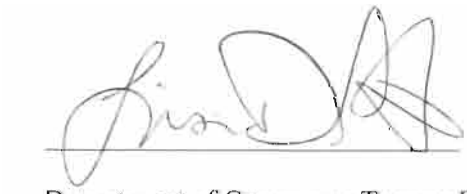
Mississippi Canyon 252 Incident

Work Plan for the Collection of Data to Determine Impacts of the Deepwater Horizon Mississippi Canyon 252 Incident on Endangered and Protected Marine Mammals in the Northern Gulf

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

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

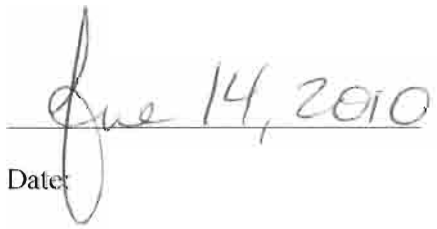
APPROVED:



Department of Commerce Trustee Representative

Date:

BP Representative:



Date:

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I. Natural Resources Being Addressed

The Deepwater Horizon incident at the Mississippi Canyon 252 (MC252) site resulted in an extensive oil spill within a region of high density and diversity of protected marine mammals. Since April 28th, 2010 aerial surveys have been conducted in this area documenting the presence of sperm whales (*Physeter macrocephalus*) that are listed as endangered under the ESA. Aerial surveys have verified the presence of pantropical spotted dolphins (*Stenella attenuate*), striped dolphins (*Stenella coeruleoalba*), spinner dolphins (*Stenella longitrostris*), bottlenose dolphins (*Tursiops truncatus*), Risso's dolphins (*Grampus griseus*), and Cuvier's beaked whale (*Ziphius cavirostris*) within or near the oil spill (National Oceanic and Atmospheric Administration, Southeast fisheries Service center (SEFSC), unpublished data). Sperm whales inhabiting the Northern Gulf of Mexico include the area near the MC252 incident within their home-ranges, and the areas of the Mississippi Canyon and DeSoto Canyon are known areas of high density for sperm whales along with other oceanic odontocetes (Jochens et al. 2008). In addition, a small, isolated population of Bryde's whales (*Balaenoptera edeni*) resides along the continental shelf break just east of the spill area (Waring et al. 2009) and is the only known resident baleen whale in the Northern Gulf of Mexico. This population may be impacted by oil as it approaches the west Florida continental shelf.

It is possible that sperm whales and other protected marine mammals encountering oiled environments experience potential detrimental effects due to skin contact, ocular irritation, inhalation of hydrocarbon vapors, and ingestion of oil (Geraci 1990). It is unknown whether or not prolonged exposure would result in direct mortality of individual animals. The area near the spill is a high-use habitat for many species, and this is likely associated with concentration of prey resources. The primary prey of sperm whales and other deep-diving marine mammals is deepwater squids that occupy water depths between 400-600m. High levels of subsurface oil from the incident may have significant direct impacts on this prey community through reduced levels of dissolved oxygen and potential toxic effects due to oil contaminants in the water column. Habitat degradation related to the spill may cause a shift in spatial distribution by these highly mobile predators possibly moving the animals into areas with lower prey densities. Such a distribution shift may have impacts on survival and productivity of the populations.

In addition to the oil released at the well site, several hundred thousand gallons of oil dispersant chemicals have been deployed within the spill region. The composition and toxic effects of the dispersants are unknown, and their impacts on marine mammals within the spill area are uncertain. As with the oil impacts, the potential impacts of chemical dispersants on marine mammals include acute exposure due to contact or inhalation, shift in distribution away from a primary feeding habitat, and/or longer-term exposure through accumulation in the food web.

Purpose/Objectives

SEFC in cooperation with BP propose a vessel-based study of sperm whales and other protected marine mammals in the deep-water habitats of the north-central Gulf of Mexico impacted by the oil spill. The study will provide critical information on the acute effects of the spill, monitor

spatial distribution in the near-term, and develop information with which to evaluate longer-term chronic effects. The objectives of the study are to:

1. Incidence of exposure to oil: direct observation of contact and occurrence of animals in oiled areas:
    a. By photodocumentation
    b. Visual and passive acoustic monitoring
    c. Satellite tags
2. Cetacean distribution related to oil exposure or other factors
    a. Passive acoustic
    b. Satellite tags
    c. Visual and passive acoustic monitoring
3. Develop information on population demographics of Sperm and Brydes whales
    a. Tissue biopsy
4. Collect habitat information including surface hydrographic data, vertical profiles of temperature, salinity, and dissolved oxygen, and collect acoustic backscatter information to characterize water column productivity and prey resources
    a. Collect habitat information
5. Conduct necropsy analysis and/or sampling of discovered carcasses.
    a. Conduct basic necropsy on delphinid carcasses and arrange for retrieval/sampling of whale carcasses for onshore necropsy

Meeting these objectives will provide initial information required to assess exposure of these animals to spilled oil and other impacts associated with this event. An additional objective of this study is to collect data similar to that collected in the past that will provide insight into each species distribution and abundance and potentially develop valuable information that will allow for better management of these protected species.

II. Study Methods

The SEFSC propose to conduct a 47-day survey of the deep waters of the north-central Gulf of Mexico focusing on the high-use areas for sperm whales, Bryde's whales, and other protected marine mammals potentially impacted by the spill. The survey is planned to take place on the NOAA research vessel *Gordon Gunter*. The ship is a 224 ft. oceanographic research vessel that has the capability to support marine mammal visual and passive surveys, deploy oceanographic equipment over the side, and support small boat operations. The vessel is currently scheduled to depart Pascagoula, MS for a three-leg cruise with the following dates:

Leg 1: 14 June – 26 June (13 Days at Sea)
Leg 2: 30 June – 16 July (17 Days at Sea)
Leg 3: 20 July – 5 August (17 Days at Sea)

The survey will focus on four primary operational areas (Figure 1). These areas include regions where sperm whale and other oceanic marine mammal densities are high during summer months based upon historical survey data. The operational areas include: (A) The shelf break region south of Louisiana, (B) The De Soto/Mississippi Canyon Area, (C) The Dry Tortugas, and (D) a region encompassing the Bryde's whale habitat. The home ranges of sperm whales within the northern Gulf of Mexico are likely to include primarily areas A and B. The Dry Tortugas region is also an area of known concentration of sperm whales, and it is unknown if these animals also

occupy the other regions of the Northern Gulf. The Dry Tortugas region is selected as a reference site given that it has not experienced significant impacts from oil or response vessels from the MS252 incident as of yet. The vessel will transit to each operational area on an adaptive basis dependent upon weather and other conditions and conduct major science operation within the area.

The major science operations during the cruise will include:

1) *Collect tissue biopsy samples of marine mammals, with a particular focus on sperm whales and Bryde's whales*

Tissue samples (including epidermis and an attached portion of blubber) will be obtained using remote biopsy. Biopsy samples are obtained from a small boat (7m Rigid Hull Inflatable) deployed from the ship using specially designed biopsy darts fired from either a rifle or a crossbow. The small boat biopsy collection will focus on sperm whales and Bryde's whales, and additional biopsy samples will be collected opportunistically from bow of the *Gordon Gunter*. The remote biopsy can provide both skin and blubber that can be analyzed for a variety of biological metrics. Genetic analysis will be conducted on skin samples for sex determination and stock identification. Other analyses to be conducted on the samples will be determined at a later date. Those later analyses explicitly are not part of this assessment plan. During close approaches to sperm whales, photographic documentation will be conducted to evaluate and document the skin lesions or other injuries possibly associated with oil exposure. Photographic data will also be collected to document the presence of calves and estimate body size of targeted individuals. Photographs may also be used to compare against previous photographs of individual whales encountered in these areas.

2) *Deploy long-term passive acoustic monitoring systems to collect data on the occurrences of acoustically active marine mammals along the 1000m isopleth from western Louisiana to the West Florida shelf, including areas near the incident site, adjacent to the immediate impact zone and at a range of distances from the impact zone.*

Two types of long-term passive acoustic monitoring buoys will be deployed along the shelf break (roughly 1,000m isobath) from western Louisiana to the West Florida shelf. The first type of passive acoustic system is referred to as a High-frequency Acoustic Recording Package (HARP), and the second type of passive acoustic system is referred to as a Marine Acoustic Recording Units (MARU). Three HARPs will continuously record sounds up to 100 kHz for 110 days with the objective of documenting the presence of acoustically active sperm whales, Bryde's whale, beaked whales and dolphins in three of the operational areas. The HARP project will be lead by Dr. John Hildebrand (Scripps Institute of Oceanography) and will complement a HARP package already placed near the site of the MC252 incident.

Twenty-two (22) MARUs will be deployed so as to provide broad-scale information on animal spatial distribution area from western Louisiana to the West Florida shelf. These units will operate on a duty cycle and record sounds up to 2.5 kHz for 110 days with the objective of documenting the presence of acoustically active sperm whales and Bryde's whale, and perhaps some dolphins at 22 sites distributed along an approximately 400-500 nautical mile portion of the 1000m isopleth. The deployment and analysis of data from these units will be lead by Dr. Christopher Clark of Cornell University. These units will complement the HARP study by providing broader spatial coverage and documenting large scale movements or distribution

shifts. Unlike the HARPs, these units will not be configured to record high frequencies required for the detection of beaked whales and delphinids.

3) *Support the deployment of satellite tags on sperm whales to document long-term movements and possible exposure to oil*

During the second leg of the survey, the small boat will be used to deploy up to 26 long-term satellite tags on sperm whales. These tags have durations of 6 to 12 months, and provide information on the movements of tagged animals through satellite telemetry. Similar tags have been deployed in previous studies of Gulf of Mexico sperm whales. This effort will be lead by Dr. Bruce Mate (Oregon State University) and will provide long term information on the movements and potential exposure of sperm whales to impacted areas within the Gulf. The tagging effort will most likely be focused within the DeSoto/Mississippi Canyon operational area.

4) *Conduct visual and passive acoustic surveys of sperm whales and other marine mammals within target areas*

Within each operational area, visual and passive acoustic tools will be used to document the occurrence and spatial distribution of sperm whales and other marine mammals. Visual surveys will be conducted by a team of three observers stationed on the vessel's flying bridge and will consist of two observers using 25x150 "bigeye" binoculars and a central observer/data recorder. Data will be recorded using the VisSurvey data acquisition program which will operate on a laptop and will record ancillary habitat and sighting condition data along with position and sighting information. Survey speed will typically be 10 knots, but may vary with sea conditions. Visual survey effort will likely be suspended during high sea states, poor visibility conditions (e.g., fog, haze, rain), or when there is lightning in the area.

Passive acoustic monitoring will be conducted simultaneously with the visual observations and continued during night or poor weather conditions when visual operations are limited. Acoustic monitoring will be conducted using a broadband acoustic array. The acoustic array will be towed behind the ship below the surface. The array will record data at frequencies up to 100 kHz, which will allow detection and recording of high frequency sounds produced by beaked whales and other delphinids. The array will be interfaced with a suite of electronics inside the ship and scientists will monitor the array when it is in tow. Signal processing equipment, recording equipment and data collection computers will be stationed in the dry lab. The passive acoustic team will record marine mammal vocalizations into a digital archive and record the location, bearing, and species identification of acoustic contacts.

5) *Collect habitat information including surface hydrographic data, vertical profiles of temperature, salinity, and dissolved oxygen, and collect acoustic backscatter information to characterize water column productivity and prey resources.*

Environmental data will be collected from the suite of instruments integrated into the vessel's Scientific Computing System (SCS), which will be in operation 24 h/day. These systems conduct continuous sampling of surface waters including metrics such as sea surface temperature, salinity, and fluorescence. In addition, CTD casts up to 500m will be made at pre-determined environmental sampling sites and at stations of opportunity identified during the survey (for example near sperm whale feeding aggregations) on an adaptive basis. XBT casts

will be made while underway during transit periods along the trackline at approximately 1 h (~ 10 mile) intervals. Following completion of an XBT cast, the collected data will be inspected for initial quality control and to identify significant features in the profile such as surface temperature (5m depth), mixed layer depth, thermocline depth, and thermocline temperature according to prescribed methods.

The SimRad EK60 scientific echosounder system will be used to continuously collect data on acoustic backscatter in the water column associated with secondary productivity (e.g., zooplankton, small fish and squids). The *Gordon Gunter* has echosounders operating at 18 kHz, 38 kHZ, 120 kHz and 200 kHz frequencies. These different frequencies allow the detection and quantification of a range of different size organisms. The data collected from the current cruise can be compared to data collected during Jan-Mar 2010 (using the same frequencies) to assess any seasonal or observed changes. In addition, a survey just prior to this cruise will evaluate the capability of the EK60 system to detect and map sub-surface oil.

IV. Justification and Expected Outcomes

The study proposed here provides a unique opportunity to quantify potential impacts of the DWH event on the oceanic marine mammal populations of the northern Gulf of Mexico. The timing of the study is critical, as it will provide an opportunity to document initial evidence of population level responses to the event. The monitoring program developed here will provide information during the initial months following the event.

In addition, the vast majority of historical data collected on marine mammal spatial distribution in the Northern Gulf of Mexico has been collected during summer months. The most recent vessel surveys were conducted in the summer of 2009, and there are historical data for the summer and fall dating back to the mid-1990s (Mullin and Fulling, 2004; Mullin and Hoggard, 2000). Therefore, there may be historical baseline to compare with data that will be collected during the summer 2010 survey. The study objectives are detailed below.

1) Evaluate the incidence of exposure to oil
    - Visual and passive acoustic line transect surveys will quantify the abundance and spatial distribution of marine mammals within the spill area and adjacent regions. These data can be compared to the known distribution of oil to assess the number and species composition of potentially exposed marine mammals and compared to baseline data available from previous cruises conducted by SEFSC to determine if the observed distribution during the spill event is significantly different from that observed in prior years, accounting for the effects of environmental variability.
    - Genetic analysis will be conducted to determine sex and to compare previous genetic studies of Gulf of Mexico sperm whales.. Any other analyses of the biopsy samples are expressly not part of this plan.
    - Photo-documentation during visual surveys or close approaches of sperm whales by a small boat will document the incidence of skin lesions or other potential external evidence of injury.
2) Satellite tagging studies will document the residence patterns of sperm whales and Bryde's whales within areas impacted by oil. As the impacts of the oil spread spatially, the tag telemetry data will also be able to document changes in animal movements with changes in the amount of oil in the environment and other factors. Assess any changes in animal distribution correlated to oil exposure

- One of the goals of the program's integrated data analyses is to look for indications that spatio-temporal changes in species-specific detection rates, are correlated with spatio-temporal changes in oil distribution or other variables.
- There is an extensive database from sperm whale satellite tagging studies in the Northern Gulf of Mexico that can serve as baseline data for comparison to the data we propose to collect in this study. In particular, it may be possible to directly evaluate whether or not there are significant changes in the home ranges and residence patterns in oiled vs. non-oiled areas.

3) Develop information on population demographics of endangered sperm whales and in Brydes whales
   - Genetic analysis of skin from biopsy samples can be used to determine the gender of sampled animals and estimate the sex-ratio of the population. Skin and blubber samples from sperm whales and other species will be stored for chemical analysis to be determined later. Those later analyses are expressly not part of this plan.
   - *Collect habitat information including surface hydrographic data, vertical profiles of temperature, salinity, and dissolved oxygen, and collect acoustic backscatter information to characterize water column productivity and prey resources.*
   - Scientific echosounders will be used throughout the cruise to quantify the spatial distribution of secondary production within the spill area and adjacent regions. These data can be compared to data collected during the summer of 2009 and just prior to the oil spill (Jan-March 2010). These data can potentially directly quantify impacts of oil exposure on the deepwater food web that supports the marine mammal populations of the Northern Gulf. This data will also be evaluated for seasonal variation.
   - Ancillary environmental data on the vertical and horizontal distribution of hydrographic variables (e.g., temperature, salinity, flouresence) throughout the survey to characterize the habitats of marine mammals in the region.

V. Disposition of Samples and Collected Data

Data collected by NOAA/SEFSC during the cruise will be provided in raw format to the NRDA Data Management Team as soon as is feasible after the completion of each cruise leg. These data will include visual survey data, data on passive acoustic contacts from the towed array, sighting sheets, biopsy sheets, acoustic backscatter data, and collected hydrographic data. All data will be handled using strict chain-of-custody and QA/QC procedures and made available to both parties. Digital photographs will be logged and maintained following chain of custody procedures developed by the NRDA Data Management team.

During sample collection, biopsy samples will be split as required for different sample storage requirements. In particular, the skin from the sample will be stored in 20% DMSO and the blubber sample will be stored in Teflon vials at -80°C. The blubber sample may be split into parts if possible. All skin samples will be transferred to the SEFSC Marine Mammal Molecular Genetics Laboratory. The frozen blubber samples will be retained at the National Seafood Inspection Laboratory at Pascagoula, MS. Secure storage and chain of custody forms will be provided as needed to NRDA data management.

The satellite telemetry, HARP raw acoustic data, and MARU data will be retained in raw form by the respective researchers. Provided, however, that the researcher shall make the satellite

telemetry, HARP raw acoustic data, and the MARU data available to BP Exploration and Production Company (BP) and/or NOAA within 21 days of a request by BP or NOAA for such data.

VI. Expected Budget and Requested Resources

This proposal focuses on the collection of data and deployment of equipment for long-term monitoring. The analytical costs to process biopsy samples after the survey are not included in this request. In addition, the costs of the passive acoustic monitoring equipment and satellite tagging studies are not included here and will be requested in separate proposals.

Vessel cost – NOAA Ship Gordon Gunter (June 14 – August 5, 2010)	
47 Days at Sea @22.7k per day at sea:	1,066,900
Operations Cost	
Contract Staff Costs (10 staff):	264,000
FTE Staff (OT and Base, 2FTEs):	28,800
Equipment and Supplies:	18,000
Small Vessel Costs:	9,800
Vessel cost – Contract Vessel for recovery of HARPs and MARUs (During Sept – Oct)	
14 Days at sea @12K per day:	168,000
SEFSC Staff (1 person- 2 weeks and travel):	5,000
Project Management, Data management, and Data analysis	
FTE Staff (1.5)	195,000
Total Cost Estimate:	**$1,755,500**

Appendix 1. Variables and products from major data collection efforts

I. Visual line transect survey

Data Description and Sampling Effort: Visual surveys will occur along transects during daylight hours when weather conditions allow. We anticipate conducting 400-500 miles of visual line-transect survey effort within each operational area.

Primary Measured Variables: For visual survey, the primary variables collected are the location, species identification, group size, and behavior of encountered marine mammals.

Additional Variables: Environmental conditions will be measured or recorded during visual effort. These include sea state, swell height, weather conditions, cloud cover, and visibility. In addition, continuous measurements will be taken of wind speed and direction, surface water temperature, surface salinity, surface fluorescence, and water depth. Position data is recording continuously provided using GPS.

Data recording: Visual data are entered into an MS Access database using a custom data-entry program. Environmental from the ship's sensors are integrated into the database at 30 second intervals. Observational data on the behaviors of animals and their response to the vessel are recorded by hand on sighting data sheets.

Expected Analytical Products:

1. Maps showing survey effort and marine mammal sightings, including overlays of surface oil from external data sources.
2. Spatial distribution of marine mammals as a function of environmental variables, including metrics for the presence/absence of oil in affected areas will be analyzed using techniques such as Generalized Additive Models (GAM; Wood 2006) or other applicable models. Line transect/Distance (Buckland et al. 2001) analysis will be used to account for the probability of observing animals and incorporated into the spatial models to provide absolute density estimates.
3. Data collected during summer 2010 will be integrated with similar data sets from summer 2003 and summer 2009 to compare the observed spatial distribution of marine mammals. Comparisons will also likely be made through the incorporation of annual effects, environmental effects, and the presence of oil within the GAM framework.

II. Towed Passive Acoustic Array

Data Description and Sampling Effort: The passive acoustic array will be towed behind the vessel nearly continuously during the visual line-transects and during periods where we are focusing on sperm whale groups for small boat sampling. Throughout the survey, we expect to collect at least 300 hours of acoustic recordings.

Primary Measured Variables: Sounds from the array are recorded continuously while it is in operation. Acoustics technicians monitor the sounds from the array and record information on detected marine mammal sounds including the type of sound (e.g., clicks, whistles, etc.) and classify the sound based on the characteristics. Bearings to the sound are calculated using

automated routines for localization. Data are recorded on the location, sound type, intensity, bearings to the contact, and the duration of the sound (start and stop time/location of the acoustic contact). When the acoustic array is being monitored simultaneously with the visual survey, the location of the acoustic contact is compared directly to visual sightings to verify species identification. The towed acoustic array will also assist in determining the locations of cetaceans for photographic and tagging efforts.

Additional Variables: Environmental conditions will be measured or recorded during acoustic effort. These include sea state, swell height, weather conditions, cloud cover, and visibility. In addition, continuous measurements will be taken of wind speed and direction, surface water temperature, surface salinity, surface fluorescence, and water depth. Position data is recording continuously provided using GPS.

Data recording: Recordings are made onto digital media. Information on confirmed marine mammal contacts data are entered into an MS Access database using a custom data-entry program. Environmental data recordings from the ship's sensors are integrated into the database at 30 second intervals.

Expected Analytical Products:

1. Maps showing survey effort and marine mammal acoustic contacts.
2. Generalized Additive Models (GAM; Wood 2006) or similar will be used to model the spatial distribution of acoustic call rates (by species) as a function of environmental variables, including metrics for the presence/absence of oil in affected areas.
3. Acoustic data collected during the survey can be compared to/integrated with visual sighting data to evaluate the relative effectiveness of these tools.
4. Visual confirmation of acoustic detections is important for calibration/species identification of acoustic detections from the HARP monitoring units. Spectral analysis is used to characterize acoustic calls from encounters where the species is known or confirmed through visual sightings (e.g., Soldevilla et al. 2008; Roch et al. 2008; Roch et al. 2007). This characterization is then used to classify acoustic contacts from the HARPs.

III. Photographic documentation of condition

Data Description and Sampling Effort: Photographs will be taken of sperm whales during biopsy collection and tagging efforts. Sampling effort will be determined by weather and sperm whale encounters; however, we hope to perform close approaches to at least 20-30 sperm whales and 5-10 Bryde's whales.

Primary Measured Variables: Photographs will be taken by experienced observers using telephoto lenses on high-quality digital cameras. We will attempt to collect images of the body, blowhole region, and other areas of the head to the extent possible.

Additional Variables: Location and behavior information are recorded during close approaches to whales.

Data recording: Data are recorded on paper during encounters including logs of photos taken.

Expected Analytical Products:
Summary of photographic results and potential observed injuries. No specific hypothesis test or statistical analysis is anticipated.

IV. Biopsy collection

Data Description and Sampling Effort: Biopsy samples are collected from a small boat with close approaches to encountered whales. Sampling effort will be determined by weather and sperm whale encounters; however, we hope to perform close approaches to at least 20-30 sperm whales and 5-10 Bryde's whales.

Primary Measured Variables: Obtained tissue samples. Information on the sampling tool used and the location of the sample on the body are recorded

Additional Variables: Ancillary information on the behavior of the group or the animal during the biopsy approach and event.

Data recording: Data are recorded on paper during encounters.

Expected Analytical Products:
The sex and stock identification of the whales will be determined from later analysis of the tissues.Any other analyses that will be conducted will be determined at a later date. Those analyses are expressly not part of this assessment plan.

V. Satellite tagging

Data Description and Sampling Effort: Satellite tagging efforts will be made primarily during the second leg of the cruise. This involves the close approach to target animals and placement of the tag on-board. We are hoping to deploy up to 20 tags, with the majority of these deployed on sperm whales. These tags remain deployed for periods of 6-12 months and provide location information several times per day dependent upon the surfacing behavior of the whale and satellite coverage of the Argos system. If we assume 2 transmissions per day occurring every other day and 12-months duration, this would result in approximately 365 positions (time, latitude, longitude) for each individual whale.

Primary Measured Variables: The satellite tags which will be deployed on sperm whales in the Gulf of Mexico are referred to as 'location only.' They provide locations through service Argos of varying degrees of accuracy depending on the number of transmissions received by a satellite during a pass (Mate *et al.* 2007). Additionally, either the number of transmissions or number of surfacings (number of times the salt water conductivity switch is broken) are also transmitted depending on the tag software (duty cycle) and whale's behavior.

Additional Variables: Information on the quality/accuracy of the location fix is also reported.

Data recording: Locations are determined based on receptions by the Argos satellite system. These locations are logged electronically on a user account associated with the specific satellite tag.

Expected Analytical Products:

A home range and core area size can be calculated from the locations for an individual or a group of individuals using for example fixed kernel methods, or, a more recently devised local convex hull method (Getz and Wilmers 2004). By assuming straight line travel between consecutive locations, a conservative swim speed can be calculated as well. We can often distinguish between transiting (linear travel movements) and more complicated foraging movements which have significant turn angles defining area restricted searches (ARS) using methods defined in Bailey (2010) using OSU blue whale data. A historical database of tag studies from 53 Gulf of Mexico sperm whales is available for comparative studies.

1. Calculate home ranges and core areas and compare to previously collected data
2. Compare the home range and core area size, location and amount of overlap between whales tracked before and after the oil spill to identify extent of differences.
3. Compare the proportion of shared home ranges by males before and after oil spill.
4. Compare water depth preferences of females before and after the spill
5. Compare swim speeds through contaminated areas with non-contaminated areas.
6. Compare the number of surfacings, locations, and messages received from tags in contaminated areas with non-contaminated areas.
7. Compare size and sex distribution of tagged whales in different habitats.

VI. Acoustic monitoring - MARU

Data Description and Sampling Effort: Acoustic data are recorded continuously while the monitoring unit is in operation. The effective band width of the units is 2.5 kHz, allowing the detection primarily of baleen whale calls and sperm whales echolocation clicks. If we assume a 110 day deployment cycle, each buoy will record 2,640 hours of acoustic data.

Primary Measured Variables: Raw acoustic data (e.g., recorded sounds) are screened using automated detection routines to identify the calls of targeted species (e.g., sperm whales, Bryde's whales, and delphinids). The number of detected calls for each taxon is the fundamental variable of interest.

Additional Variables: The recordings also result in a continuous record of ambient noise including vessel noise, seismic exploration, wind, waves, other animals etc.

Data recording: Acoustic data are recorded onto digital media as are post-data collection analysis of call type and frequency.

Expected Analytical Products:

1. Determine Sperm whale hourly presence and estimates of number of acoustically active animals: For each hour of data, Bioacoustics Research Program (BRP) will determine whether or not sperm whales were acoustically detected by a combination of automated call detection software and expert human validation. For the hour with the greatest number of detected sperm whale sounds an estimate of the minimum-maximum number of whales during that hour will be made.
2. Determine Bryde's whale daily presence and estimates of number of acoustically active animals: For each day of data, BRP will determine whether or not Bryde's whales were acoustically detected by a combination of automated call detection software and expert

human validation. For the hour with the greatest number of detected sperm and Brydes's whale sounds an estimate of the minimum-maximum number of whales during that hour will be made.

3. Determine delphinid daily presence: For each day of data, BRP will determine whether or not delphinid whistles and clicks were acoustically detected by a combination of automated call detection software and expert human validation. If possible, these acoustic detections will be identified to species.
4. Comparison of similarities and differences in the sample areas: The data from items (1), (2), and (3) will be integrated and interpreted in order to map spatial and temporal variability in the occurrences of the different species. Mapping products will show time series of observations, especially the acoustic work with HARP and MARU. Data products should reflect changes, if any, over the period of data collection
5. Assess noise conditions: A statistically significant sample of the acoustic data will be processed to compute a set of statistics and informative acoustic measures. This initial data conversion and reduction process will include, but not necessarily be limited to daily (i.e., 24-h) spectrographic images, ambient noise order statistics (stats: 5%, 25%, 50%, 75%, 95%), and time-varying 1/3 octave received levels. These analyses will be used to quantitatively describe the ambient noise environment throughout the project area throughout the duration of the project.

VI. Acoustic monitoring - HARPs

Data Description and Sampling Effort: Acoustic data are recorded continuously while the monitoring unit is in operation. The effective band width of the units is 100 kHz, allowing the detection of delphinids such as dolphins and beaked whales in addition to baleen whale calls and sperm whales echolocation clicks. If we assume a 110 deployment cycle, each buoy will record 2,640 hours of acoustic data.

Primary Measured Variables: Raw acoustic data (e.g., recorded sounds) are screened using automated detection routines to identify the calls of targeted species. Processing and analyzing large, long-term acoustic data sets is challenging. Automated detectors have been useful in finding cetacean sounds in large data sets, but require extensive training to provide good performance and typically only detect sounds with known characteristics, missing new or uncharacterized sounds. As an efficient alternative, Long-Term Spectral Averages (LTSAs) provide an overview of a large data set, along with providing a means to search for and evaluate events of interest such as cetacean calling bouts. LTSAs are essentially spectrograms with each time slice representing many (1000's) spectra averaged together, allowing multiple hours or days of wideband acoustic data to be displayed on a single page or viewing screen. "Triton" (http://cetus.ucsd.edu/technologies_Software.html) is a software package developed in MATLAB (www.mathworks.com) to analyze HARP data including calculating and displaying LTSAs. In addition to providing a long-term view of acoustic data, LTSAs provide a means of quickly accessing the fine scale data via selecting events from the LTSA spectrogram display for more detailed analysis. Automated detectors can also be used on LTSAs, for example, to identify start and end times of calling bouts, which then can be used to define periods upon which to execute fine scale automated detectors for individual calls.

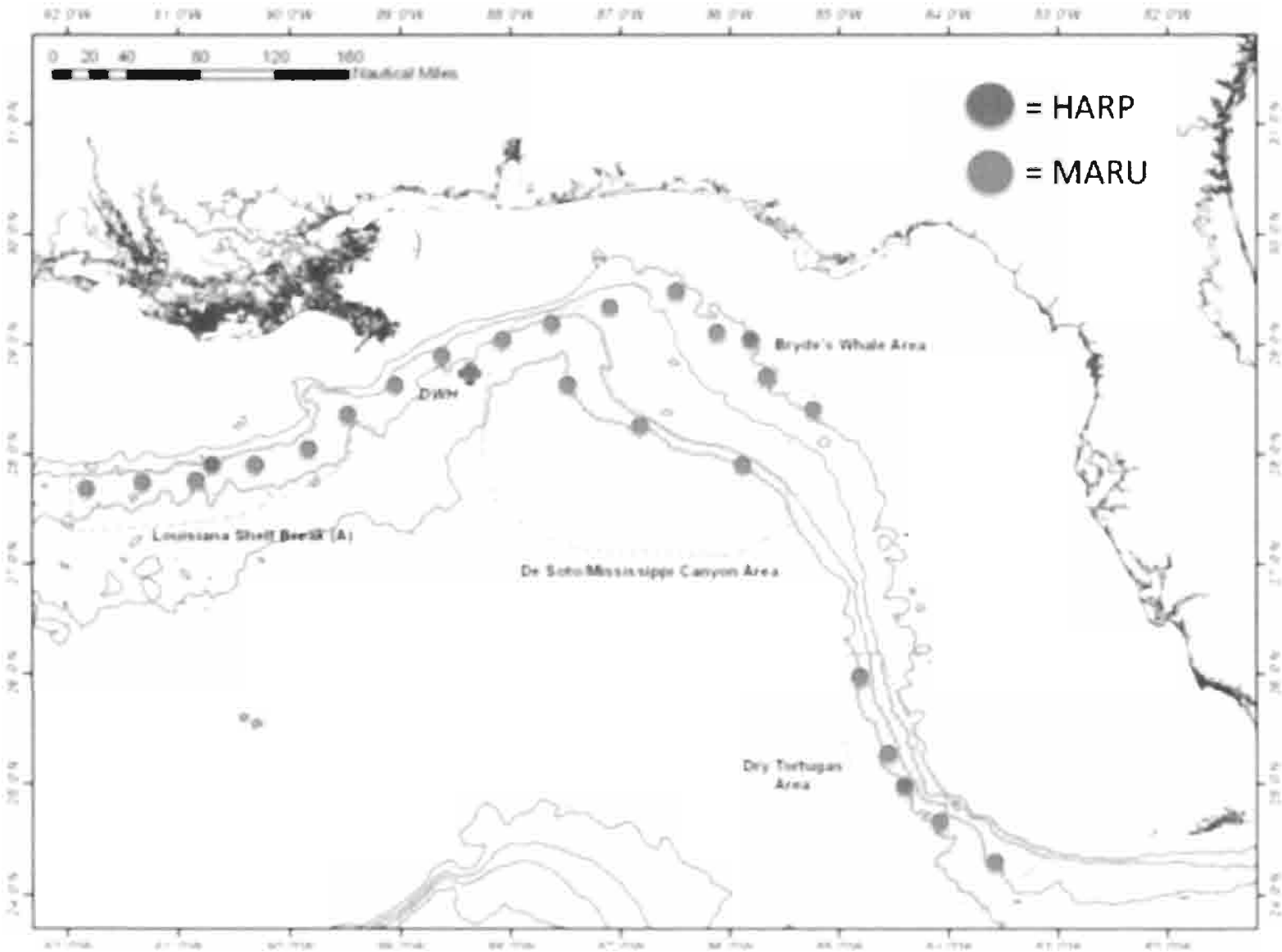
As with the MARU monitoring, number of detected calls or "acoustic bouts" for each taxon is the fundamental variable of interest.

Additional Variables: The recordings also result in a continuous record of ambient noise including vessel noise, seismic exploration, etc.

Data recording: Acoustic data are recorded onto digital media as are post-data collection analysis of call type and frequency.

Expected Analytical Products: Similar to the analysis of MARU data, the HARP analysis will focus on quantifying marine mammal presence over time at each location. Analyses will focus on diurnal patterns in call detections, changes in the quantity and types of calls made, and changes in these factors over time and in reference to the movement of oil within each habitat.

The high bandwidth of the recordings and the analysis of echolocation clicks for classification is a recently developed method. The classifications from the buoy data may be verified by high-bandwidth recordings from groups with confirmed species identification on the towed array. The analytical methods for call detection and classification will be similar to approaches described in Soldevilla et al. 2008, Roch et al. 2008, and Roch et al. 2007.


0 20 40 80 120 160
Nautical Miles
= HARP
= MARU
Bryde's Whale Area
DWH
De Soto Mississippi Canyon Area
Dry Tortugas Area