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

NRDA Biological Acoustics Data Processing Plan

Principal Investigator: Dr. Kevin Boswell, Florida International University

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Prepared by:

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1. Project Description

This work plan describes processing of biological acoustic data (Simrad EK60 single-beam echosounder and Dual-Frequency Identification Sonar [DIDSON]) collected as part of the Deepwater Horizon Oil Spill (DWHOS) Natural Resource Damage Assessment (NRDA) and other sampling efforts in 2010-2011. The data that may be compiled and processed under this plan include those data collected as part of the cruises in which NOAA NRDA Technical Working Groups (TWGs) participated (led by NOAA NRDA, NOAA Response, BP or its contractors, and/or third party investigators) as listed in Attachment 1. The cruises that will initially be processed pursuant to this work plan are listed in Table 1 chosen because they encompass the various sampling platforms and concurrent sampling gear deployed throughout the program. A decision on whether to cooperatively process additional biological acoustic data will be made during or after processing the data listed in Table 1. Any plans to increase capacity for cooperatively processing acoustic data will be presented as addenda to this plan. The Trustees reserve the right to proceed independently and process additional acoustic data if agreement is not reached with BP.

Table 1. First priority data sets from Attachment 1.

Survey	Dates	Data Types
Pisces Midwater	Select days, September 2011	Simrad EK60
Pisces Midwater	June – July 2011	Simrad EK60, DIDSON
Meg Skansi MOC10	Spring 2011	Simrad EK60
McArthur II Epipelagic	September – October 2011	Simrad EK60, DIDSON, Video
Gordon Gunter Midwater	October 2010	Simrad EK60

Dr. Kevin Boswell, Florida International University (FIU), will be the Project Principal Investigator. The data products resulting from this processing plan will be biological acoustic

datasets, by deployment, that have been processed and quality controlled using the industry-standard software (Echoview).

Prior to commencing with full data processing for any given deployment type (i.e., downward-looking EK60, upward-looking EK60, or DIDSON deployment) as described above, a partial dataset will be analyzed. The analysis of these small datasets will allow for (1) providing an exemplar of data processing procedures for each type of data to the Responsible Parties and Trustees, (2) opportunities for applying the internal review procedure (see section 3) and developing procedures for 14-day review stage (see section 4.1), and (3) provide a processed dataset to all parties in a relatively short time frame. At least one teleconference/webinar will be held for each new deployment type. The intent of these webinars is to provide opportunities for the parties to prepare for their respective reviews and analyses by becoming familiar with the data and processing.

2. Data Processing Procedures

Acoustic data will be processed by Dr. Boswell or other acoustics experts under his direction with the industry-standard software Echoview (version 5.2, Myriax Pty Ltd, Hobart, Tasmania). Prior to processing a particular dataset, an Echoview Template file will be developed which outlines all processing procedures to be implemented within Echoview. Application of this template enables processing parameters and settings (e.g., transducer parameters, calibration coefficients.) to remain consistent across all relevant files. This also increases the processing efficiency. Following set processing steps, an Echoview file (EV file) will be provided to the parties as part of the data package. This EV file archives each data review and pre-processing action (i.e., bottom exclusion, bad data region, etc.) required to generate the final dataset.

Separate processing standard operating procedures (SOPs) were developed for each configuration of sensor type (e.g., Simrad EK60, DIDSON) and how it was deployed in the field. Further details of these procedures can be found below and in the attachments.

2.1 Simrad EK60 Echosounder Data – Downward Looking

Raw data (.raw) files collected from the Simrad EK60 echosounder will be loaded into Echoview to facilitate data processing procedures. The transducer parameters will be verified for the volume or areal backscattering variable of interest (S_V or Nautical Area Scattering Coefficient (NASC), respectively; see MacLennan et al., 2002) based on calibration reports provided by the manufacturer and those derived during shipboard calibration efforts conducted throughout the survey period. Following the confirmation of proper calibration coefficients (e.g., Sa correction, transducer gain, pulse duration, and two way equivalent beam angle) which can be edited in Echoview, water column sound speed and sound absorption coefficients will be determined from conductivity, temperature, and depth (CTD) profile data (processed under a separate cooperative NRDA plan) following Mackenzie (1981) and Francois et al. (1982). The geometric mean of the water column temperature and salinity profiles will be calculated and then entered into equations to determine the water column sound speed and the absorption coefficient. In Echoview, horizontal line features are used to segment areas of an echogram within which data are to be analyzed. A surface line will be applied on each echogram and will be calculated at a depth that is 2x the near-field region for each frequency used (i.e., ca. 2 m at 120 kHz). Additionally, bottom features will be isolated from the water column data following a line-picking algorithm

within Echoview and then manually edited to ensure that bottom-classified data are eliminated from the water column.

Water column data will be evaluated for data quality and areas of the echogram containing compromised data will be identified as non-viable data and excluded from the analysis (e.g., false bottom detections, bubble ringdown, ship and environmental noise). Regions identified as non-viable data will be propagated through all successive operations, thus retaining a record of data designated as non-viable.

Following the review described above, further data processing will be comprised of two main components, both developed to reduce and eliminate sources of noise in the acoustic record:

1) Intermittent and stochastic noise spikes, which are generally related to interference with other sonars, ship noise, or sea conditions, will be eliminated by comparing the per sample intensity values in decibels (dB) with both the preceding and following samples, across all pings. Spurious spike samples will be identified and removed if they differ by 10 dB or more from adjacent samples. By eliminating only single samples that exceed the 10 dB threshold, the effects of stochastic noise will be removed while preserving biological features of interest.

2) Background noise will be removed using a process based on the concepts described in DeRobertis and Higginbottom (2007) originally designed for NOAA deepwater surveys. The process estimates the noise within each ping and then subtracts it from the samples within each ping, thereby reducing the effects of background noise amplified by time-varied gain. A minimum signal-to-noise ratio of 6 dB will be applied as a threshold. Samples that do not satisfy this threshold will be considered as indistinguishable from background noise and eliminated. In accordance with established methods (DeRobertis and Higginbottom 2007), we will apply a maximum noise threshold of -125 dB. This value specifies the maximum acceptable and expected upper limit of noise, and is a function of vessel noise, environmental conditions, and the specific echosounder system used. This value may change amongst deployments or vessels and will be evaluated, tuned accordingly, and reported. Following the noise correction process, an operator (algorithm) will be applied to estimate the proportion of samples that have been removed thus providing a measure of the percentage of data not considered for analysis. Within each Echoview file (.EV) created during this process, each operand will be fully notated to describe the processes and parameters applied.

The Echoview processing workflow described above is provided as Attachment 2.

2.2 Simrad EK60 Echosounder Data – Upward Looking

The upward looking Simrad EK60 echosounder data will be handled in much the same way as described in Section 2.1. Raw data will be imported in Echoview and calibration settings applied as described above. Similarly, line features will be used to isolate the water column scattering data from the surface reverberation and the near-field exclusion zone. Depth profiles of the towfish and towfish behavior were recorded from paired sensors mounted on the towfish. Data collected from depth sensors attached to both the nose and tail of the towfish will be averaged to estimate the actual depth of the towfish. These depth profiles will be matched in time with coincident shipboard echosounder data. Contamination for noise and spikes will be handled as

described above. A current limitation with towfish deployments is accounting for variable towfish behavior, whose effects can be propagated through the echosounder data often resulting in non-viable data during periods of turbulent sea conditions and unpredictable ship behavior. Thus, towfish data will be scrutinized for effects of vehicle behavior and classified as non-viable for analysis when appropriate (i.e., surface noise exceeds signal, water column contains a high-degree of entrained air, towfish behavior is erratic (+/- 30° pitch or roll, when available).

The Echoview processing workflow described above is provided as Attachment 3.

2.4 DIDSON Data

The imaging sonar (DIDSON) is a unique tool that provides near-video imagery of targets simultaneously observed with the Simrad EK60 echosounders. Imaging sonar data will be imported into Echoview for post-processing. The imaging sonar provides acoustic imagery of both the targets and the background distributed within a sampled volume within the same transmitted pulse. Thus, sequential data files with similar backgrounds will be analyzed together in an effort to increase processing efficiency. Within the series of files with similar background levels, a subset of approximately 50 pings (equivalent to approximately 7 seconds of elapsed time) with few to no targets distributed in the field of view will be manually selected (in accordance with Boswell et al., 2008). This 50 ping subset with no targets will serve to represent the average background response and will be subtracted from all remaining pings with detected targets. In essence this process is acting to remove static background values that may otherwise be erroneously detected as signals from fish targets. This process will be repeated for each subsequent and related set of files with similar background data. Following background subtraction, a 3x3 median matrix filter will be applied to smooth the image and further aid in eliminating spike interference occasionally observed. Following the smoothing procedure, a target detection algorithm (multibeam target detection) will be applied to isolate individual targets identified within each ping that sufficiently exceed background intensity levels and satisfy the target detection algorithm. Lastly, the accepted targets identified in the aforementioned step will be converted into single-targets that maintain metadata information on the length, direction of movement, orientation, compactness, thickness, and area of each target. Fish tracks can be identified and defined with the Echoview alpha-beta tracking algorithm yielding speed of movement and behavior data.

The Echoview processing workflow described above is provided as Attachment 4.

3. Quality Assurance and Quality Control Procedures

3.1 Data Evaluation

Quality assurance and quality control (QA/QC) will be established through several processes. First will be the manual scrutiny of the data by the technician in conjunction with data processing. A constant among all acoustic data are contributions to backscatter arising from noise and environmental conditions. The industry standard for addressing these issues is manual scrutiny of all acoustic data used in analyses and this will be used in this work as well. As part of this process, all echograms will be reviewed manually and non-viable data will be highlighted and classified as ‘bad-data’ through the creation of Regions in Echoview. Regions in Echoview were designed such that they are fully documented and can be easily reviewed and edited at any time. Additionally, the creation and editing of Echoview files does not alter the original data;

rather it works as a filter to show which data have been deemed appropriate for use. Therefore, when edits take place, the underlying data are automatically re-processed and a record of these activities is automatically created.

Second, processing steps themselves are scripted in the form of 'workflow' diagrams and are available for review. Thus, all review, flagging, and editing are fully documented, transparent, and can be reviewed by any party using the data.

3.2 Review of Data

In addition to the QA/QC program built into the processing routines, all data (100%) processed as part of this plan will be reviewed by an expert (Dr. Boswell or another acoustics expert working with the Trustees) with experience in biological acoustic methods. The expert will determine that the data have been processed appropriately based on the parameters laid out in the SOPs. All decisions and data set adjustments will be tracked and documented.

All information and notes, including corrections, will be retained and maintained during all steps of this processing plan and stored in secure locations under trustee control as directed by the NOAA NRDA Data Management Team. The NOAA NRDA Data Management Team will pair field sample metadata with results and perform a completeness check to ascertain that the laboratory information matches up properly with field sample information and all field information has associated laboratory information.

Since the whole process is based on electronic data, transcription from paper data sheets to electronic media is not anticipated. However if transcription does occur, a cross-check of 100% of all transcriptions will be conducted by someone other than the person who completed the original transcription.

4. Distribution of Compiled Datasets

4.1 Data Release and Consensus Data Sets

Data sets will be made available to the parties when a reasonable amount of data for an instrument (e.g., EK60, DIDSON) from an entire cruise has been verified. At the time of approval of the processing plan, a more precise definition of "amount of data" is not plausible as these data were collected continuously from the time the ships left the dock to their return at the end of the cruise. All parties will be alerted when a parcel of data has been identified to be released as a single data set; this alert will include an estimate of data volume.

Upon completion of the expert review, the principal investigator (Dr. Kevin Boswell) will deliver all products generated as part of this work plan to the NOAA NRDA Data Management Team for upload to the NOAA NRDA Content Management System which will serve as a repository for information. Anticipated products as part of this plan include the organized raw acoustic data, the EV files, and areal and volumetric acoustic scattering strength estimates. Once the Data Management Team has completed its review of the station metadata, the data and metadata will be made available to the parties to this agreement via appropriate means (e.g., portable hard drives, etc.) as determined by the NOAA NRDA Data Management Team. NOAA and the Louisiana Oil Spill Coordinator's Office (LOSCO) on behalf of the State of Louisiana and BP (or Cardno ENTRIX on behalf of BP) will be alerted when these data become available.

In the interest of maintaining one consistent data set for use by all parties, only the verified and validated data set made available by the NOAA NRDA Data Management Team shall be considered the consensus data set. In order to ensure reliability of the consensus data and full review by the parties, no party shall publish consensus data until 14 days after such data have been made available to the parties. Any questions raised on the consensus data set shall be handled consistent with the procedures in Section 7.2 of the Deepwater Horizon NRDA Analytical Quality Assurance Plan.

- The Trustees and BP shall each designate an individual responsible for raising questions, if any, on the consensus data set.
- If questions are raised, the two designated individuals will meet to determine the source of the difference and resolve.
- The questions raised and their resolution shall be distributed to all parties.
- No changes to the consensus data set will be made if the differences are considered immaterial by both designated individuals, acting on behalf of the parties.
- If the parties agree that changes to the dataset should be made, the dataset will be updated in accordance with the resolution and reposted with a notation that the dataset has been revised.
- If the designated individuals do not agree on how to resolve the difference concerning the consensus data set, the designated individuals shall request assistance from the Assessment Managers for the trustees and BP.

4.2 Sample Retention

All information will be retained and maintained during all review steps in the process, stored in secure locations under trustee control, and will be made available to all parties should a need for such supplemental information be identified.

All materials associated with the collection or analysis of samples under these protocols or pursuant to any approved work plan, including any remains of samples and including remains of extracts created during or remaining after analytical testing, must be preserved and disposed of in accordance with the preservation and disposal requirements set forth in Pretrial Orders ("PTOs") # 1, # 30, #35, # 37, #39 and #43 and any other applicable Court Orders governing tangible items that are or may be issued in MDL No. 2179 IN RE: Oil Spill by the Oil Rig "DEEPWATER HORIZON" (E.D. LA 2010). Destructive analytical testing of oil, dispersant or sediment samples may only be conducted in accordance with PTO # 37, paragraph 11, and PTO # 39, paragraph 11. Circumstances and procedures governing preservation and disposal of sample materials by the trustees must be set forth in a written protocol that is approved by the state or federal agency whose employees or contractors are in possession or control of such materials and must comply with the provisions of PTOs # 1, # 30, # 35, #37, #39 and #43.

5. Progress Reporting Schedule

Progress reports will be submitted quarterly (March, June, September, December) to the NRDA Water Column TWG by Kevin Boswell which will describe the status of data processing, data upload and any other relevant topics for the previous three-month reporting period. A standardized format will be used for all progress reports (Attachment 5).

6. Budget

The parties acknowledge that this budget is an estimate, and that actual costs may prove to be higher due to a number of potential factors. The costs indicated in Budget Chart # 1 below and any additional reasonable costs within the scope of this workplan that may arise shall be reimbursed by BP upon receipt of written invoices submitted by the Trustees. The Trustees will make a good faith effort to notify BP in advance of any such increased costs.

Budget Chart #1. NOAA costs.

Analysis Costs	Total
NOAA Contractor Labor:	
Kevin Boswell, PI	[redacted]
Postdoctoral Researcher	[redacted]
Acoustic Technicians (2)	[redacted]
Acoustic Expert for QA/QC Review	[redacted]
Travel	$14,000
Supplies	$6,500
Hardware & Software	$139,989*
Fringe & Indirect Costs	[redacted]
Total Budget	**$426,889**

***** Hardware and software costs are based on quotes for non-educational institutions.

7. References

Boswell, K. M., Wilson, M. P., and Cowan Jr., J. H. 2008. A Semiautomated Approach to Estimating Fish Size, Abundance, and Behavior from Dual-Frequency Identification Sonar (DIDSON) Data. North American Journal of Fisheries Management, 28:799-807.

De Robertis, A., and Higginbottom, I. 2007. A post-processing technique to estimate the signal-to-noise ratio and remove echosounder background noise. ICES Journal of Marine Science, 64: 1282–1291.

Francois R.E. and Garrison, G.R. 1982 Sound absorption based on measurements. Part II: Boric acid contribution and equation for total absorption**.** Journal of the Acoustical Society of America. 72, 1879-90.

Mackenzie K.V. 1981. Nine-term equation for sound speed in the ocean**.** Journal of the Acoustical Society of America. 70, 807-12.

MacLennan, D. N., Fernandes, P. G., and Dalen, J. 2002. A consistent approach to definitions and symbols in fisheries acoustics. ICES Journal of Marine Science. 59:365–369.

8. Attachments

Attachment 1. Biological Acoustics Data Inventory

Attachment 2. EK60 Processing Standard Operating Procedures- Downward-Looking Shipboard Echosounders

Attachment 3. EK60 Processing Standard Operating Procedures- Upward-Looking Towfish Mounted Echosounders

Attachment 4. DIDSON Processing Standard Operating Procedures

Attachment 5. Quarterly Progress Report Template

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Principal Investigator: Dr. Kevin Boswell, FIU

Plan Date: March 14, 2013

Approvals

Approval of this sample processing 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 plan.

	Printed Name	Signature	Date
BP Approval	Joyce Mi Ley	Joyce Mi Ley	3/28/2013
Federal Trustee Approval	Daniel Hahn		4/29/13
Louisiana Approval	KAROLIEN DEKUSSCHENE		4/17/13