops are water samples taken as part of this Plan.

2.3.3 Deep Water

Review of existing data indicated that the water in this region was extensively sampled. However, a major gap was identified in understanding the potential distribution of oil on the sea floor, including oil entrained with water-based drilling mud released into the environment as part of the top kill operation, and oil that may have been transported to the sea floor by other mechanisms, such as scavenging by denser organic matter. Evaluations of microbial degradation rates have been conducted to evaluate plume attenuation.

The water in this region is currently being sampled with a targeted and adaptive approach. Taking into account oceanographic data, modeling, and existing observations of water anomalies (fluorescent signals as an indicator of oil and dissolved oxygen as an indicator of biodegradation), and bathymetry, an adaptive sampling plan was implemented. Sampling of the water was initiated around the well head, with a series of transects radiating outward. Based on the initial water sampling results, an extended sampling area was created to the southwest.

Observations of the subsurface plume consisting of small oil particles showed significantly different movement than on the surface. Figure 2.9 is a composite of expected subsurface movement based driven with a 3D current model and confirmed with Acoustic Doppler Current Profiler (ADCP) current meter data from near the well head. Several modeling activities were undertaken to support locations for water column and sediment sampling for the deep water zone. Well blowout models were used to determine the expected height of plume separation (where the mechanical and thermal energy from the release were no longer dominating the rise of oil particles). These models indicated a height of about 300 m above the bottom for plume separation. At this level, particles that are very small (<60 microns) move with the current and rise so slowly that they essentially stay with the water mass. Several observations of fluorescence as an indicator of oil, and later dissolved oxygen as an indicator of degraded oil, confirmed this layer of dispersed droplets at 1,000 – 1,300m below the water surface. The NOAA Gulf of Mexico model was used to drive an oil trajectory model (General NOAA Operational Modeling Environment - GNOME) for this deep layer. The composite shown in figure 2.9 represents a 90 percent envelope of where any deep (1,000m-1,300m) particles were forecast to be during any time between 23 April and 15 August. On the water surface, oil can be observed and trajectory forecasts can be updated and refined based on these observations. In the deep water, observational data is significantly more limited. For this modeling effort, Acoustic Doppler Current Profilers (ADCPs) were used to confirm the general speed and direction of the NGOM current predictions.

While it would be unusual to expect sediment-laden waters at this depth, this is an area where marine snow would be at the highest concentrations. These areas were considered in selecting deep water sediment sample locations. In addition, concentrations of oil adsorbed onto drilling mud would be expected to be highest near the well head (where the oil was mixing with the mud as it was leaving the well). In depressions near the well head, higher deposition rates of marine snow and oil sorbed particles might be expected because of bathymetric channeling of the water (i.e., troughs between the salt domes and perhaps as far east as DeSoto Canyon.)

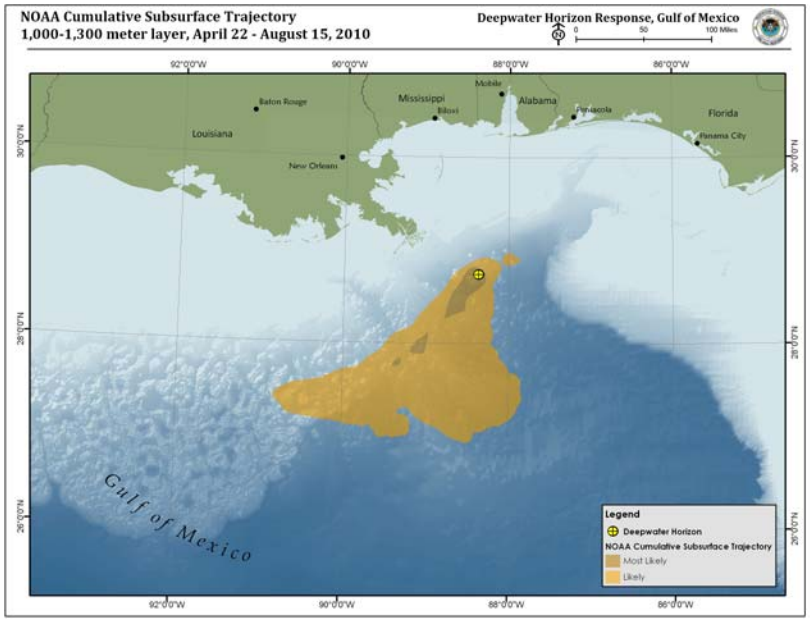

Figure 2.9 Cumulative area of model forecasts for deep water (1,000m-1,300 m) for 23 April–15 August, 2010.

The number of sediment samples analyzed in deep water was directed using a targeted instead of a statistically robust approach. A MegaCorer was employed in a radial sampling pattern starting at the wellhead. Several additional locations were selected to consider DeSoto Canyon (to build on observations from an earlier University cruise), with a higher density of samples in low lying areas where floc may accumulate, and additional samples placed to correspond to observed and modeled subsurface oil locations. Sediment samples were collected for laboratory analysis that will include oil fingerprinting, metals, PAHs and dispersant indicators. All samples were screened for toxicity using the Microtox method. Reference locations will be identified using analysis of sediment chemistry and historical sampling results.

Acoustic methods have been used to identify seeps in the well head area and will help identify sources for any detected PAH concentrations. Additional analysis in seep areas were considered to ensure that water samples would be available for fingerprinting of the oil source. Review of existing seep data was carried out to determine if adequate data already existed.

2.4 Determining Microbial Degradation Rates

Deep water sampling for analysis of microbial communities to understand degradation rates of oil compounds has been conducted to assist in interpreting deep water oil concentrations, distribution, and plume attenuation times. This work included studies by scientists at University of California at Santa Barbara and Texas A&M University (Valentine et al, 2010[6]) to investigate microbial respiration in deep water oil plumes. In June, bacterial capacity for propane and ethane biodegradation was evaluated by adding ^{13}C-labelled material into freshly collected plume waters and monitoring conversion to ^{13}C-CO_2. The plume closest to the wellhead had the highest levels of hydrocarbons and the least evidence for biodegradation, and yielded the lowest proportion of hydrocarbon degraders relative to typical bacteria present in the water column. The authors believed this represented an early stage in the bloom of hydrocarbon oxidizing bacteria. Results were presented in terms of biological oxygen demand and maximum potential propane and methane oxidation rates. In addition, Hazen (personal communication) calculated the alkane biodegradation rate coefficient to be 0.310 per day (approximately one third of the alkanes degrade each day), which is twice that reported by prior studies using the same BOD consumption of 2.7 mg/L. This work is under review by the JAG, and a report on biodegradation will be produced.

Microbial degradation is one factor in the attenuation of deep water oil plumes, in addition to mixing, dilution, and scavenging by particles. If additional biodegradation work is necessary, additional water samples will be collected in areas where oil or effects of oil degradation (low DO) have been observed, as well as reference samples from above and below the depth where the plume has been detected. If further work is deemed necessary, hydrocarbon degradation rates could be evaluated with additional ^{13}C tracer measurements, and with natural abundance isotope samples. Additional microbial community composition work could also be completed.

Sediment oil degradation may be evaluated if oil components are detected in sediment and they exceed screening benchmarks or reference concentrations, and if they are fingerprinted to MC252 oil. This will include characterizing chemical composition of sediments relative to fresh oil samples to evaluate weathering.

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[6] David L. Valentine, John D. Kessler, Molly C. Redmond, Stephanie D. Mendes, Monica B. Heintz, Christopher Farwell, Lei Hu, Franklin S. Kinnaman, Shari Yvon-Lewis, Mengran Du, Eric W. Chan, Fenix Garcia Tigreros, Christie J. Villanueva, 2010. *Propane Respiration Jump-Starts Microbial Response to a Deep Oil Spill*, www.sciencexpress.org, 16 September 2010.

3 DATA INTERPRETATION AND DECISION MAKING

Analyses performed and data collected under this plan were evaluated using the decision process in Figure 3.1.

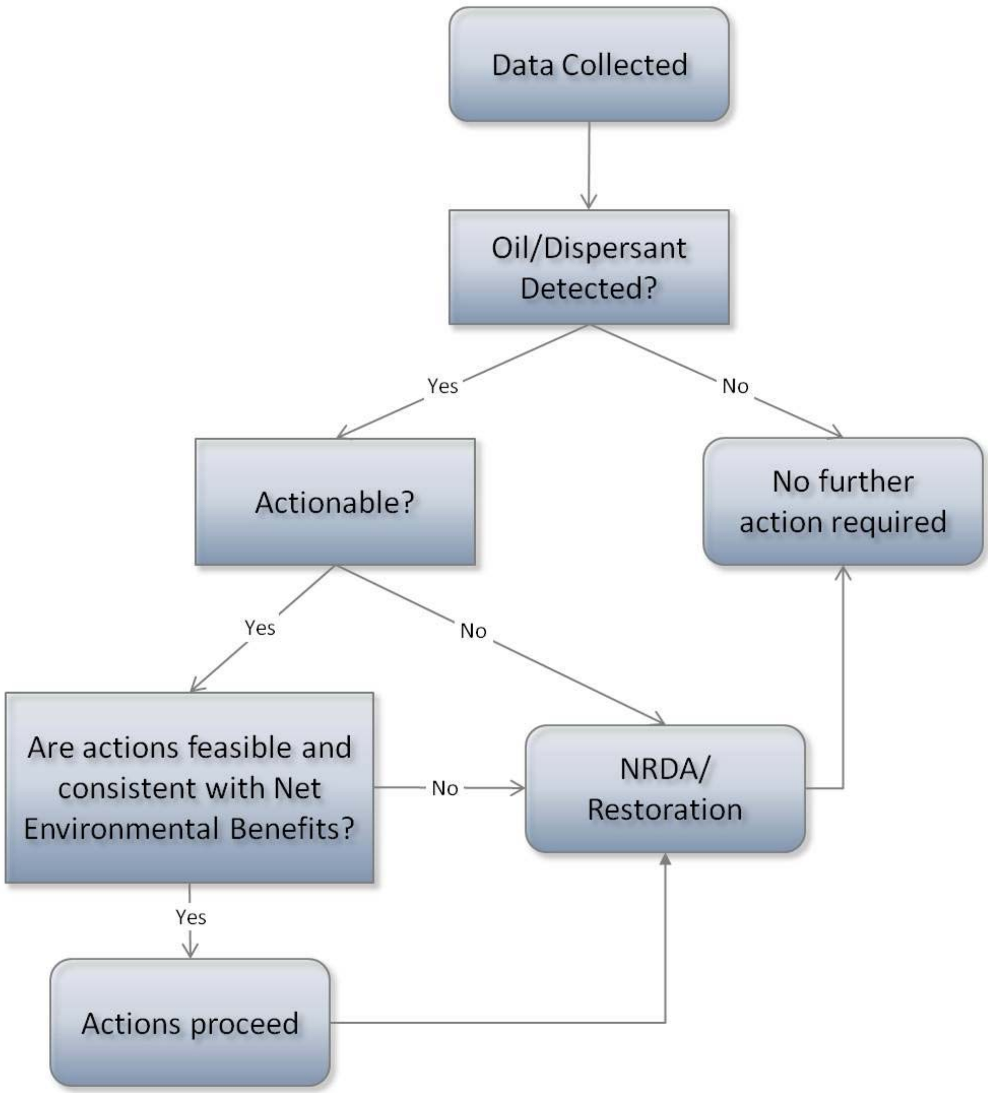

Figure 3.1 Decision process implemented by the federal on-scene coordinator (FOSC) in consultation with appropriate tribal, federal, and state authorities and trustees.

Indicators **Observations and measurements will be compared to:**			
	Nearshore	**Offshore**	**Deep water**
Water	1. Public Health Taskforce Human Health Benchmark for Child Swimmer[1] 2. Fishery closures[2] 3. Observations using qualitative methods (vipers, snares, sorbent pads) 4. EPA acute and chronic aquatic benchmarks for PAHs[1] 5. Aquatic benchmarks for dispersant compounds[3]	. 1. EPA acute and chronic aquatic benchmarks for PAHs[1] 2. Fishery closures[2] 3 3. Aquatic benchmarks for dispersant compounds[3]	1. Indicators of hypoxia <u>(dissolved oxygen concentration of ≤2.0 mg/L)</u> 2. Fishery closures[2] 3. EPA acute and chronic aquatic benchmarks for PAHs[1]
Sediment	1. EPA acute and chronic sediment benchmarks for PAHs[1] 2. Observations using qualitative methods (ponar grabs) 3. Significant toxicity to benthic invertebrates 4. Concentrations measured at the same station earlier in the year 5. Average concentrations at reference stations	1. EPA acute and chronic sediment benchmarks for PAHs[1] 2. Average concentrations at reference stations	1. EPA acute and chronic sediment benchmarks for PAHs[1] 2. Average concentrations at reference stations

Table 3.1. Indicators that will be used to assist in evaluation of data.

[1] http://www.epa.gov/bpspill/health-benchmarks html

[2] http://sero nmfs noaa.gov/deepwater_horizon_oil_spill.htm

[3] http://www.epa.gov/bpspill/dispersant-methods.html

The question of whether oil or dispersants have been "detected" at levels of concern is being evaluated using a suite of indicators, including exceedances of public health or environmental benchmarks, trends over time (comparisons between pre- and post-impact conditions), or comparisons to reference locations. These indicators did not automatically trigger decisions. Recommendations regarding interpretations and further evaluation steps were considered in the context of removal actions. Indicators are listed in the Table 3.1.

If comparisons to indicators suggested that oil was not present at levels of concern for human health or the environment, no further removal actions were required. Specific indicators for each zone and media are discussed in later sections. These indicators do not represent injuries to natural resources under NRDA authorities in OPA, which may occur at lower concentrations than specified here.

If comparisons to any of the indicators suggested that concentrations were of, several additional actions will be considered. Depending on the indicator, additional sampling or investigation could occur to verify and clarify the findings. If PAHs exceeded aquatic life criteria and sediment samples were toxic, additional sediment samples may have been suggested to further delineate the extent and magnitude of contamination. The possibility that any observed oil was from sources other than the Deepwater Horizon was also evaluated based on the results of fingerprinting studies. If indicators suggested that concentrations were of concern, and oil fingerprinting evaluations indicated that the source was the Deepwater Horizon, further removal actions were considered and evaluated. If oil were detected, additional microbial degradation rate or attenuation information was considered to determine potential recovery timeframes and inform response actions. In addition, data collected to support other non-response efforts (i.e., NRDA or research) was used to inform a better understanding of observed oil distribution or attenuation (e.g., sediment traps placed for NRDA work may be useful in evaluating sedimentation rates.) In making response decisions, oil, dispersants, or oil contaminated sediments were evaluated as to whether they would be considered "actionable" based on several factors, including feasibility/practicality and "Net Environmental Benefit," specifically considering the following:

1. The recovery/removal/treatment action would not present an undue safety risk to response personnel.
2. The recovery/removal/treatment actions would not cause or increase injury to adjacent habitat or resources.
3. The recovery/removal/treatment action would decrease the recovery time of the threatened resource or habitat over either natural attenuation of the contaminant or the NRDA process.

The determination of whether response actions were necessary will be made based on the best professional judgment of the FOSC, under authorities described in the Federal Water Pollution Control Act and OPA90, which includes consultation with Natural Resource Trustee agencies. If response actions were implemented, additional data collection could be required to document effectiveness of the action. However, given that time is of the essence for response efforts, every effort was made to expeditiously analyze and interpret the data and provide recommendations.

3.1 Nearshore Indicators

3.1.1 Water Quality

The EPA aquatic life benchmarks and Public Health Taskforce Human Health Benchmark for Child Swimmer provide screening information to identify the need for further evaluation of sampling data. Texas, Louisiana, Mississippi, Alabama, and Florida have additional criteria to assess water quality. Each of these benchmarks include thresholds for multiple individual chemical. For example, there are 13 specific chemical benchmarks developed to protect child swimmer health. While these specific benchmarks do not represent all the possible components that may be detected, they do represent some components of the crude oil mixture. Water samples were compared to the established aquatic life or Child Swimmer screening level benchmarks as appropriate, and exceedances reported to state and local health officials to determine the need for further evaluation or other actions.

The human health benchmarks represent water concentrations of individual chemicals that, if not exceeded, are considered acceptable for the exposure scenario based on conservative assumptions. These values were derived using toxicity information to evaluate cancer and non-cancer risks) from studies of the individual chemicals. Toxicity information for the complex and varied mixture of chemicals that are found in crude oil is not available. There is uncertainty regarding the level of protectiveness of these benchmark concentrations, and benchmarks are not available for all compounds.

Evaluating fisheries re-openings and sustained seafood safety provides an additional, indirect measure of nearshore water quality for public safety. National Marine Fisheries Service (NMFS), in conjunction with the U.S. Food and Drug Administration (FDA), makes determinations regarding seafood safety using results of sensory and chemical analysis of various fish collected throughout the area. The areas where fish are being sampled to evaluate seafood safety are shown in Figure 3.2.

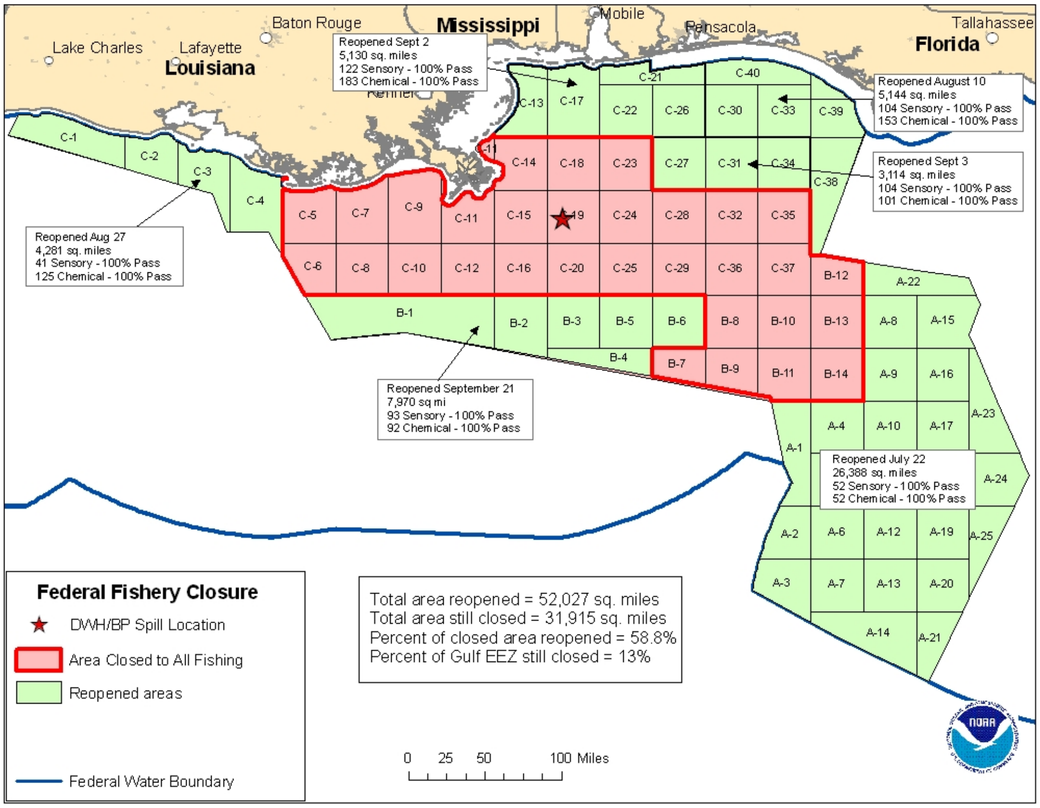

Figure 3.2 Seafood Safety Sampling Areas (closure area is as of 21 September 2010.)

The quality of nearshore waters is also being evaluated using snare sentinels and sorbent pads deployed along areas of the coast. If oil is not observed using these qualitative methods , this indicator provided a line of evidence that migrating or actionable oil was not present. If oil were observed using qualitative methods, verification through chemical analysis of additional water or sediment grab samples would be recommended. T systems have been in place for several months and have been checked every three to five days.

Individual water samples collected in nearshore areas are also being compared to EPA acute and chronic aquatic life benchmarks for PAHs. These thresholds are based on data from aquatic toxicity tests and best scientific judgments. Acute benchmarks use toxicity tests from 8 different taxonomic families of marine/estuarine aquatic life in which mortality or immobility was the test endpoint. Acute benchmarks represent the highest one-hour average concentration that should not result in unacceptable effects on aquatic organisms. Chronic benchmarks are based on toxicity tests using the same organisms as acute tests, but they consider long-term survival, growth and reproduction of marine/estuarine aquatic life. Chronic benchmarks represent the highest 4-day average concentration that should not result in unacceptable toxicity during a long time event.

Data interpretation methods for comparison of water samples to child swimmer benchmarks and acute and chronic aquatic life benchmarks include comparisons of individual values in data sets under consideration to individual and composite benchmark values (for example, individual PAH concentrations and benchmarks, as well as comparisons to benchmarks for total PAHs). Statistical comparisons among water concentrations in different areas will be examined as appropriate.

Comparisons to aquatic life benchmarks are being used to evaluate the need for additional sampling to determine the extent and magnitude of PAH concentrations in water. The possibility that any observed oil is from sources other than the Deepwater Horizon was also evaluated based on the results of fingerprinting studies. Samples were also compared to the screening level for dispersant compounds. Results are being shared with NMFS and FDA as needed to evaluate seafood safety screening needs.

3.1.2 Sediment Quality

In waters with high suspended sediment concentrations, oil may be scavenged and deposited to the seafloor. Oil stranded on shorelines or in marshes may be washed back into the environment by storms and tides. Marshes may also export oil combined with organic material. These are natural processes associated with coastal environments. To inform response decisions, observations will be compared to several indicators that suggest the presence of oil in nearshore sediment.

Sediment PAH concentrations in individual samples is being compared to EPA sediment benchmarks. These indicators represent multiple individual chemical thresholds (for example, there are 43 specific chemicals in the benchmark table). Many sample locations were sampled in May and re-sampled in September and October. For these stations, comparisons with prior concentrations of PAHs will be made. Concentrations of PAH in sediment at individual stations will also be compared to the average PAH concentrations at reference locations. Statistical comparisons between pre- and post-impact nearshore conditions for each state will be evaluated, as well as comparisons among individual state and reference locations. If concentrations exceed sediment benchmarks, previously reported values, or those at reference locations, additional sediment characterization could be recommended to confirm sources and delineate extent and magnitude. The possibility that any observed oil is from sources other than the Deepwater Horizon will be evaluated based on the results of fingerprinting studies.

Additional qualitative data indicators of oil in sediment or bottom waters include qualitative screening of sediment from ponar grabs. If oil is observed in grabs, this could be an indicator of the presence of actionable oil. Chemical analysis of these samples would then be considered.

Finally, nearshore sediment samples are being tested for potential toxicity to invertebrates. Observed toxicity that is significantly greater than control samples will be evaluated as an indicator of oil contamination. However, it is possible that toxicity is due to other contaminants. The possibility that any observed oil is from sources other than the Deepwater Horizon will be evaluated based on the results of seep and fingerprinting studies. Statistical comparisons among sediment toxicity in different areas will be examined as appropriate, including comparisons with toxicity at reference locations. Additional sediment characterization may be recommended where sediments are observed to be toxic if it appears that toxicity is related to the presence of oil compounds from the Deepwater Horizon.

If Deepwater Horizon oil is present in nearshore sediments at concentrations of concern, additional microbial degradation rate studies may be recommended to evaluate recovery timeframes.

3.2 Offshore Indicators

3.2.1 Water Quality

The EPA aquatic life benchmarks provide appropriate indicators to assess potential aquatic life risk. Water samples are being compared to the established aquatic life benchmarks as appropriate. Evaluating fisheries re-openings and sustained seafood safety provides an additional, indirect measure of water quality for public safety. NMFS, in conjunction with FDA, makes determinations regarding seafood safety using results of sensory and chemical analysis of various fish collected throughout the area.

Data interpretation methods for comparison of water samples to acute and chronic aquatic life benchmarks include comparisons of individual values in data sets under consideration to individual and composite benchmark values (for example, individual PAH concentrations and benchmarks, as well as comparisons to benchmarks for total PAHs). If samples exceed these standards, additional testing to determine the extent and magnitude of PAH concentrations could be recommended. Exceedances of water quality benchmarks could result in further evaluations of seafood safety (results will be discussed with NMFS and FDA). The possibility that any observed oil is from sources other than the Deepwater Horizon is also being evaluated based on the results of fingerprinting studies. Samples are also being compared to screening levels for dispersant compounds. At least one indicator of dispersants, either Diocytlsufosuccinate or Di(Propylene Glycol) – Butyl ether is considered to evaluate dispersant presence. Results indicating oil presence are being shared with NMFS and FDA to evaluate seafood safety screening needs. Statistical comparisons among water concentrations in different areas will be examined as appropriate (for example, along transects away from the well-head).

3.2.2 Sediment Quality

Sediment PAH concentrations in individual samples are being compared to EPA sediment benchmarks and average PAH concentrations at reference locations. Stations where PAH concentrations exceed benchmarks and reference concentrations are potential indicators of the presence of oil. If concentrations that exceed sediment benchmarks or reference concentrations are observed, additional sediment characterization could be recommended to delineate extent and magnitude and verify the source of contamination. The possibility that any observed oil is from sources other than the Deepwater Horizon are also being evaluated based on the results of fingerprinting studies. In addition, statistical comparisons among sediment concentrations in different areas will be examined as appropriate (for example, along transects away from the well-head). If Deepwater Horizon oil is present in offshore sediments at concentrations of concern, evaluation of oil weathering may be conducted.

3.3 Deep water Indicators

3.3.1 Water Quality

Delineation and quantitative characterization of the deep water sub-surface dispersed oil includes oxygen concentrations, fluorescence as an indicator of oil pollution, and analytical chemistry. Monitoring for fisheries re-openings and sustained seafood safety provide an additional, indirect measure of water quality for public safety. NMFS, in conjunction with FDA, makes determinations regarding seafood safety using results of sensory and chemical analysis of various fish collected throughout the area.

The potential for hypoxic conditions to develop is an indicator of the potential presence of actionable oil in the deep water zone. This indicator is represented by dissolved oxygen concentrations less than or equal to 2.0 mg/L. Samples that exceed EPA acute or chronic aquatic water quality benchmark concentrations for PAHs also indicate a potential concern for water quality. It should be noted that water quality benchmarks are developed based on toxicity tests using commonly occurring coastal species, such as bivalves, minnows, and flatfish (although copepods are included in the database). The breadth of taxa evaluated in establishing aquatic life benchmarks is intended to provide protection for most species. Because the toxicity of PAHs to deep sea organisms have not been well studied, the protectiveness of these benchmarks for the deep sea environment is less certain.

Data interpretation methods for comparison of water samples to acute and chronic aquatic life benchmarks include comparisons of individual values in data sets under consideration to individual and composite benchmark values (for example, individual PAH concentrations and benchmarks, as well as comparisons to benchmarks for total PAHs). The possibility that any observed oil is from sources other than the Deepwater Horizon is also being evaluated based on the results of fingerprinting studies. Results indicating oil presence are being shared with NMFS and FDA to evaluate seafood safety screening needs. Statistical comparisons among water concentrations in different areas are being examined as appropriate.

Results of microbial degradation rate studies may be applied to interpret and evaluate findings, and can be used to estimate plume attenuation if concentrations are above levels of concern.

3.3.2 Sediment Quality

Deep water sediment quality samples were taken to address the concerns that oil may have mixed with water-based drilling mud released into the environment as part of the top kill operation, or transported to sediments by scavenging by denser organic matter. Samples are being fingerprinted and quantified by detailed chemistry to assess origin and PAH concentrations as appropriate

Sediment quality benchmarks and average PAH concentrations at reference locations are used as indicators of the presence of oil at levels of concern. Sediment PAH concentrations in individual samples are being compared to EPA sediment benchmarks and to average reference station concentrations. The possibility that any observed oil is from sources other than the Deepwater Horizon will also be evaluated based on the results of fingerprinting studies. In addition, statistical comparisons among sediment concentrations in different areas will be examined as appropriate (for example, along transects away from the well-head). If Deepwater Horizon oil is present in deep water sediments at concentrations of concern, evaluations of oil weathering may be conducted to estimate long term fate of the oil identified.

3.4 Documenting Decisions

As it becomes available, the On-scene Science Advisory Team (OSAT) is reviewing data and information to compare results with indicators. Recommendations based on these comparisons are being made to the FOSC via the scientific support coordinator (SSC) and the project manager. Recommendations include a summary of data and information collected and reviewed, comparisons to relevant indicators, and interpretations regarding the presence of oil and/or dispersants. If the presence of oil and/or dispersants is indicated, recommendations regarding any further activities needed to verify and clarify the findings are included (a format for this report is included in Appendix G).

Findings that inform seafood safety evaluations are communicated to NMFS and FDA by the SSC. NMFS evaluates the need for further sampling to determine changes in fishery closures.

The FOSC reviews the OSAT recommendations and evaluates whether further removal actions are required based on any detected oil and/or dispersants, whether the findings indicate the presence of oil and/or dispersants attributable to the Deepwater Horizon, or whether more information is required.

If no further removal actions are required based on the lack of detected oil or dispersants, the FOSC documents these findings in a memo.

If the presence of oil and/or dispersants is indicated, the FOSC evaluates feasibility, practicality, and Net Environmental Benefit factors, and documents the findings in a memo. This memo then is briefed to the federal and state trustees and parishes before being published by the UAC.

If more information is required, the FOSC will direct further activities.

4 COMMUNICATIONS

The NIC and FOSC have identified the sub-surface monitoring program as central to determining the presence of actionable concentrations of oil that would then guide response actions, and to inform follow-on restoration and recovery efforts. Effectively communicated, the results of the program serve as a means of informing the public about the unified response, seafood safety, and the future of the Gulf. Additionally, this process provides further information to Gulf stakeholders looking to understand the ultimate fate of the oil.

4.1 Goals

There are three communications goals in support of this Plan; 1) transparency and timeliness, 2) engagement with the scientific community and 3) making science accessible to the public. Several outreach activities have been and will continue to be implemented throughout the course of subsurface sampling and analysis efforts to ensure these goals are met.

To support these goals, a communications team has been established that works closely with the UAC (and previously with the JIC), OSAT and SMU to ensure that relevant information is conveyed to the public and other constituents in a timely and efficient manner. This team is managed out of the UAC and includes representation from USCG, NOAA, PHS and other agencies as appropriate.

The communications team will present information on http://restorethegulf.gov to effectively communicate about this effort and provide information on how to access oceanographic and analytical chemistry data.

The communications team supports online, media, and constituent communications with the production of fact sheets, frequently-asked-questions, talking points, videos, graphics, photos, feature stories, vignettes, and/or presentations.

The communication team conducts regular community meetings and media briefings to:

- Update the status of sampling and monitoring data, including the release of new data
- Announce new scientific findings or results
- Highlight academic and private research institution partnerships
- Introduce and explain specific topics
- Educate the public on sampling program and techniques

The team engages and informs local communities and constituencies by participating in local forums. In particular, collaboration with academic and private research institutions for this outreach is promoted whenever possible.

4.2 Data Management and Access

Since April 20, 2010, a significant amount of data have been collected related to oceanographic conditions, oil observations, and chemistry. These data are presently not all available from a single source, nor are these sources consistent in their ability to view, sort and search the data. A separate Data Management Technical Addendum to this plan will be developed to describe how the data will be archived and made more easily accessible. At present and during the development of this Data Addendum, a number of websites will be maintained to ensure access to data.

Figure 4.1 shows the present flow of data. Oceanographic data are available through NODC (http://www.nodc.noaa.gov/General/DeepwaterHorizon/support.html). Analytical chemistry for water column and sediment data are received from the data providers and are posted to http://www.GeoPlatform.gov as available. Analytical chemistry data will also be available at the NODC web site provided above. When the Data Management Technical Addendum is completed, notice and links will be provided through http://restorethegulf.gov.

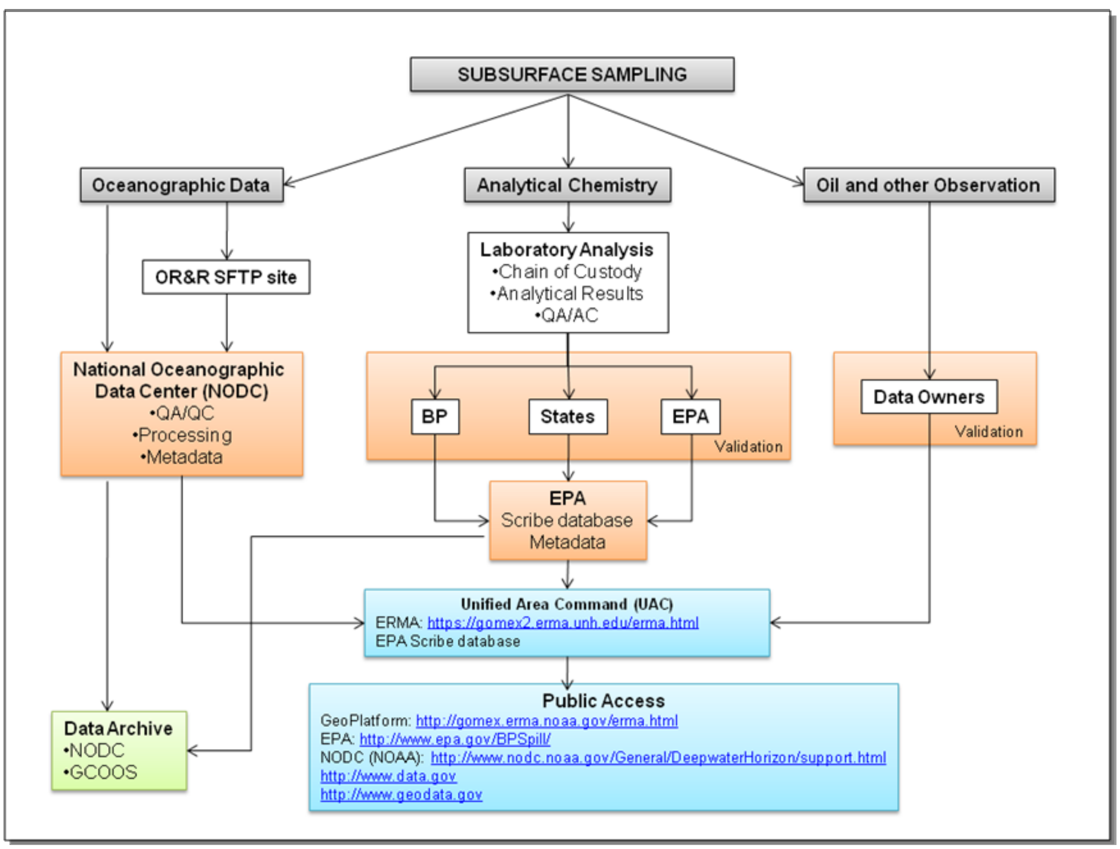

Figure 4.1 General Data Flow as of 30 September 2010.

5 ROLES, RESPONSIBILITIES, AND PARTICIPATION

Sub-surface and sub-sea monitoring and analysis efforts will continue to be executed by an interagency team, at the direction of the FOSC. All of the participating agencies and organizations listed in this section are essential to this mission and each has a unique role.

5.1 State Agencies

The States of Texas, Louisiana, Mississippi, Alabama, and Florida have been involved in the sampling of their waters from the beginning of the response and continue to be engaged in adapting the sampling plan within their waters should adaptive sampling be required. Additionally the States provide baseline data for use in making response decisions. These States are also engaged in outreach to inform the public about this monitoring effort.

5.2 Federal Agencies

The federal agencies charged with regulatory oversight, as well as those with substantive interest in this response, have been engaged within the UAC and the ICPs in the creation and implementation of sampling plans and continue to be engaged in this mission through the interagency team established in Section 9, the Operational Science Advisory Team (OSAT). Below is a description of each agency's role and their affiliation with OSAT:

- United States Coast Guard (USCG): As the lead agency during the response, USCG maintains overall command and control via the FOSC. The USCG serves as a permanent member of OSAT.
- National Oceanic and Atmospheric Administration (NOAA): As stated in the NIC's Directive of 13 Aug 2010, NOAA leads operations for this mission. NOAA's leadership responsibilities include designing sampling plans (with support by numerous partner agencies) and executing those plans, as well as developing and implementing the communications strategy. Additionally, NOAA provided for Federal representatives on sampling missions and will coordinate the recovery of direct response activity costs incurred by formal academic partners. NOAA is a permanent member and the lead of OSAT.
- Environmental Protection Agency (EPA): EPA provides technical expertise in chemistry, toxicology, and data management. Additionally, EPA designed statistically valid sampling plans for nearshore and offshore water and sediments. EPA will continue to maintain data in the Scribe database during the response mission and will develop data management and data sharing policies, with the goal of eventually transferring Scribe data to another organization to provide public access in on a long term basis. EPA is a permanent member of OSAT.

- United States Geological Survey (USGS): USGS provides expertise on marine sediments and helped develop protocols for conducting sediment sampling. USGS serves as a permanent member of OSAT.
- Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE): As the federal agency that manages the nation's natural gas, oil and other mineral resources on the outer continental shelf, BOEMRE has provided acoustic amplitude interpretation in the near field (within 40 kilometers of the wellhead) and GOM sediment sampling locations. BOEMRE also shares baseline sediment and water chemistry information for this region in the GOM and serve as a permanent member of OSAT.
- National Science Foundation (NSF): As the academic liaison, NSF works with the academic community to engage independent research scientists during the Response. The agency identifies scientists from academic institutions that are able and willing to spend time at the UAC to help communicate response activities to the academic community and assist in identifying research scientists in the Gulf who might collaborate with the response mission by conducting research or sharing previously collected data. NSF serves as an advisor to OSAT.
- United States Public Health Service (USPHS): USPHS assists in defining indicators based on human health standards. USPHS provides advisory support to OSAT.
- United States Food and Drug Administration (FDA): FDA coordinates with NOAA-National Marine Fisheries Service (NMFS), state health agencies, USPHS, and the UAC to ensure results of sub-surface and sub-sea monitoring are effectively incorporated into food safety decision-making and informational bulletins.
- Office of Science and Technology Policy (OSTP): OSTP helps guide interagency coordination within this mission, and may also help coordinate the development of long-term science needs for the GOM.
- United States National Park Service (NPS): NPS participated in plan design and execution. The NPS has also been designated by the FOSC to act as the Historic Properties Specialist (HPS), to oversee Section 106 compliance, and to provide overall guidance on the protection of historic properties, including shipwrecks and submerged cultural resources.
- United States Fish and Wildlife Services (FWS): FWS participated in plan design and execution review to ensure operations did not violate any FWS enforced regulations.

5.3 Responsible Party

BP, as a Responsible Party (RP), is providing data it has collected and continues to collect for the response as well as providing assets to conduct the required sampling. In addition, the RP provides technical expertise as a permanent member of OSAT.

5.4 Academic and Private Institutions

Academic and private institutions have a unique contribution to make to this response plan. This includes open sharing of information and data, and consulting with and involving independent scientists in missions when feasible and appropriate. Engagement and involvement with academic and private institutions is described in more detail in section 6.

5.5 Operational Analysis

5.5.1 Operational Science Advisory Team (OSAT)

The OSAT is a small group charged with providing analysis of data from the sub-surface and sub-sea monitoring effort to the FOSC. The role of this group is to inform the FOSC (via the Environmental Unit, the NOAA Science Support Coordinator and the Project Manager) in a timely manner about indicators and trends in the data. This specialized team within the UAC provides the crucial link between the directed daily review of data, results, and the path to the SSC and FOSC on indicators to inform response decisions.

The initial task of this group is to review all relevant data collected thus far (including papers and studies relevant to the half-life of the source oil, and dispersant application data). If necessary, the OSAT works with supporting statisticians to compare results to indicators, and to evaluate fingerprinting data. After initial evaluation, the OSAT makes regular recommendations on sampling gaps based on data collected thus far, and planned execution of the sub-surface and sub-sea monitoring efforts. States are given an opportunity to review recommendations and provide comments prior to submission to the UAC.

The team primarily focuses on the most recent findings and translating them to tactical recommendations for the sampling missions. The team also provides a weekly written report to the SSC to present to the FOSC on the progress made towards plan indicators in the past seven days. The OSAT makes presentations to the JAG via telephone or video conferences to present expected upcoming major recommendations, the JAG provides input and concerns to these recommendations within 12 hours. The OSAT uses the JAG as a source of expertise, thus ensuring access to other Federal and academic scientists for specific issues.

OSAT is comprised of six permanent members: NOAA, USCG, BOEMRE, EPA, USGS and the RP. These members are matched to six specific scientific specialties needed to analyze data on a daily basis. The JAG and Public Health Service may also advise the OSAT. In addition to the permanent members, expertise from other agencies or the JAG may be requested by the SSC and may rotate through as appropriate to the issues at hand. Members will work at UAC and report to the Scientific Support Coordinator (SSC) and the Environmental Unit.

5.6 Joint Analysis Group

The Joint Analysis Group (JAG) for surface and sub-surface oceanography, oil and dispersant data is a working group with membership from key agencies, including NOAA, EPA, USGS, and OSTP. The JAG members are located throughout the country and meet via conference call.

The JAG was formed to analyze sub-surface oceanographic data being derived from the sampling efforts by private, federal and academic scientists. The goal of the JAG is to provide comprehensive characterization of the GOM sub-surface conditions as well as the fate and transport of dispersed petroleum as a result of the Deep Water Horizon oil spill.

The JAG is not a research group or activity, but is an analytical team. The JAG analyses are provided to the UAC in direct support of the response efforts related to the sub-surface monitoring and mitigation in matters such as the placement of booms, use of sub-sea dispersants, skimming activities, modeling requirements (parameters and locations), and any UAC informational needs. The JAG processes the data, provides quality control/quality assurance, and incorporates the results into visualization and mapping applications. As the data form a clearer picture, the results are published in reports for the UAC and the public and provided in ERMA and Geoplatform.gov as well as published at http://ecowatch.ncddc.noaa.gov/JAG. External academics may provide input and expertise and are invited to weekly JAG meetings.

The JAG has developed a consistent set of data standards and an electronic database from which the analytical team can draw information on depth, salinity, temperature, oxygen, fluorescence and oil concentration data, as well as other oceanographic parameters. Additionally, the JAG may include additional data sources in their analysis such as observations gathered by ocean gliders, Acoustic Doppler Current Profilers (ADCPs) and shipboard acoustic data.

6 ENGAGEMENT WITH ACADEMIC AND PRIVATE RESEARCH INSTITUTIONS

Academic and private research institution scientists (hereafter called 'academic scientists') strengthen and complement the knowledge, tools and technology otherwise available to the UAC. This section describes some of the numerous ways that academic scientists have and will continue to be involved in subsurface monitoring for oil and/or dispersants. Notably, academic scientists have contributed directly to the formulation of the plan via four meetings held in the Gulf region, additional in person and on-line meetings to review drafts of the plan, and submission of comments on drafts. Over 50 academic scientists provided written comments on earlier versions of this plan. This input has helped refine the plan.

During the current phase of the response, there has been an immediate need for free and rapid exchange of information relevant to the characterizing actionable oil and dispersants and their breakdown products in the near shore, offshore, and deep water environments. To that end, the UAC has worked to engender collaborative alliances with members of the US academic community. These collaborations are valuable and will continue during the execution of the sub-surface monitoring plan.

Major collaborations that have occurred so far, or are ongoing, include:

- Participation by numerous scientists from the academic community on monitoring expeditions in the Gulf of Mexico. Expeditions focused variously on locating, quantifying and imaging subsurface oil, characterizing the loop current, and monitoring protected species.
- Academic representation on the JAG: Academic scientists with expertise on oceanography, ecology, and environmental chemistry provide weekly input to the Joint Analysis Group (JAG).
- Participation of university-based scientists with expertise in pre-spill state of the GOM: Numerous academics have agreed to share their substantial environmental data archives in support of the response. Most of these data date from the 1990s; a few extend as far back as the first quarter of the 20th Century.
- Exchange of information and data regarding ongoing missions: A number of university scientists who have recently received funding to study the chemistry, microbial ecology, hydrodynamics, and sedimentology of the oil spill have provided data and discussion on their research activities.
- Communications and information exchange at sea: In the early weeks following the DWH rig explosion, UAC secured arrangements with several academic scientists to coordinate sea-going activities in the GOM. The UAC also provided logistical help for NSF-UNOLS cruises.

- Chief Scientist Support: Academic researchers have agreed to serve as chief scientists on non-UNOLS mission agency-funded monitoring and assessment cruises.
- Environmental Unit liaison: Through NSF coordination, an academic liaison has provided on-scene support to the UAC Environmental Unit. This role has been invaluable in providing additional expertise and skills to the Environmental Unit, as well as providing a more direct link between the UAC and academia. For example, in addition to contributing to discussions on implementing deep water sediment sampling, the academic liaison negotiated the set-aside of one core from each multi-corer collection site for later academic access.
- IOOS ocean glider data from Rutgers University, University of Delaware, University of South Florida, University of Southern Mississippi, Monterey Bay Aquarium Research Institute (MBARI), University of Washington, WHOI, Scripps and iROBOT have been collected and used by mission modeling teams since May.
- The University of California Santa Barbara has conducted microbial degradation and community structure research since May 2010, yielding the most comprehensive set of data to date regarding the acute impacts of the DWH spill to the biological community.

Many of the ongoing collaborations will continue and, in addition, the sampling activities described in this plan were implemented with the involvement of academic and private researchers using the following approach:

- NSF Rapid Grants relating to the spill (listed in Appendix E) will be evaluated to identify which projects closely intersect with activities under this plan. There are several grants that relate to marine snow and sedimentation (University of Southern Mississippi and University of California, Woods Hole Oceanographic Institution, Stony Brook University), some projects that determine benthic impacts (University of Georgia, and University of Southern Mississippi); and many that assist in determining microbial degradation rates (University of Maryland, University of Oklahoma, Massachusetts Institute of Technology, University of South Carolina, Oklahoma State University, Stony Brook University, Florida State University, University of Colorado, University of North Carolina, University of California Santa Barbara).
- The sections of the plan relating to these grants will be shared with the RAPID grant recipients to coordinate their work with appropriate mission components.
- The Southeastern Universities Research Association (SURA), IOOS Regional Associations (SECOORA, GCOOS, and CaRA), Gulf of Mexico Alliance, and other key institutions will be asked to assist with education and outreach, community engagement, and evaluation of long-term science priorities subsequent to the response phase.

It is anticipated that academic scientists will continue to participate in the monitoring, analysis and evaluation steps of the plan.

7 PRODUCTS, METRICS, AND REPORTING

7.1 Products

The products listed below are intended to communicate findings and results to the scientific community and the public, and inform other science-based monitoring strategies including the seafood safety and monitoring, and to make data available in an easily accessible format in a timely manner. Map-based and tabular products have been developed for three primary purposes: briefings to the FOSC to inform the decision-making process; operational and analysis activities; and public information.

The Environmental Unit maintains a comprehensive map showing all observation points and sampled locations to-date (Figure 7.1). All maps proposed in this section are produced and printed on a weekly basis and made available to the UAC in printed form and in digital form, including via ERMA, and to the public via printed form and relevant response web sites, including ERMA's public face, GeoPlatform.gov. Each map is accompanied by summary statistics.

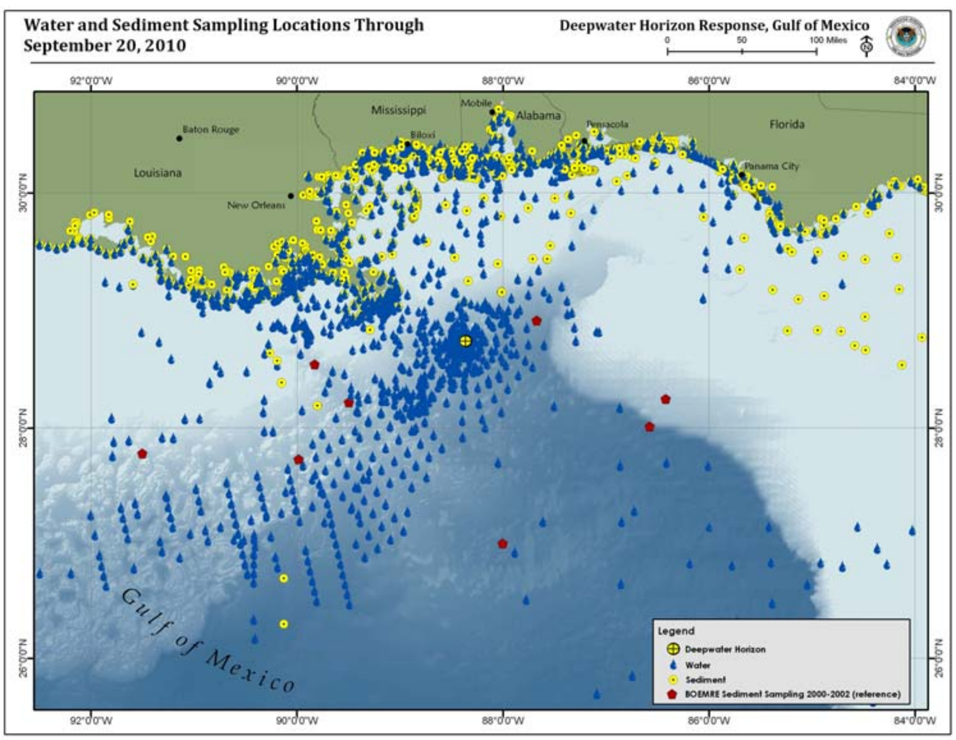

Figure 7.1 Comprehensive map of all observation points and sampled locations as of 20 September 2010. Points include sediment, surface water and water column. This map is produced on a weekly basis.

7.1.1 Information Products

The Communications Team works closely with the science team members to produce and distribute informational products through a range of channels. These products could include both printed and web-based versions of customized maps, informational, and video. Initial informational sheets will include an overview of sub-surface monitoring activities and results, an overview of relevant ocean dynamics, and an overview of technologies applied in sampling activities. Subsequent informational sheets are determined by the FOSC and public audience needs.

7.1.2 Metrics

Each week a metrics summary table is produced for inclusion in reporting requirements transmitted to the Department of Homeland Security. The metrics summary includes progress towards indicators and will be used to inform the Unified Command, state, branch, parish and public stakeholders about the number of samples that have been collected for each parameter. This is closely aligned with the Communications Strategy associated with this Plan. The number of quantitative samples yielding values above established aquatic life and public health thresholds will also be presented.

7.1.3 Reporting

The OSAT produces brief progress reports three times weekly and presents any recommendations on additional sampling needs, and science issues relevant to any potential response actions. Each week the OSAT also produces a summary report detailing progress on indicators for each element of the sampling plan (See Appendix G for a sample report format).

As per the referenced directives, comprehensive synthesis reports will be produced by the Joint Analysis Group (JAG). These reports will address needs of the UAC.

Each week the UAC reviews information provided by the SSC summarizing progress on indicators. Recommendations come to the FOSC from the OSAT via the SSC. Once a science-based decision is reached by the UAC, a formal memorandum is produced to detail the information collected quantifying the parameter, current conditions relative to any measurable endpoints, and explanation of final resolution for each sampling activity.

7.1.4 Schedule for Delivery and Review of Initial Operational Products

Product	Production Schedule	Responsibility
Metrics Report	Weekly (At a Glance)	Delivered by: OSAT Reviewed by: SSC
OSAT Recommendations, Appendix G	Two times weekly	Delivered by: OSAT Reviewed by: SSC
Sampling Summary Maps, Figure 7.1	Weekly	Delivered by: OSAT/SSC Reviewed by: FOSC
Report on Missions and Progress	Weekly	Delivered by: SMU Chief Scientist Reviewed by: SSC

Table 7.1. Initial products delivery and review schedule

8 ADAPTIVE STRATEGY

8.1 Rationale and Approach

The rational and approach for using an adaptive strategy to guide sampling locations is described in this section. Water sampling in deep water has occurred since early May. Until mid-July, the locations of sampling were selected by individual vessels. This resulted in concentrated data in a small zone. Ships were focused on hitting 'hotspots' and little communication occurred between vessels. There were multiple times that vessels re-sampled the same locations on the same day. This constrained the overall understanding of the extent and behavior of dispersed oil in the sub-surface. There were a few points where dispersed oil was found, but the extent and changes through time could not be determined.

Efficient and effective sampling of water with multiple vessels can create a 3D image of dispersed oil in the sub-surface over time. A circular sampling scheme was set up around the wellhead (up to 75 nm) to guide additional sampling directions. Locations with dissolved oxygen lows (SSW of the well head) were revisited to determine boundaries of these observations. Sites have been re-sampled to determine changes over time, which has provided the best operational information to the FOSC to support decisions consistent with the response objectives.

8.2 Mission Guidance

The sub-surface monitoring unit hosted daily mission guidance phone calls to task all the chief scientists detailed to vessels sampling water in the deep water zone. The mid-day call allowed each chief scientist to share initial findings and allowed for vessels to coordinate next day operations. Following the call, the sub-surface monitoring unit/OSAT discussed the observations of the last 24 hours and gaps in sampling. Based on recommendations from the OSAT, the sub-surface monitoring unit then passed operationally significant information to the FOSC via the NOAA SSC and, as appropriate, to key stakeholders such as the National Marine Fisheries Service's Southeast Regional Office. Where initial findings indicated the need for a temporary deviation in a ship's immediate mission, the sub-surface monitoring unit recommended and managed re-tasking. By midnight the vessels sent in all of their data and a write-up of findings for that day to the sub-surface monitoring unit to feed the next day's decisions.

Where indicated by initial findings from data analysis, additional sampling missions or activities were added to the plan as an annex. Periodic reviews of data informed this decision making. Recommendations for additional sampling and information were made by the OSAT based on these reviews of data and comparison to indicators. Findings that inform seafood safety evaluations were communicated to NMFS by the SSC. NMFS evaluates the need for further sampling to determine changes in fishery closures.

The FOSC reviews the OSAT recommendations and evaluates whether more information is required. If more information is required, the FOSC directs further activities.

Annexes to this sampling plan include a summary study plan, an outline of resources and assets necessary, timeframes and deliverables. All additions are coordinated by the SSC and are subject to approval by the UAC.

9 RELATIONSHIP TO NATURAL RESOURCE DAMAGE ASSESSMENT

Under the Oil Pollution Act of 1990 (OPA 90; 33 U.S.C. 2701 *et seq*), there exists a clear separation between actions conducted under the authority of the Response phase and those conducted in support of the natural resource damage assessment (NRDA.) The primary purpose of this monitoring plan is to measure indicators pursuant to the emergency response phase of this spill.

Separately, but in parallel, the DWH NRDA, which is led at the federal level by the Department of the Interior (DOI) and NOAA, seeks to assess the injuries caused by the oil spill and response actions to natural resources, and the lost use of services provided by those resources. In general, the objectives of the NRDA are different from those of the response phase. NRDA requires more detailed and complex environmental analyses to evaluate the linkages between the released oil, the oil's environmental pathway, exposure to the oil, and ecological injury to the resources or habitats.

Throughout the spill, NRDA has been working alongside the response, focusing their actions on determining baseline conditions, identifying possible natural resource injuries, and developing/conducting studies to assess/quantify injury. NRDA staff have and will continue to work closely with the Response to create synergy between the two separate categories of actions currently under the incident command structure. During the ongoing sub-surface monitoring action, NRDA scientists will work closely with responders and scientists working in the UAC Environmental Unit. When the FOSC makes a determination that the response action is complete, NRDA scientists will incorporate the data collected as part of this response action and integrate it into an evolving understanding of the types and magnitude of natural resource injury caused by the DWH release.

10 POTENTIAL LONG TERM ASSESSMENT ACTIVITIES

In developing this plan a number of suggestions were put forward that, while not consistent with removal actions, may help inform the long term recovery efforts for the Gulf and assist in developing important information for responding to future spills. This section of the plan captures some of those ideas. While these activities are important, they were not carried out as part of the strategic monitoring effort for sub-surface sampling developed as part of the response action.

10.1 Modeling

Understanding the fate and extent of transport of oil and/or dispersants can be further enhanced through conducting a robust discussion and comparison of modeling approaches used during the spill and development of new models/modeling approaches.

During the course of the spill, three transport models were consistently used operationally (GNOME (NOAA), SIMAP (ASA) and OSCAR (SINTEF)). A number of data sources, hydrodynamic, and atmospheric models were critical in supporting these operational transport models. Independent or academic models served as resources for additional information. Further exploration of existing models and additional model development will contribute to assessing long term fate of the oil or dispersants. A focused modeling and data workshop would provide the modeling community with information to enhance modeling capabilities for additional long term assessment of the DWH or for future spill events.

10.2 Fluorometry Validation and Comparisons

Fluorometers were used to indicate the presence of subsurface oil throughout the course of the spill. Two types of fluorometers were most common, the WetLabs CDOM and the Chelsea Aquatracka. Evaluation and calibration of the response of these fluorometers in the presence of oil that has been chemically and spectrally characterized would improve the interpretation of previously collected fluorometry data, and would assist in deciding which technology to apply in future subsurface spills. Initially CDOM fluorometers were exclusively used, but in August the Aquatracka fluorometers were able to detect signals that were no longer detectable with the CDOMs. A better understanding of the excitation/emission spectra appropriate for the MC-252 oil would provide important information for making use of data collected throughout the spill. In addition, fluorescence detected by either fluorometer in the presence of dispersant may be higher than for raw oil. Additional studies of this possibility would also allow previously collected data to be further interpreted.

10.3 Biodiversity

Several comments received during the development of this plan suggested the need for long term biological sampling to evaluate biodiversity of the Gulf of Mexico. Characterization of hard bottom community components, sediment toxicity, benthic faunal abundance and diversity, and additional habitat mapping and characterization were suggested. Further understanding of the effects of oil on marine and estuarine species, including food web organisms, will be part of the NRDA.

10.4 New Technologies

High frequency acoustics have successfully been used to identify seep areas during the course of the DWH oil spill. This technique may have potential for identifying oil in bottom sediments but it is impossible to determine this until more is known about the physical and acoustic properties of the oil/sediment system. Appropriate high-frequency acoustic systems are readily available in both the NOAA and commercial fleets and if oil is found on bottom sediments in nearshore, shallow waters (30-60m), this could provide a simple and inexpensive opportunity to test this approach. In deeper waters a high-frequency acoustic system would have to be brought relatively close to the bottom by ROV or AUV.

In addition, several other innovative technologies were proposed that were not included in this plan because of time operational constraints or other factors. The use of sediment profile imagery, micro GPS sensors for tracking oil movement, semi-permeable membrane devices or other passive samplers for evaluating dissolved oil, deep water LISST particle analyzers, and remote sensing to monitor bio-optical properties indicating adverse effects are all potentially useful technologies that should be considered for response and assessment of future spills.

10.5 Synthesis of Findings

The massive amounts of data and information generated as a result of the DWH oil spill has the potential to result in significant developments in oil spill response science. Important long-term science questions in the aftermath of the spill include: the adequacy and implications of response techniques (including building diversionary berms, skimming oil under different conditions, burning, and applying dispersants on the surface and at depth), long term weathering and biodegradation, building an oil fate budget, and improving modeling techniques and data management have all been identified as high priority areas for continued science involvement, assessment, or research. As part of the Plan, the OSAT will be evaluating data relative to indicators for different zones, and these evaluations will be directed to providing information to the FOSC for making decisions on remaining actionable oil. Data supporting these decisions will be summarized in the final decision documents for the response. However, a more comprehensive review and discussion of information collected during the response will be an important undertaking. This review could occur in the form of workshops and symposia to inform spill response research and long-term Gulf restoration and recovery efforts. Ultimately, the JAG should prepare a comprehensive report of these findings.

APPENDIX A: NEARSHORE SAMPLING PROGRAMS

Results of qualitative sampling programs through 11 September, 2010 are summarized in Table 1.2 of the main document.

A.1 Snare Sentinel and Drag/Trawl Programs (including VIPERS)

The Mobile and Houma command posts conducted observations of oiling using nets rigged to collect floating tar mats or to determine whether oil is observed on towed sorbent material. Visual inspection determined if the poms were oiled or not oiled during the trawl. If there was evidence of oiling, material was collected for confirmation and forensic analysis.

Nets were used to trawl for samples in the near shore 1) within two feet of the surface or 2) along the bottom to characterize the extent of sub-surface oil in terms of density and distribution. Stations were located on transects using the most recent field information of shoreline stranding and shrimpers' knowledge of local waters. The density of tar balls went down over time. Any tar balls recovered were collected for analysis for oil and dispersant markers.

Sampling was conducted prior to the opening of the commercial shrimping season in the area of Breton Sound using modified shrimp trawl/nets with absorbent snares attached.

- Between 14-15 August 2010 a total of 163.8 nm were surveyed using 8 vessels. A total of 108 trawls were made.
- A trace of oil was observed on two poms from Team #6 and two poms from Team #2. A total of four samples were collected representing the total amount of material found during the sampling event.
- Analytical results indicated trace amounts of DWH weathered oil captured on the poms, equivalent to a total of 10 mg of oil (less than a drop) within the 163.8 nm trawled. The four samples collected came from the same general areas representing four trawls. No oil was observed in the remaining 104 trawls.

VIPERS are shrimping vessels outfitted with nets rigged to collect floating tar mats or oil. The nets, which can be dragged at any depth, were deployed at 15 minute intervals, after which the nets were retrieved and examined for any evidence of contact with oily products.

A.2 Bottom Sediment Sampling

This program delineated the potential of submerged tar mats in nearshore areas. It consisted of a targeted systematic sampling plan based on Shoreline Cleanup and Assessment Team (SCAT) survey results that identified regions of potential submerged mats and shorelines with repeated tarball observations. The methods involved sediment grabs from dedicated Vessels of Opportunity (VOO) using Ponar sediment grab samplers. Collected sediment underwent visual inspection for presence of oil, with oily material being collected for laboratory testing for further analysis.

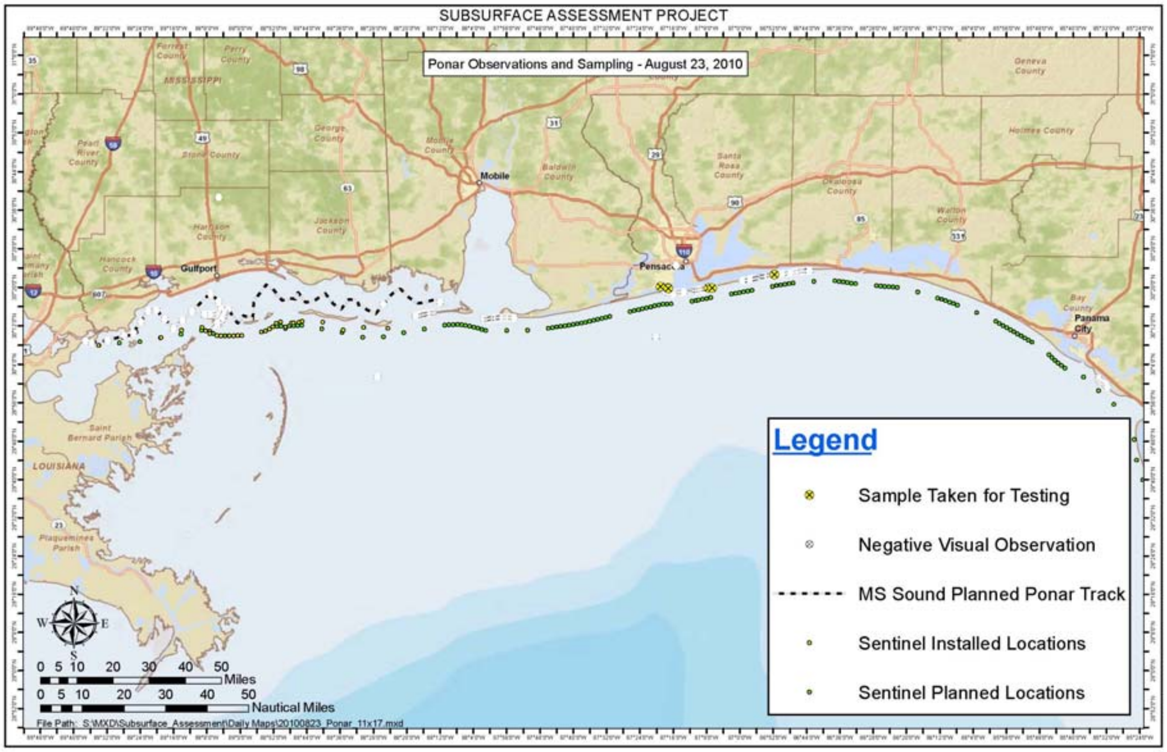

Figure A-1: Example of sampling status map for Sector Mobile sub-surface monitoring program.

A.3 Fluorometer Transects

Specified transects were tested for presence/absence of oil along using a towed fluorometer to detect hydrocarbon concentrations in the water column. If oil was detected, water samples were collected for further analysis.

A.4 Sorbent Pad Drops

Using vessels of opportunity the entire Mississippi Sound was surveyed in 2 X 2 nm^2 grid cells. Sorbent pads attached to a weighted line were used to detect the presence of subsurface oil. If oil was detected, one of seven sampling vessels with qualified technician onboard was deployed to collect an analytical sample.

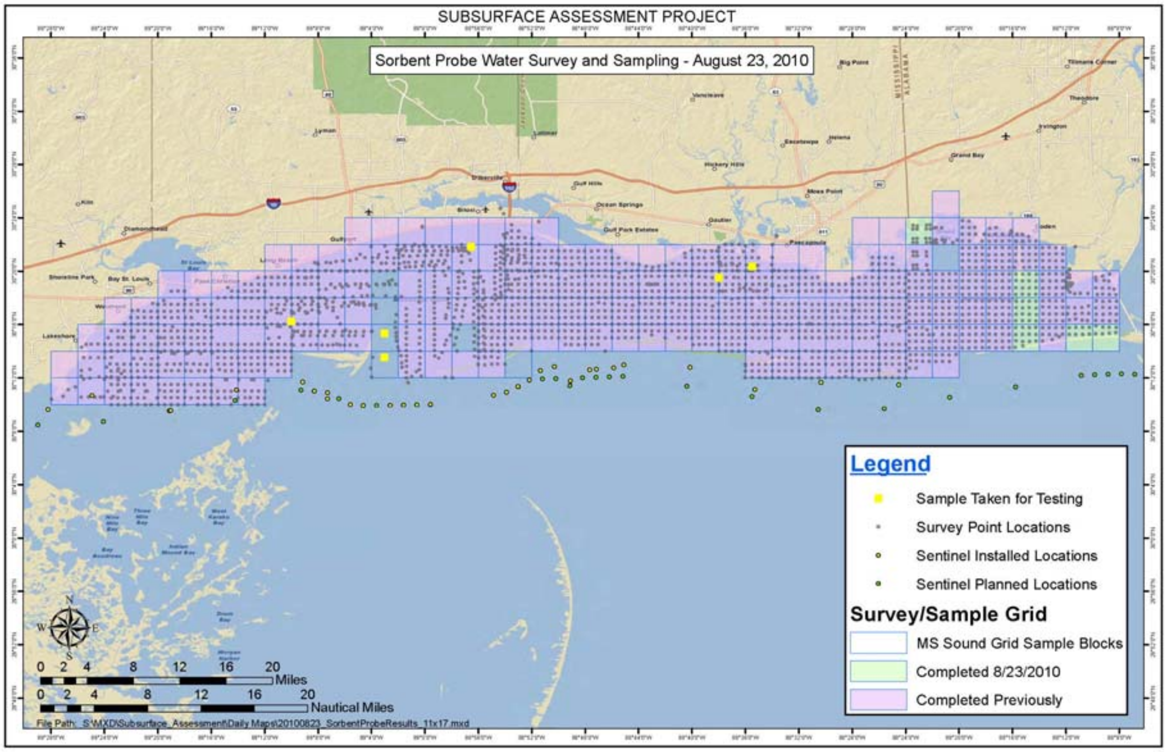

Figure A-2: Example of sampling status map for Sector Mobile sub-surface monitoring program.

A.5 Snare Sentinel Program

Both Houma and Mobile AOR maintained a Snare Sentinel Program (SSP). The SSP uses "snares" (pom-poms) on a rope or on a PVC pipe. They are placed at representative shoreline types previously oiled and un-oiled. This program monitored for the presence of nearshore subsurface oil that could threaten un-oiled, sensitive shoreline and shallow sub-tidal habitats. It also monitored for the presence of subsurface oil in proximity to previously oiled shorelines resulting from the remobilization of stranded, sediment-entrained oil. 148 fixed Sentinel stations were deployed at approximately the 25 foot depth contour along shorelines of Florida, Alabama, and Mississippi with snares at 3 foot intervals. Snare sentinels were retrieved daily and visually inspected for presence of oil. If oil was suspected to be present, samples of snare material, water, and sediment were collected. Forensic analysis is attempted if sufficient oil was recovered.

A.6 Fate of Oil Research Team (FORT) - Coastal Sediment and Water Column Survey

Collection of water column and sediment samples (top 2cm) in coastal offshore (<200 ft) water and in nearshore areas along the Louisiana and Texas coast was conducted by teams comprised of members from the Incident Command Post Environmental Units. Samples were collected for chemical analysis and toxicity studies to identify the fate and effects of the dispersed oil. Samples will be tested for oil and dispersant markers. Toxicity tests are conducted with representative GOM species. The M/V *International Peace* was used for coastal water sample collection; and vessels of opportunity were used for shallower water. The sample location transects were identified using FRAT (See Section A.8), and Snare data (Sections A.1 and A.6) and subsurface oil reports.

A.7 Forensic Rapid Assessment Team (FRAT) – Rapid Response to Oil Reports

FRAT teams (like FORT), were established by the Incident Command Post Environmental Units. They provided quick response to reports of subsurface oil and oiled sediments. The FRAT vessels were only equipped to collect samples for analytical testing in very shallow water (< 10 ft). Samples will be analyzed for oil and dispersant markers in onshore facilities.

A.8 Surface Water Oil & Dispersant Sampling

The M/V *International Peace* has conducted monitored dispersant effectiveness monitoring in coastal waters. CTD, dissolved oxygen, and fluorescence were measured and toxicity tests were performed on water samples collected at 1 and 10 m depths. Data will be available on concentration of oil and dispersant in the water column. This sampling was conducted to monitor dispersant effectiveness and environmental impact in support of dispersant application from boats and aircraft.

A.10 Sub-Surface Oil & Dispersant Sampling

This sampling was conducted by the R/Vs *Brooks McCall* and *Ocean Veritas*. Sampling consisted of full CTD profiles, analysis of water samples with a LISST (laser in-situ scattering and transmissometry) particle analyzer, vertical profiles of fluorescence, and dissolved oxygen using on-board analyses. Surveys were conducted in the area near the well.

APPENDIX B: CHOOSING SAMPLE LOCATIONS

B.1. Sampling Plan Design Introduction

The overall strategy used to develop the sampling plan for the GOM Removal Action was to apply an adaptive hybrid approach that was robust and science-driven. This approach combined statistically based designs of sample sizes and locations with targeted sampling. Statistical power analyses were conducted to determine sample sizes for the evaluation of pre-impact to post-impact periods or to detect hot spots of a given size. Targeted sampling in specific locations and areas of interest that were identified by technical experts in UAC were also incorporated into the design. For example, in the nearshore area of the GOM, the United States Geological Survey (USGS) reoccupied locations that were sampled prior to oil impact. Another example of areas of special interest is a selected number of NCCA sampling points identified by EPA’s Offices of Water and Research and Development.

This adaptive, hybrid strategy was deemed to be the most favorable solution that would be capable of being simultaneously responsive to the needs outlined in the removal action directive issued by the National Incident Commander (Appendix H) and the immediate needs of the various Federal and State partners who are responding to this incident. Furthermore, it allowed for rapid coordination of various efforts being conducted or planned under separate authorities and/or objectives. Numerous sources of data from both Federal and State Agencies were evaluated during the sampling design process. This included data and information from EPA Regions 4 and 6, USGS, NOAA, the States of Louisiana, Alabama, Mississippi, and Florida, and a responsible party (RP), BP. Chemical analyses have included an extensive suite of contaminant classes such as VOCs, SVOCs, dispersants, Polycyclic Aromatic Hydrocarbons (PAHs), Total Petroleum Hydrocarbons (TPHs); benzene, toluene, ethylbenzene, and xylene, (BTEX); metals, and others.

The nearshore area (operationally defined as a sampling zone for the removal action) is the most data-rich of the zone in this sampling design effort for the GOM. EPA Regions 4 and 6 collected most of these data under approved sampling plans. This allowed the UAC Environmental Unit to conduct a statistical analysis to establish a sampling strategy to characterize the post-impact zone within a reasonable level of confidence. Sampling designs for the remaining zone, which include offshore and deep water, were designed following the development of the nearshore area plan. The following sections provide details on the analyses and considerations that led to the final project sampling program.

B.2. Sediment and Surface Water Locations and Design by Zone Objectives

A total of 658 sediment samples and 4,291 water samples were considered for use in determining statistically based sampling designs. The data included analytical results of the response-related sampling conducted along the GOM coastline prior to impact, during impact, and post-impact by

EPA Regions 4 and 6. Sixty-seven analytes were included in the datasets for sediments and water.

The GOM was categorized by three general zones: nearshore, offshore, and deep water. One test is to determine if average concentrations of oil related contaminants were higher in sediment and surface water after the spill compared to conditions pre-impact. Another is to ensure that a hot spot of a given size can be detected. Recognizing that thousands of samples have been collected, and many more are planned, this work was undertaken to develop a statistically rigorous geospatial design augmented with targeted sampling to achieve the objectives. Sampling designs were developed for each zone.

B.3. Nearshore Sediment and Surface Water Locations

The development of sampling design began with nearshore sediment data because there was a substantial set of pre-and post-impact sediment data from EPA and State sampling efforts. The statistical analyses began by focusing on the following suite of analytes that are commonly associated with oil, or refined oil products: Total PAHs, BTEX, Toluene, TPH DRO, TPH GRO, TPH ORO. Total PAHs were obtained by summing the 16 individual Priority Pollutant PAH concentrations per sample. BTEX was obtained by summing the concentrations of the six analytical components for each sample. In all cases a conservative approach was adopted for the statistical analysis in order to ensure the collection of sufficient data to inform decision-making.

B.3.1 Software Tools: Visual Sample Plan

VSP software (http://www.frtr.gov/decisionsupport/DST_Tools/vsp.htm) was used to explore sample sizes. VSP (http://vsp.pnl.gov/) is a software package that was familiar to all parties involved and provided a mapping tool as well as a report generator which assisted in streamlining the efforts required under the rigid timeline. Furthermore, EPA has successfully used VSP during the development of sampling plans associated with other emergency responses (Hurricanes Katrina and Rita) and in earlier phases of the present response. VSP's combined geographic and statistical components made it feasible to visualize the sample size computations, explore various confidence levels, specify actionable levels, and vary uncertainty. SAS version 9.0 software was used to explore the data and to compute basic descriptive statistics.

B.3.2 Development of Nearshore Sampling Plan: Approach

The initial approach for this effort was to determine numbers and locations of samples required to compare results to an "Average to a Benchmark Value" for human health. This methodology would compare the average of a specific analyte to a threshold value acquired from www.epa.gov/emergency/bpspill/sediment-benchmarks.html. However, the following issues created challenges:

1. There are no available human health benchmarks for TPH-GRO, TPH-DRO, TPH-ORO, which are among the most commonly detected oil components. Moving forward, sample results will be compared to those compounds with available benchmarks.

2. There were no sediment benchmarks currently available for human health; however there are benchmarks available for aquatic life. Moving forward, aquatic life benchmarks will be indicators of oil presence.

3. To determine PAHs in sediment, it is important to factor in the amount of organic carbon in the sediment. When organic carbon is present in sediment, PAHs bind to the organic carbon, making the PAHs less available to aquatic life, thus lessening their toxicity. The aquatic benchmarks available for PAH mixtures are based on carbon normalized concentrations of the individual PAHs. Application of these benchmarks would require measurements of total organic carbon (TOC) for each sample. However, at the time of this analysis, TOC measurements were available for only 9% (16 of 172) of the post-event data. TOC ranged from 0.06 to 2.01% with a median value of 0.93%. TOC would have to be estimated for 91% of the data, which would result in a high level of uncertainty. Moving forward, TOC will be measured for each sediment sample.

These challenges suggested that an alternative approach for determining necessary sample size and distribution would be required. The alternative approach for developing a sampling plan for the nearshore sediment and surface water was based on comparison of post-impact data with pre-impact conditions. In other words, the statistical analysis determined the optimum sample size for establishing a significant difference between the average of pre-impact and post-impact analytical results for each state (Florida, Alabama, Mississippi and Louisiana). Data for Total PAHs, BTEX, Toluene, TPH DRO, TPH GRO, TPH ORO were examined, and basic statistics were computed per state and per impact category. The distribution of these data was examined to determine appropriate statistical comparison techniques (normality and log-normality of the data distributions could not be confirmed for these analytes, and the distributions did not demonstrate symmetry). A non-parametric (non-distribution dependent) statistical approach was used to calculate the appropriate sample sizes.

Based on the results of the distributional analyses, a non-parametric statistical power analysis using median values was conducted within VSP. The coefficients of variation (CV) for each analyte were examined to identify the analyte and state that demonstrated the greatest amount of variability in relation to their means. Selecting the state with the highest variability to inform sample size calculations for the other states was an appropriately conservative approach to identify sampling requirements. Louisiana sediment concentrations had the greatest CVs. Additionally, the Louisiana data set contained the largest number of pre-impact hydrocarbon samples. Total PAHs had the greatest CV across analytes; however a large percentage of the results were at or below method detection levels. This rendered the total PAHs as 'technically prohibitive' for the sample size computations (i.e., an analyte with substantially more detects in the data set is needed to address the statistical objective of the pre- vs. post-baseline hypothesis test). Ultimately, total petroleum hydrocarbons (TPH), specifically, TPH-DRO, were selected as the hydrocarbon group to drive the statistical power analysis.

Iterations of VSP were conducted using the median and standard deviation of sediment concentrations for pre-impact samples collected in Louisiana assuming a non-symmetrical population distribution. The hypothesis tested was that the post-impact median is greater than the pre-impact median (*i.e., "the sample area is dirty from the oil spill"*). This is known as a "one-tailed" hypothesis test. A systematic grid design was chosen to provide geographical coverage and address assessment adequacy. Iterations included varying alpha (α, probability of falsely rejecting the null hypothesis that 'the site is dirty'), beta (β, probability of falsely accepting the null hypothesis; i.e., saying the site is dirty when in fact it is clean), the percent difference to be identified as significant between pre- and post-impact means, and regions of decision uncertainty (gray region). Iterations included all combinations of:

- α = 0.05, 0.10;
- β = 0.20, 0.25, 0.30;
- Percent difference = 20%, 30%, 50%, 100%; and
- Gray region = 10%, 15%, 25%, 50%.

Iterations of these parameters produced a range of sample sizes based on TPH-DRO distributions. Results suggested a sample size of 80 for each of two discreet sections along the gulf shoreline would be adequate. One section was the state waters off the coast of LA (EPA Region 6), while the other included the state waters off the coast of states of MS, AL and FL (EPA Region 4). This sample size was computed based on α=.05, β =.20, and percent difference of 50%. A region of decision uncertainty (gray region) with a 20% chance of falsely accepting (β) the null hypothesis was set at 25% of the median. In other words, if the computed median from post-impact sampling falls within 25% of the pre-impact median, there is a 20% probability that an incorrect decision would be made that the post-impact median is statistically different (or "dirty") from the pre-impact median. In summary, 80 samples along the coast of each of two EPA regions would allow us to determine differences between median concentrations before and after the spill.

B.3.3 Development of Nearshore Sampling Plan: Methods

A map of the sediment locations was generated in VSP from the analysis described above, and was then further focused by considering additional input. First, a systematic grid emanating from a randomly selected point within the nearshore zones was applied to place 80 non-biased locations per EPA Region because the length of each region's shoreline is approximately equal. These statistically derived locations were then compared to existing post impact sample location to determine if any of the locations have already been sampled. Non-biased station placement meets the underlying assumptions of the statistical analysis approach. Systematic grid locations inland from the coast were removed from further consideration. Additionally, the map was overlain with existing locations from recently sampled NCCA locations. If a VSP generated point fell close (within ¼ the distance between random points; 4.25 nm in Region 6, 3 nm in Region 4) to an NCCA point, it was moved to the location of the NCCA point. To the extent that the NCCA locations did not compromise the representation of the VSP generated locations; it was felt that it would be important to make the slight adjustments in order to take advantage of the long term data set that will be available at these locations in the future. If a VSP generated point fell the same distance to a sample location from the post impact sampling programs, it was eliminated for additional collection.

Existing nearshore pre-event water data was also examined to evaluate sample sizes for future water sampling. Data was explored for Total PAHs, BTEX, TPH DRO, TPH GRO, TPH ORO, and basic statistics were computed per impact category. Normality and log-normality could not be confirmed for these analytes, nor were the distributions symmetrical. Any statistical construct would have been a non-parametric (non-distribution dependent) approach. However, the water data only contained a small percentage of analytical results that were reported as detects, and ultimately, none of the analytes were viable candidates to conduct a statistical power analysis to calculate a sample size for water. Therefore, we relied on the statistical power analysis result from sediments, and co-located future water and sediment samples.

The process described above resulted in a sampling plan that included approximately 150 locations in the nearshore area of the GOM from the LA/TX border to the Apalachicola Bay in the Florida panhandle (Figure B-1). These locations will be sampled for both water column and sediment parameters.

In summary, the selection of approximately 150 sampling locations between the border of Texas and Louisiana and Apalachicola Bay in the nearshore zone will be sufficient to determine changes over time in oil-related components in water and sediment. Stations were distributed between states, and were randomly located, and adjusted if random locations were close to long-term monitoring sites previously established by the NCCA. The statistical rigor employed in this sampling plan will provide confidence to decision makers so that they can: A) determine a site is dirty when it really is; and B) avoid accidentally concluding a site is clean when it is in fact dirty.

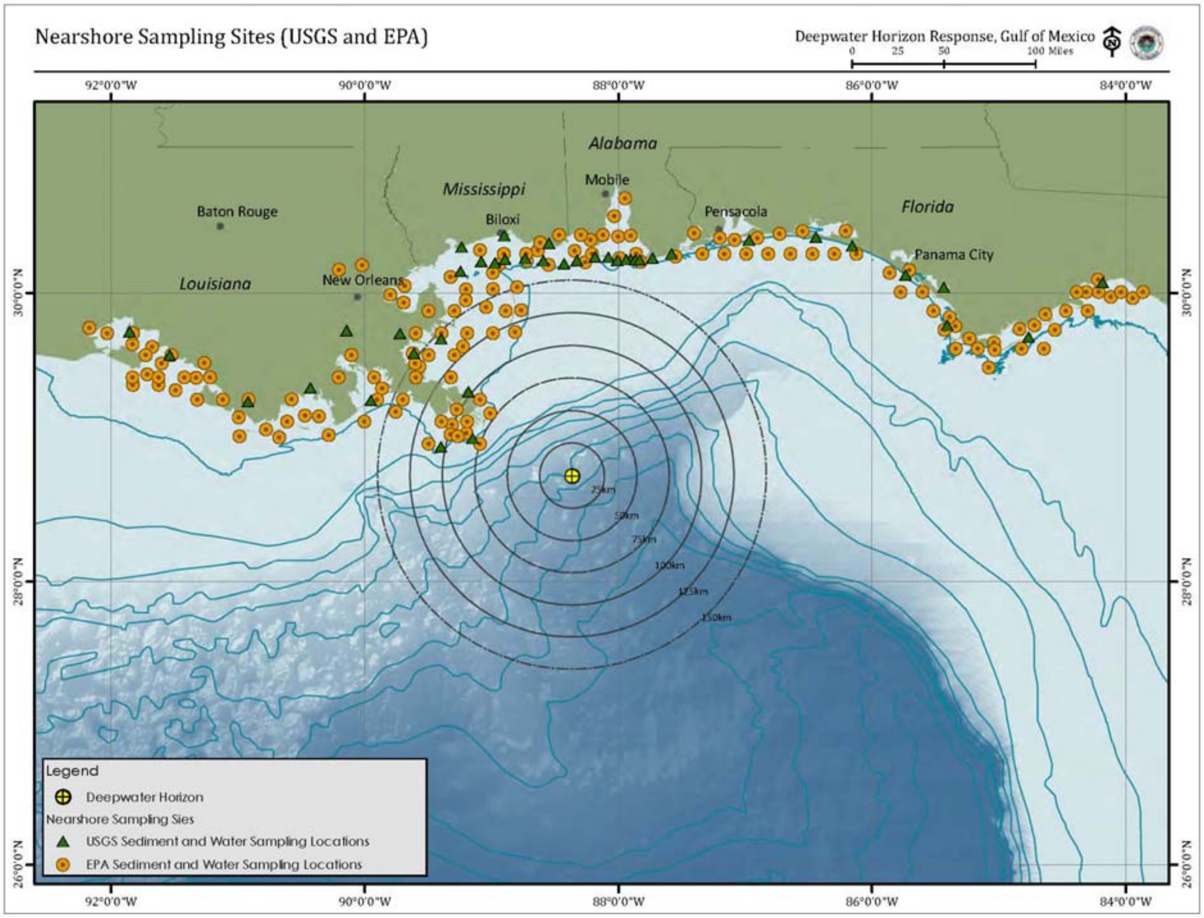

Figure B-1: Nearshore Water and Sediment Sampling Locations

B.3.4 Development of Offshore Sampling Plan: Approach

Statistically robust sampling in the offshore zone is much more challenging than the nearshore. The challenging aspect is the lack of prior detected concentrations of analytes, which would be used to determine the variance parameter in estimating the number of samples needed for hypothesis testing

The development of this offshore (shelf) sediment sampling component—within the overall sediment investigation associated with the removal action—again combines targeted sampling design with statistically based design of sample numbers and location. The initial design for sampling the offshore (shelf) sediments targeted four cross-shelf corridors where it was expected that surface oil was most likely to have accumulated.

This initial sampling strategy placed a total of 60 sampling locations along transects placed in the center of each of the four corridors and at the wellhead. In addition, samples were placed along radials in locations suggested by pathway hypothesis. An offshore polygon was established to bound the area where oil is most likely to be detected based on these hypotheses. In addition to the targeted samples, a statistical analysis was conducted to place additional gridded samples within the polygon to allow detection of a hotspot of given size with 95% certainty.

VSP was used to place an additional 106 locations across the entire polygon, with a grid spacing of 7.86 nautical miles (approximately 14, 554 meters), providing at least a 95% chance of locating a hot spot which is as small as 1.87% of the total area. If oil is found ("hit") at a sampling location(s), an adaptive approach to defining the size/dimension of the hot spot, or investigating whether oil deposited to the east and/or west of the hot spot, would be considered.

APPENDIX C: ASSETS AND RESOURCES

Table of common measurements used in sub-sea and sub-surface sampling and monitoring efforts. NOTE: Some sampling data are used for multiple purposes and have supported modeling and tactical decision-making (e.g., mission guidance). Table includes a wide range of measurement types which have been used at various times during the response phase. Both qualitative and quantitative measures are listed to demonstrate the comprehensive nature of the approach to sub-surface monitoring over the course of the entire response.

Measurement	What is analyzed?	What does it tell you?	Selectivity	Measurement (Qualitative, semi-qualitative, quantitative)	Uncertainty	Comments
Over the side measurements						
conductivity	cations and anions in seawater	salinity; useful oceanographic parameter	very high	quantitative	very little	Standard technology; little or no chance of performance to be affected by oil
temperature	temperature	useful oceanographic parameter	very high	quantitative	very little	Standard technology; little or no chance of performance to be affected by oil

Measurement	What is analyzed?	What does it tell you?	Selectivity	Measurement (Qualitative, semi-qualitative, quantitative)	Uncertainty	Comments
pressure	pressure	water depth	very high	quantitative	very little	Standard technology; little or no chance of performance to be affected by oil
depth	echo-sounder	water depth	very high	quantitative	very little	Standard technology; little or no chance of performance to be affected by oil
oxygen sensor (electrode)	oxygen	water mass tracer and indicator of organic matter respiration	very high	quantitative	Yes, sensitive to oil content. For example, refer to technical notes from Seabird, i.e., hysteresis	Parallel Winkler oxygen titrations are necessary
CDOM	fluorescence of organic matter	amount of organic matter that responds to excitation and emission wavelengths	semi-selective, provides a bulk measurement	semi-quantitative	Yes, difficult to constrain what is being detected	Was not made for oil analysis but is standard on most oceanographic vessels. Limited dynamic range.
aromatic	fluorescence	amount of	semi-selective,	semi-	Yes, only	Only recently been

Measurement	**What is analyzed?**	**What does it tell you?**	**Selectivity**	**Measurement (Qualitative, semi-qualitative, quantitative)**	**Uncertainty**	**Comments**
Aquatracka	of organic matter, tuned for aromatic hydrocarbons	organic matter that responds to excitation and emission wavelength similar to those of aromatic hydrocarbons	provides a bulk measurement but more robust than CDOM	quantitative	responds to aromatic hydrocarbons, which only compose a small percentage of the total oil	added to vessels. Care should be taken interpreting results as it only measures one fraction of the oil. More sensitive than CDOM sensors.
transmissometer	Light beam attenuation	Measures particle content	Bulk particles, may indicate oil droplets	qualitative	Yes, questionable	Usefulness still being evaluated
SIMRAD	Multi-beam mapping	Measures density differences	Bulk	Qualitative	Yes, may be sensitive to other signals	useful if major oil in concentrated form is present
On the deck						
Winkler titration	Oxygen content of seawater	Oxygen content of seawater	Selective	Quantitative	Very little	Gold standard for dissolved oxygen. Involves some wet chemistry. Chemicals and waste.

Measurement	What is analyzed?	What does it tell you?	Selectivity	Measurement (Qualitative, semi-qualitative, quantitative)	Uncertainty	Comments
C_1-C_5 hydrocarbons	Hydrocarbons in the range of methane to pentane	Natural gas component of the release	Selective	Quantitative	Very little	Need an operating gas chromatograph with gas standards. Skilled operator
larger hydrocarbon analysis (solvent extraction)	Wide range of petroleum hydrocarbons	Petroleum hydrocarbons in the water	Selective (with gas chromatography) Semi-selective (with fluorescence)	Quantitative, semi-quantitative	If GC based, little. Fluorescence, better than deployed from the ship but still a bulk analysis	Need solvents and instruments. Skilled operator. Chemicals and waste.
Respiration rates	Change in oxygen concentration over time	Bulk rate of microbial organic matter degradation	Doesn't tell you what the microbes are degrading.	Semi-quantitative (rates in plume detectable, but background rates outside plume not)	Question on the effects of depressurization on microbes.	Can be conducted with Winkler titrations.
Bacterial growth rates	Incorporation in radioactive DNA and protein	Bulk rate of microbial growth.	Doesn't tell you who is growing.	Semi-quantitative (rates in plume	Question on the effects of depressurization on microbes.	Radioisotopes present numerous logistical challenges.

Measurement	**What is analyzed?**	**What does it tell you?**	**Selectivity**	**Measurement (Qualitative, semi-qualitative, quantitative)**	**Uncertainty**	**Comments**
	precursors with time.			detectable, but background rates outside plume not)		
Preserved and Analyzed back on shore						
volatile organic analysis for petroleum hydrocarbon	Volatile organic carbons, generally those with more than 6 and less than 12 carbons	Petroleum hydrocarbons in the water, for sub-surface they represent the most water soluble	Selective	Quantitative	Need to determine if analysis is via GC-MS or GC-FID	Depending on method, the number of compounds will vary. Methods are well established
semi-volatile organic analysis for petroleum hydrocarbons	Volatile organic carbons, generally those with those greater than 12 carbons	Petroleum hydrocarbons in the water	Selective	Quantitative	Need to determine if analysis is via GC-MS or GC-FID	Depending on method, the number of compounds will vary. Methods are well established
dispersants	Some of the compounds	Insights into the fate and	Selective	Quantitative but methods	low	Only a few labs capable of analyses

Measurement	What is analyzed?	What does it tell you?	Selectivity	Measurement (Qualitative, semi-qualitative, quantitative)	Uncertainty	Comments
	present in the dispersants	transport of these compounds		are quite new		when compared to GC-based techniques. Detection limits may be too high for significant value.
metabolites (hydrocarbons or dispersants)	Wide variety of compounds	Indicator of abiotic and biotic processes	Selective	Quantitative	Some	Could be many different compounds.
nutrients	Nitrogen and phosphorous species	Water mass tracer and needed for bacterial cell growth (and hence hydrocarbon degradation)	Selective	Quantitative	Low	Coupled with oxygen data may be insightful. Review work by Pfaender et al (1980) after Ixtoc I spill
Cell counts	Concentrations of bacterial cells	More cells in plume, suggest microbial response	Semi-selective (except in surface waters, standard techniques don't distinguish	Quantitative	Low. Already applied by Hazen et al (2010)	Small volumes may be collected and analyzed by flow cytometry with reasonable throughput.

Measurement	**What is analyzed?**	**What does it tell you?**	**Selectivity**	**Measurement (Qualitative, semi-qualitative, quantitative)**	**Uncertainty**	**Comments**
			species)			
Polar lipids and/or polar lipid fatty acids	Concentrations of membrane lipids	More cells in plume, suggest microbial response	Semi-selective (except in surface waters, standard techniques don't distinguish species)	Quantitative	Low. PLFAs already applied by Hazen et al (2010)	One-liter samples must be filtered on deck and frozen.

APPENDIX D: <u>OIL COMPOSITION</u>

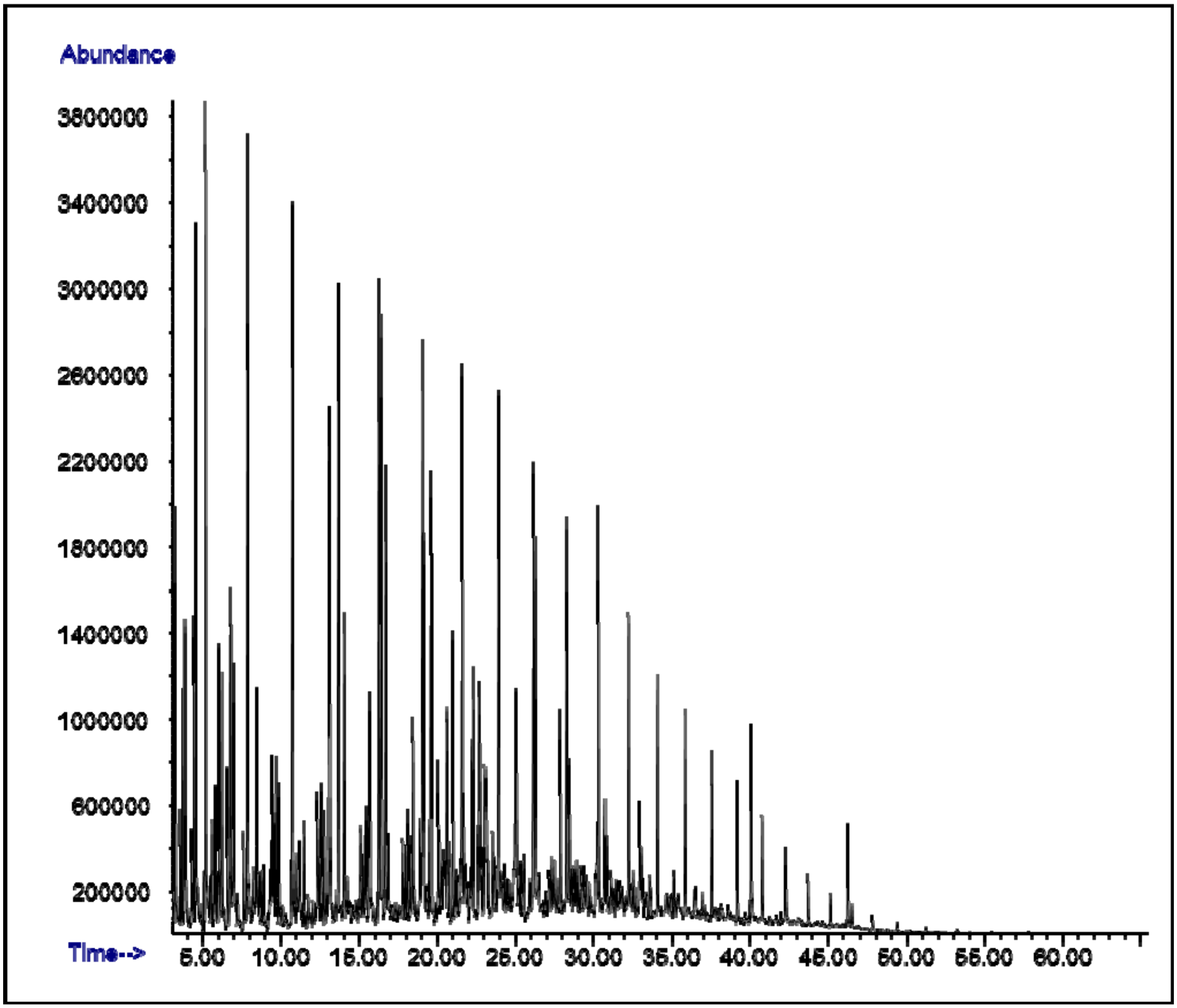

Figure E-1: GC/MS Total Ion Chromatogram of Source Oil (pre-spill) (LSU, 2010)

Quantitative PAH Composition of MC252 pre-spill oil (LSU, 2010)

PAH Compound	Concn mg/kg
Naphthalene	750
C1-Naphthalenes	1600
C2-Naphthalenes	2000
C3-Naphthalenes	1400
C4-Naphthalenes	690
Fluorene	130
C1-Fluorenes	340
C2-Fluorenes	390
C3- Fluorenes	300
Dibenzothiophene	53
C1-Dibenzothiophenes	170
C2-Dibenzothiophenes	220
C3- Dibenzothiophenes	160
Phenanthrene	290
C1-Phenanthrenes	680
C2-Phenanthrenes	660
C3-Phenanthrenes	400
C4-Phenanthrenes	200
Anthracene	6.1
Fluoranthene	4.2
Pyrene	8.9
C1- Pyrenes	68
C2- Pyrenes	84
C3- Pyrenes	96
C4- Pyrenes	54
Naphthobenzothiophene	11
C-1 Naphthobenzothiophenes	48
C-2 Naphthobenzothiophenes	37
C-3 Naphthobenzothiophenes	22
Benzo (a) Anthracene	5.5
Chrysene	36
C1- Chrysenes	100
C2- Chrysenes	100
C3- Chrysenes	54
C4- Chrysenes	19
Benzo (b) Fluoranthene	2.3
Benzo (k) Fluoranthene	1.8
Benzo (e) Pyrene	6.6

Benzo (a) Pyrene	1.0
Perylene	0.92
Indeno (1,2,3 - cd) Pyrene	0.20
Dibenzo (a,h) anthracene	1.3
Benzo (g,h,i) perylene	1.2

Quantitative Hydrocarbon Composition of MC252 pre-spill oil (LSU, 2010).

Hydrocarbon Compound	Concn mg/kg
nC-10 Decane	2600
nC-11 Undecane	2600
nC-12 Dodecane	2600
nC-13 Tridecane	2500
nC-14 Tetradecane	2400
nC-15 Pentadecane	2000
nC-16 Hexadecane	1800
nC-17 Heptadecane	1700
Pristane	960
nC-18 Octadecane	1500
Phytane	770
nC-19 Nonadecane	1300
nC-20 Eicosane	1300
nC-21 Heneicosane	1100
nC-22 Docosane	1000
nC-23 Tricosane	940
nC-24 Tetracosane	890
nC-25 Pentacosane	600
nC-26 Hexacosane	510
nC-27 Heptacosane	350
nC-28 Octacosane	300
nC-29 Nonacosane	250
nC-30 Triacontane	230
nC-31 Hentriacontane	150
nC-32 Dotriacontane	120
nC-33 Tritriacontane	100
nC-34 Tetratriacontane	90
nC-35 Pentatriacontane	92

APPENDIX E: APPROVED NATIONAL SCIENCE FOUNDATION (NSF) RAPID GRANT DWH PROJECTS

Institution	Proposal Title	Proposal Status	Award Date
University of Texas at Austin	RAPID: Collaborative Research: Extension of the ADCIRC Coastal Circulation Model for Predicting Near Shore and Inner Shore Transport of Oil from the Horizon Oil Spill	Proposal has been awarded	5/26/10
University of North Carolina at Chapel Hill	RAPID: Collaborative Research: Extension of the ADCIRC Coastal Circulation Model for Predicting Near Shore and Inner Shore Transport of Oil from the Horizon Oil Spill	Proposal has been awarded	5/26/10
Louisiana State University & Agricultural and Mechanical College	RAPID: Collaborative Research: Extension of the ADCIRC Coastal Circulation Model for Predicting Near Shore and Inner Shore Transport of Oil from the Horizon Oil Spill	Proposal has been awarded	5/26/10
University of Notre Dame	RAPID: Collaborative Research: Extension of the ADCIRC Coastal Circulation Model for Predicting Near Shore and Inner Shore Transport of Oil from the Horizon Oil Spill	Proposal has been awarded	5/26/10
University of Texas at Austin	RAPID - Collaborative Research: Impact of the New Horizon oil spill on ecosystem metabolism	Proposal has been awarded	5/27/10
Michigan State University	RAPID - Collaborative Research: Impact of the New Horizon oil spill on ecosystem metabolism and gas exchange in the northern GOM hypoxic region	Proposal has been awarded	5/27/10
Oregon State University	RAPID Collaborative Proposal: Spatially-explicit, High-resolution Mapping and Modeling to Quantify Hypoxia and Oil Effects on the Living Resources of the Northern GOM	Proposal has been awarded	6/2/10

East Carolina University	RAPID Collaborative Proposal: Spatially-explicit, High-resolution Mapping and Modeling to Quantify Hypoxia and Oil Effects on the Living Resources of the Northern GOM	Proposal has been awarded	6/2/10
University of Maryland Center for Environmental Sciences	RAPID Collaborative Proposal: Spatially-explicit, High-resolution Mapping and Modeling to Quantify Hypoxia and Oil Effects on the Living Resources of the Northern GOM	Proposal has been awarded	6/2/10
University of Southern Mississippi	RAPID: Collaborative Research: Deepwater Horizon Oil Spill, Marine Snow and Sedimentation	Proposal has been awarded	6/18/10
University of California-Santa Barbara	RAPID: Collaborative Research: Deepwater Horizon Oil Spill, Marine Snow and Sedimentation	Proposal has been awarded	6/18/10
Massachusetts Institute of Technology	RAPID: Collaborative Research: Multiscale dispersed oil modeling of the Deepwater Horizon oil-well blowout for environmental impact assessment and mitigation	Proposal has been awarded	8/8/10
Texas Engineering Experiment Station	RAPID: Collaborative Research: Multiscale dispersed oil modeling of the Deepwater Horizon oil-well blowout for environmental impact assessment and mitigation	Proposal has been awarded	8/8/10
GA Tech Research Corporation - GA Institute of Technology	RAPID: Collaborative Research: Multiscale dispersed oil modeling of the Deepwater Horizon oil-well blowout for environmental impact assessment and mitigation	Proposal has been awarded	8/8/10
University of Colorado at Boulder	RAPID: Seamless Marine-wetlands-coastal Soils Database to Support Urgent Decision-making Against the Deepwater Horizon Coastal Oiling	Proposal has been awarded	8/5/10
University of New Orleans	RAPID: Seamless marine-strandline-wetlands sediments data structure to support decision-making against the Deepwater Horizon coastal oiling	Proposal has been awarded	8/5/10
University of Miami Rosenstiel School of Marine&Atmospheric Sci	RAPID: Collaborative Research: Genetic Impact of the Deepwater Horizon Oil Release	Proposal has been awarded	8/16/10

Texas State University - San Marcos	RAPID: Collaborative Research: Genetic Impact of the Deepwater Horizon Oil Release	Proposal has been awarded	8/16/10
Louisiana State University & Agricultural and Mechanical College	RAPID: Collaborative Research: Genetic Impact of the Deepwater Horizon Oil Release	Proposal has been awarded	8/16/10
Massachusetts Institute of Technology	RAPID: Collaborative Research: Deepwater Horizon: Simulating the three dimensional dispersal of aging oil with a Lagrangian approach	Proposal has been awarded	7/7/10
University of Maryland Center for Environmental Sciences	RAPID: Collaborative Research: Deepwater Horizon: Simulating the three dimensional dispersal of aging oil with a Lagrangian approach	Proposal has been awarded	7/7/10
University South Carolina Research Foundation	RAPID-Collaborative Research: The Microbial Response to the Gulf Oil Spill: Linking Metabolomes and Metagenomes	Proposal has been awarded	8/14/10
University of Oklahoma Norman Campus	RAPID-Collaborative Research: The Microbial Response to the Gulf Oil Spill: Linking Metabolomes and Metagenomes	Proposal has been awarded	8/14/10
University of Texas at Arlington	RAPID: Collaborative Research: GOM Oil Spill Impact on Beach Soil: Radar and Radar Sensor Network-Based Approaches	Proposal has been awarded	7/29/10
Michigan State University	RAPID: Collaborative Research: GOM Oil Spill Impact on Beach Soil: Radar and Radar Sensor Network-Based Approaches	Proposal has been awarded	7/29/10
University of Alabama Tuscaloosa	RAPID:Collaborative Research:Nematostella as an Estuarine Indicator Species for Assessing Molecular and Physiological Impacts of the Deepwater Horizon oil spill.	Proposal has been awarded	8/17/10
Woods Hole Oceanographic Institution	RAPID: Collaborative Research: Nematostella as an Estuarine Indicator Species for Assessing Molecular and Physiological Impacts of the Deepwater Horizon Oil Spill	Proposal has been awarded	8/17/10

University of Georgia Research Foundation Inc	RAPID: Evolutionary Effects of the Deepwater Horizon Oil Spill on Coastal Louisiana Iris Populations	Proposal has been awarded	8/12/10
Oklahoma State University	RAPID: Understanding Early Time Biogeophysical Signals of the Microbial Degradation of Crude Oil from the BP Spill in Saline Marshlands	Proposal has been awarded	8/12/10
Tulane University	RAPID: Enhancement of Fishnet2 for Disaster Impact Assessment	Proposal has been awarded	8/16/10
University of South Florida	RAPID Deep water Horizon Oil spill: Trophic organization of sandy beach ecosystems across gradients of development and oiling	Proposal has been awarded	5/28/10
University of California-Irvine	RAPID: Chemical Analysis of Atmosphere Associated with Gulf Oil Spill	Proposal has been awarded	8/12/10
Colorado State University	RAPID: A Double Dunk: How the Oil Spill is Affecting Katrina-Impacted Residents	Proposal has been awarded	7/14/10
Auburn University	RAPID: Ectoparasites and endoparasites of fishes as bioindicators of acute and chronic environmental perturbation after the 2010 Deepwater Horizon Oil Spill in the GOM	Proposal has been awarded	8/16/10
Woods Hole Oceanographic Institution	RAPID: Mapping Sub-surface Hydrocarbon Dispersed oil Distribution and Structure near MC Block 252	Proposal has been awarded	6/9/10
Columbia University	RAPID: Rapid Assessment of Extent and Photophysiological Effects of the Deepwater Horizon Oil Spill	Proposal has been awarded	7/8/10
MacNeilLehrerProductions	Rapid Response: Getting word out about the science being done to determine the true scope and impact of the gulf oil spill	Proposal has been awarded	7/22/10
Arizona State University	RAPID: Oil Clean-up and Recovery through Novel Interfacial Engineering	Proposal has been awarded	8/6/10

Georgia State University Research Foundation, Inc.	RAPID: Enhancing Biodegradation of Deepwater Horizon Contaminant Hydrocarbons in Louisiana Salt Marsh Using High Layer Charge Montmorillonites	Proposal has been awarded	8/4/10
Louisiana State University Agricultural Center	RAPID: A Survey of Tabanid and Ceratopogonid Populations along Coastal Louisiana to Establish Baseline Data for Measuring the Impact of the BP Oil Spill on Tidal Marsh Communities	Proposal has been awarded	8/16/10
Florida International University	RAPID response to measuring the ecological effects of the Deepwater Horizon oil spill on the Florida Coastal Everglades	Proposal has been awarded	7/19/10
University of Louisiana at Lafayette	RAPID: Impacts of the Deepwater Horizon crude oil spill on the diversity of macroalgae and macrocrustaceans inhabiting deepwater hard banks in the NW, NE and SE GOM	Proposal has been awarded	8/16/10
University of Southern Mississippi	RAPID: Assessment of the impacts of the Deep Horizon oil spill on Bluecrab, Callinectes sapidus, spawning and recruitment in the northcentral GOM.	Proposal has been awarded	6/18/10
Woods Hole Oceanographic Institution	Rapid Response in GOM: Sediment Trap Investigations	Proposal has been awarded	7/28/10
Oklahoma State University	RAPID Proposal to Conduct a Comparative Study of Community Impacts of the 2010 BP Oil Spill	Proposal has been awarded	7/8/10
SUNY at Stony Brook	RAPID: Metal Oxide Nanogrids as Photocatalysts for the Decomposition of Oil in Water	Proposal has been awarded	8/9/10
Marine Environmental Sciences Consortium	RAPID: Resolving higher trophic-level change within the northern GOM ecosystem as a consequence of the Deepwater Horizon oil spill	Proposal has been awarded	5/28/10
University of Southern Mississippi	RAPID: Effect of oil spill on organic carbon partitioning and transformation in the water column in the northern Gulf	Proposal has been awarded	5/26/10

North Carolina State University	RAPID: 3-D Model Forecast of the Vertical and Horizontal Distributions of the Oil Dispersed oils Arising From the DeepWater Horizon Spill	Proposal has been awarded	6/2/10
University of Southern Mississippi	RAPID: Preparing the USM/GCRL Museum Invertebrate Holdings Data For Physical and Electronic Access by the Scientific Community in the Aftermath of the Deepwater Horizon Oil Spill	Proposal has been awarded	8/16/10
Environmental Forensics LLC	RAPID: Environmental Bioaerosol Generation and Potential Environmental Health Risks with Hydrocarbon Weathering on Oil-Spill Impacted Shoreline	Proposal has been awarded	8/12/10
Old Dominion University Research Foundation	RAPID: Selection in Action: Will the GOM oil leak increase the frequency of mottled black fish?	Proposal has been awarded	8/10/10
Florida State University	RAPID: Rates and mechanisms controlling the microbial degradation of crude oil from the MC252 spill in GOM beach sands	Proposal has been awarded	6/9/10
University of Pennsylvania	RAPID: Effects of the Mississippi River dispersed oil on the spread of the Deepwater Horizon oil slick	Proposal has been awarded	8/3/10
Tulane University	RAPID: Self Assembly of Chemical Dispersant Systems in the Treatment of Deep Water Hydrocarbon Releases	Proposal has been awarded	6/29/10
Louisiana State University & Agricultural and Mechanical College	RAPID on Gulf Oil Spill: Phytoplankton and environmental stressors as determinants of Vibrio ecology	Proposal has been awarded	6/2/10
University of Georgia Research Foundation Inc	RAPID Deepwater Horizon Oil Spill: Deep pelagic and benthic impacts of the oil spill	Proposal has been awarded	6/1/10
University of Southern Mississippi	RAPID: Responsive Oil Spill Outreach Based in Science	Proposal has been awarded	7/29/10
Louisiana State University & Agricultural and Mechanical College	RAPID: Social Context and Emotional Response to Disaster	Proposal has been awarded	5/26/10

Texas A&M Research Foundation	RAPID: The effect of methane laden oil on climate and dissolved oxygen: using the Deepwater Horizon oil spill as an analog for clathrate decomposition and seeping methane	Proposal has been awarded	5/26/10
Western Environmental Technology Laboratories, Inc.	RAPID Deepwater Horizon Oil Spill: In-situ tracking of oil in seawater and the aging process using spectral fluorescence	Proposal has been awarded	7/13/10
Woods Hole Oceanographic Institution	RAPID: Mass Spectral Characterization of the Water-Soluble Component of Crude Oil Released During Deepwater Horizon Oil Spill	Proposal has been awarded	7/15/10
Villanova University	RAPID: Manipulating plant and microbial resource environment to optimize oil degradation in coastal marshes	Proposal has been awarded	8/16/10
University of Wisconsin-Madison	RAPID: Rapid Evolutionary Response of Coastal Copepods to the Gulf Oil Spill	Proposal has been awarded	8/12/10
University of California-Santa Barbara	RAPID: Fossil-Fuel Extraction Industry Methane Emission Ground Reference Measurements during the AVIRIS Response to the Gulf Oil Spill	Proposal has been awarded	7/28/10
University of South Florida	RAPID-Plant Species Effects on Rapid Stabilization of Nitrogen in Soil Organic Matter of Mangrove Ecosystems at Risk from the BP Deepwater Horizon Oil Spill	Proposal has been awarded	8/16/10
University of Colorado at Boulder	RAPID: Photochemical Fate of Oil Dispersants Used in the Gulf Oil Spill Clean-up	Proposal has been awarded	7/1/10
University of South Alabama	RAPID: Effects of PAH Exposure on Aquatic Plant Community Structure, Productivity, and Resilience as a Result of the Deepwater Horizon Oil Spill	Proposal has been awarded	8/16/10
Columbia University	RAPID: Impact of Gulf Oil Surface Films on Atmosphere-Ocean Exchange	Proposal has been awarded	7/29/10
Florida State University	RAPID: Census activities and a workshop on baseline coastal data for the Deepwater Horizon oil spill	Proposal has been awarded	8/13/10

Mississippi State University	RAPID: Quantifying the Impact of the BP Deepwater Horizon Oil Spill on the Health and Productivity of Louisiana Salt Marshes	Proposal has been awarded	8/16/10
East Carolina University	RAPID: Marine-to-Land Fluxes of Dissolved and Particulate Carbon Derived from the Deepwater Horizon Surface Slick During the 2010 Hurricane Season	Proposal has been awarded	6/18/10
East Carolina University	RAPID: MRI - Acquisition of an Accelerated Solvent Extractor (ASE) to Rapidly Extract Petroleum Hydrocarbons from Atmospheric Samples in the Field During the 2010 Hurricane Season	Proposal has been awarded	8/16/10
University of Alabama Tuscaloosa	RAPID: Accelerating biodegradation of hydrocarbons from the Deepwater Horizon Oil Spill in the GOM with Naturally Occurring Marine Substrates	Proposal has been awarded	5/25/10
University of Miami Rosenstiel School of Marine&Atmospheric Sci	RAPID: Sub-Mesoscale Dynamics of Buoyant Dispersed oils	Proposal has been awarded	6/2/10
University of Miami Rosenstiel School of Marine&Atmospheric Sci	RAPID: Evaluation of the near term impact of the Deepwater Horizon blowout to the South Florida coast	Proposal has been awarded	7/7/10
University of Houston	RAPID Deepwater Horizon Oil Spill: Insights into salt marsh food webs from the Deepwater Horizon oil spill	Proposal has been awarded	6/18/10
University of South Alabama	RAPID: Trophic interactions in floating Sargassum communities of the GOM: potential consequences of habitat degradation.	Proposal has been awarded	6/9/10
Virginia Polytechnic Institute and State University	RAPID: Affect of Petroleum Deposit Geometry on Biodegradation Potential and Long-Term Persistence	Proposal has been awarded	8/15/10
Woods Hole Oceanographic Institution	RAPID: Hydrocarbon Dissolution Fluxes from the Deepwater Horizon Oil Dispersed oil: GCxGC Chemical Analysis and Mass Transfer Modeling	Proposal has been awarded	5/28/10

Louisiana Universities Marine Consortium	RAPID: Effects of oiling and hydrologic remediation on bald cypress swamp elevation and ecosystem processes in the context of the BP Deepwater Horizon Oil Spill	Proposal has been awarded	8/16/10
Tulane University	RAPID: Increasing through-put of novel Ramped Pyrolysis Radiocarbon Preparation Technique for Gulf Coast oil spill studies - Instrumentation Development	Proposal has been awarded	8/10/10
University of California-San Diego Scripps Inst of Oceanography	RAPID: Glider observations in the GOM in response to the oil spill	Proposal has been awarded	6/3/10
Case Western Reserve University	RAPID: Polymer Aerogels to Protect America's Waterways	Proposal has been awarded	7/15/10
University of Central Florida	RAPID: Oil Optimized Particle Surfaces (OOPS)	Proposal has been awarded	7/26/10
University of Southern Mississippi	RAPID: Deepwater Horizon Oil Spill Effects on Metal, Nutrient, and Organic Matter Distributions in the Water	Proposal has been awarded	5/26/10
New School University	RAPID: What Counts as Crude Oil?: Measuring the Extent and Effect of the Deepwater Horizon Oil Spill	Proposal has been awarded	7/14/10
Colorado School of Mines	RAPID: Gas Hydrate Formation and Inhibition at the Conditions Encountered in the GOM Oil Leak from the Deepwater Horizon Well	Proposal has been awarded	7/13/10
Florida International University	RAPID: Formation, Persistence and Mobility of Oil Emulsions after Major Spills at Sea	Proposal has been awarded	7/1/10
Tulane University	RAPID Deepwater Horizon oil spill: Impacts on Blue Crab population dynamics and connectivity.	Proposal has been awarded	5/28/10
University of North Carolina at Chapel Hill	RAPID: The Microbial Response to the Deepwater Horizon Oil Spill	Proposal has been awarded	6/9/10
Southern University New Orleans	RAPID: Oil Spills and (evolutionary) Changes in Intestinal Microbiota of Fish	Proposal has been awarded	8/12/10

University of South Florida	RAPID Deepwater Horizon Oil Spill: Impact of sub-surface oil dispersed oils on mesopelagic micronekton	Proposal has been awarded	6/16/10
SUNY at Buffalo	RAPID for GOM Oil Spill: Interactions of Crude Oil with Dispersants and Naturally Occurring Particles	Proposal has been awarded	8/8/10
Louisiana State University & Agricultural and Mechanical College	RAPID: Community-level Wetland Stressors, Northern GOM	Proposal has been awarded	8/16/10
University of California-Santa Barbara	RAPID: Assessing the impact of chemical dispersants on the microbial biodegradation of oil immediately following a massive spill	Proposal has been awarded	5/20/10
Woods Hole Oceanographic Institution	RAPID: Impact of Nutrient Limitation on Microbial Degradation of Deepwater Horizon Oil in the GOM	Proposal has been awarded	6/10/10
University of South Florida	RAPID: Emergency Field Investigation of Oil-Beach Interaction along the Alabama and Florida Beaches Following the BP Deepwater Horizon Oil Spill	Proposal has been awarded	6/15/10
Purdue University	RAPID: Assessing flow rate of Macondo oil spill	Proposal has been awarded	8/15/10
University of Southern Mississippi	RAPID: Quantifying the potential impacts of the BP Deepwater Horizon oil spill on carbon services of salt marshes along the northern Gulf Coast	Proposal has been awarded	8/16/10
University of Southern Mississippi	RAPID Deepwater Horizon Oil Spill: Responses of Benthic Communities and Sedimentary Dynamics to Hydrocarbon Exposure in Coastal Ecosystems of the northern GOM	Proposal has been awarded	6/2/10

APPENDIX F: WATER, SEDIMENT AND HUMAN HEALTH BENCHMARKS

Public Health Taskforce Human Health Benchmark for Child Swimmer (http://www.epa.gov/bpspill/health-benchmarks.html)

Water, Sediment and Human Health Benchmarks						
		Water Quality Benchmarks (µg/L)		**Sediment Quality Benchmarks (mg/kg)**		**Human Health Benchmark**
Metals, µg/L	**CAS Number**	Acute Benchmark	Chronic Benchmark	Acute Benchmark	Chronic Benchmark	**Child Swimmer µg/L**
Nickel	7440-02-0	74	8.2	51.6	20.9	15,000
Vanadium	7440-62-2		50	--	57	5,400
PAH Compounds		**Acute Potency Divisor (µg/L)**	**Chronic Potency Divisor (µg/L)**	**Acute Potency Divisor (µg/kg C)**	**Chronic Potency Divisor (µg/kg C)**	
PAH Mixtures	--	See NOTE 1, below.		See NOTE 1, below.		
Benzene	71-43-2	27,000	5,300	3,360,000	660,000	380
Cyclohexane	110-82-7	1,900	374	4,000,000	786,000	
Ethylbenzene	100-41-4	4,020	790	4,930,000	970,000	610

Isopropylbenzene / Cumene	98-82-8	2,140	420	5,750,000	1,130,000	20,000
Total xylene	108-38-3	3,560	700	4,980,000	980,000	18,000
Methylcyclohexane	108-87-2	463	91	4,960,000	976,000	
Toluene	108-88-3	8,140	1,600	4,120,000	810,000	120,000
Naphthalene	91-20-3	803	193	1,600,000	385,000	1,800
C1-Naphthalenes	--	340	81.7	1,850,000	444,000	170
C2-Naphthalenes	--	126	30.2	2,120,000	510,000	
C3-Naphthalenes	--	46.1	11.1	2,420,000	581,000	
C4-Naphthalenes	--	16.9	4.05	2,730,000	657,000	
Acenaphthylene	208-96-8	1,280	307	1,880,000	452,000	
Acenaphthene	83-32-9	232	55.8	2,040,000	491,000	2,500
Fluorene	86-73-7	164	39.3	2,240,000	538,000	12,000
C1-Fluorenes	--	58.1	14	2,540,000	611,000	
C2-Fluorenes	--	22	5.3	2,850,000	686,000	
C3-Fluorenes	--	7.99	1.92	3,200,000	769,000	

Phenanthrene	85-01-8	79.7	19.1	2,480,000	596,000	
Anthracene	120-12-7	86.1	20.7	2,470,000	594,000	22,000
C1-Phenanthrenes	--	31	7.44	2,790,000	670,000	
C2-Phenanthrenes	--	13.3	3.2	3,100,000	746,000	
C3-Phenanthrenes	--	5.24	1.26	3,450,000	829,000	
C4-Phenanthrenes	--	2.33	0.559	3,790,000	912,000	
Fluoranthene	206-44-0	29.6	7.11	2,940,000	707,000	UD
Pyrene	129-00-0	42	10.1	2,900,000	697,000	4,100
C1-pyrene/fluoranthenes	--	20.3	4.89	3,200,000	770,000	
Benz(a)anthracene	56-55-3	9.28	2.23	3,500,000	841,000	UD
Chrysene	218-01-9	8.49	2.04	3,510,000	844,000	UD
C1-Chrysenes	--	3.56	0.856	3,870,000	929,000	
C2-Chrysenes	--	2.01	0.483	4,200,000	1,010,000	
C3-Chrysenes	--	0.699	0.168	4,620,000	1,110,000	
C4-Chrysenes	--	0.294	0.0706	5,030,000	1,210,000	

Perylene	198-55-0	3.75	0.901	4,020,000	967,000	
Benzo(b)fluoranthene	205-99-2	2.82	0.677	4,070,000	979,000	UD
Benzo(k)fluoranthene	207-08-9	2.67	0.642	4,080,000	981,000	UD
Benzo(e)pyrene	192-97-2	3.75	0.901	4,020,000	967,000	
Benzo(a)pyrene	50-32-8	3.98	0.957	4,020,000	965,000	UD
Indeno(1,2,3-cd)pyrene	193-39-5	1.14	0.275	4,620,000	1,110,000	UD
Dibenz(a,h) anthracene	53-70-3	1.17	0.282	4,660,000	1,120,000	UD
Benzo(g,h,i)perylene	191-24-2	1.83	0.439	4,540,000	1,090,000	

UD = Under Development

NOTE 1: Potency divisors are not chemical specific benchmarks, but are used in calculating aggregate toxicity of a mixture. To assess hazard, the sum of calculated values is compared to a hazard index of 1. A value greater than 1 indicates potential effects.

NOTE 2: This table represents the basic quantitative measurements for the three primary sets of indicators (i.e., human health, aquatic, and sediment). Detailed explanations and descriptions (e.g., PAH mixtures, etc) for each are provided here:

http://www.epa.gov/bpspill/water-benchmarks.html

http://www.epa.gov/bpspill/health-benchmarks.html

http://www.epa.gov/bpspill/sediment-benchmarks.html

APPENDIX G: OSAT REPORT EXAMPLE

Operational Science Advisory Team (OSAT

Weekly Report to the Scientific Support Coordinator

DATE

ZONE: (i.e., nearshore, offshore deep water) STRATA: (i.e., water, sediment)

Data Set Time Frame (i.e., 14-day, 30-day, etc.)

1. Number of Samples in Data Set
2. Number of Samples that exceed the indicators

Analysis

OSAT Recommendations

Dissenting Opinions

State Comments

APPENDIX H: REFERENCED USCG DIRECTIVES AND STRATEGIES

(1) Sub-Sea and Sub-Surface Oil and Dispersant Detection, Sampling and Monitoring Strategy, Directive memo 16451 of 18AUG10

(2) Sub-Sea and Sub-Surface Oil and Dispersant Detection, Sampling and Monitoring Strategy, Directive memo 16451 of 13AUG10

(3) UAC Adaptive Sub-Surface Sampling Strategy for Transition from Response to NRDA Approved 03AUG10

APPENDIX I: LIST OF ACRONYMS

ADCP	Acoustic Doppler Current Profilers
ASA	Applied Science Associates
AUV	Autonomous Underwater Vehicle
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CEQ	Council on Environmental Quality
CO-OPS	Center for Operational Oceanographic Products and Services
COP	Common Operating Picture
CTD	Conductivity, Temperature and Depth
DIF	Data Integrated Format
DOI	Department of Interior
DWH	Deepwater Horizon
EPA	Environmental Protection Agency
ERMA	Environmental Response Management Application
EU	Environmental Unit (UAC)
FDA	Food and Drug Administration
FWS	Fish and Wildlife Services
GCOOS	Gulf of Mexico Coastal Ocean Observation System
GIS	Geographic Information System
GOM	Gulf of Mexico
IOOS	Integrated Ocean Observing System
JAG	Joint Analysis Group
LISST	Laser In-situ Scattering and Transmissometry
NCCA	National Coastal Conditions Assessment
NCDDC	National Coastal Data Development Center
NCP	National Contingency Plan
NDBC	National Data Buoy Center
NIC	National Incident Commander

NMFS	National Marine Fisheries Service
NOAA	National Oceanic Atmospheric Administration
NODC	National Ocean Data Center (NOAA)
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
NSF	National Science Foundation
OGC	Open Geospatial Consortium
OPA 90	Oil Pollution Act of 1990
OSAT	Operational Science Advisory Team
OSTP	Office of Science and Technology Policy
USPHS	United States Public health Service
OR&R	Office of Response and Restoration (NOAA)
QA/QC	Quality Assurance and Quality Control
QAPP	Quality Assurance Project Plan
PAHs	Polycyclic Aromatic Hydrocarbons
SDF	Standard Data Format
SMB	Sub-Surface Monitoring Branch
SOS	Sensor Observation Service
SSC	Scientific Support Coordinator
SURA	Southeastern Universities Research Association
SVOC	Semi Volatile Organic Carbons
UAC	Unified Area Command
UNOLS	University-National Oceanographic Laboratory System
USCG	United States Coast Guard
USGS	United States Geological Survey
VIPERS	vessels with petroleum ensnaring and recovery systems
VOC	Volatile Organic Carbons
VSP	Visual Sample Plan

APPENDIX J: ACKNOWLEDGEMENTS

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