U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

Data Acquisition & Processing Report

Type of Survey *Sidescan and Singlebeam Sonar*

Project No. *OPR-K977-SA-08*

Time Frame: 22 October 2008 – 04 July 2009

LOCALITY

State *Louisiana*

General Locality *Gulf of Mexico*

2008-2009

CHIEF OF PARTY

Paul L. Donaldson
Science Applications International Corporation

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NOAA FORM 77-28 (11-72) U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	REGISTRY NO.
HYDROGRAPHIC TITLE SHEET	**H11783** **H11784** **H11785**
INSTRUCTIONS – The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.	FIELD NO. **A, B, C**

State: Louisiana

General Locality: Gulf of Mexico

Sublocality: *Caillou Bay to Isles Dernieres, Isles Dernieres to Timbalier Island, and Timbalier Island to Belle Pass*

Scale: 1:20,000 Date of Survey 22 October 2008 – 04 July 2009

Instructions Dated: March 17, 2008 Project No. OPR-K977-SA-08

Vessel *M/V Sea Beneath MI 7826BK* and *F/V Lacey Marie LA6708FC*

Chief of Party: Paul L. Donaldson

Surveyed by: *Alex Bernier, Brian Biggert, Dan Burgo, James Cole, Gary Davis, Paul Donaldson, Chuck Holloway, Ralph Hutchinson, Jason Infantino, John Kiernan, Collette Lebeau, Scott Leger, Rick Nadeau, Gary Parker, Evan Robertson, Jeremy Shambaugh, Deb Smith, Hays Stephens, Jen Stone, Tom Waddington, Lance Walker, Bridget Williams*

Soundings taken by **echo sounder**, hand lead, pole: Odom Echotrac CVM and Reson 8101

Graphic record scaled by

Graphic record checked by Automated plot

Verification by

Soundings in fathoms, feet, **meters** at MLW, **MLLW**

REMARKS: **Contract**: DG133C-05-CQ-1088

Contractor: Science Applications International Corp., 221 Third Street; Newport, RI 02840 USA

Subcontractors: Rotator Staffing Services, PO Box 366, 557 Cranbury Rd., E. Brunswick, NJ 08116; Lowe Engineers 2000 RiverEdge Parkway, Suite 400, Atlanta, GA 30328; EMC, Inc., PO Box 8143, Greenwood, MS 38935; John Oswald & Associates, LLC. 2000 E. Dowling Rd, Suite 10, Anchorage, AK 99507

Times: All times are recorded in UTC

UTM Zone: Zone 15

Purpose: To provide NOAA with accurate hydrographic survey data suitable for item detection and debris mapping in the assigned areas: Sheets A (H11783), B (H11784) and C (H11785) in the Gulf of Mexico, Louisiana.

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ACRONYMS

Acronym	Definition
ASCII	**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange
BAG	**B**athymetric **A**ttributed **G**rid
CMG	**C**ourse **M**ade **G**ood
CTD	**C**onductivity, **T**emperature, **D**epth profiler
CUBE	**C**ombined **U**ncertainty and **B**athymetric **E**stimator
DGPS	**D**ifferential **G**lobal **P**ositioning **S**ystem
DPC	**D**ata **P**rocessing **C**enter
DR	**D**escriptive **R**eport
EPF	**E**rror **P**arameters **F**ile
GPS	**G**lobal **P**ositioning **S**ystem
GSF	**G**eneric **S**ensor **F**ormat
GS+	**G**eo**S**wath **Plus**
GUI	**G**raphical **U**ser **I**nterface
IHO	**I**nternational **H**ydrographic **O**ganization
IMU	**I**nertial **M**easurement **U**nit
ISO	**I**nternational **O**rganization for **S**tandardization
ISS-2000	**I**ntegrated **S**urvey **S**oftware 2000
ISSC	**I**ntegrated **S**urvey **S**ystem **C**omputer
JD	**J**ulian **D**ay
KW	**K**ilo**w**att
LUMCON	**L**ouisiana **U**niversities **M**arine **Con**sortium
MB	**M**ulti**b**eam
MVE	**M**ulti-**V**iew **E**ditor
MVP	**M**oving **V**essel **P**rofiler
NAS	**N**etwork **A**ttached **S**torage
NMEA	**N**ational **M**arine **E**lectronics **A**ssociation
NOAA	**N**ational **O**ceanic and **A**tmospheric **A**dministration
PFM	**P**ure **F**ile **M**agic
POS/MV	**P**osition **O**rientation **S**ystem/**M**arine **V**essels
RDF	**R**aw **D**ata **F**ormat
RPM	**R**evolutions **P**er **M**inute
SABER	**S**urvey **A**nalysis and area **B**ased **E**dito**R**
SAIC	**S**cience **A**pplications **I**nternational **C**orporation
SAT	**S**ea **A**cceptance **T**ests, or **S**wath **A**lignment **T**ool
SDF	**S**onar **D**ata **F**ormat
SSP	**S**ound **S**peed **P**rofile
SV&P	**S**ound **V**elocity and **P**ressure Sensor
SWP	**Sw**ath **A**mplitude
TPE	**T**otal **P**ropagated **E**rror
TPU	**T**ransceiver **P**rocessing **U**nit
UPS	**U**ninterruptible **P**ower **S**upply
USB	**U**niversal **S**erial **B**us
XTF	e**X**tended **T**riton **F**ormat

A. EQUIPMENT

For the Gulf of Mexico, Louisiana debris mapping surveys, Science Applications International Corporation (SAIC) employed two survey vessels each with the same data acquisition systems for the primary survey effort. The *M/V Sea Beneath* and the *F/V Lacey Marie* used Odom Echotrac CVM singlebeam sonar, Klein 3000 sidescan sonar, and an SBE 19-01 CTD for data collection. A Reson 8101 multibeam sonar was installed on the *M/V Sea Beneath* after completion of the primary survey effort and was used for all item investigations. Both vessels used a POS/MV 320 version 4 for vessel attitude and positioning. Further details about the vessels, acquisition systems and software, and processing software are provided in the sections below.

THE SURVEY VESSELS

The *M/V Sea Beneath* (Figure A-1) and the *F/V Lacey Marie* (Figure A-2) were the vessels used for all survey operations. Vessel characteristics for both platforms are presented in Table A-1.

Table A-1. Survey Vessel Characteristics, *M/V Sea Beneath* and *F/V Lacey Marie*

Vessel Name	LOA	Beam	Draft	Max Transit Speed	Max Survey Speed
M/V Sea Beneath	30’	7’	2.0’	30 kts	9 kts
F/V Lacey Marie	41’	12’	2.5’	14 kts	7 kts

Figure A-1. *M/V Sea Beneath*

Figure A-2. ***F/V Lacey Marie***

ECHOSOUNDER SYSTEMS AND OPERATIONS ON THE *M/V SEA BENEATH* AND THE *F/V LACEY MARIE*

The Odom Echotrac CVM singlebeam sonar was installed on each vessel. The *M/V Sea Beneath* had the singlebeam transducer mounted within a moon pool located in the aft deck while the *F/V Lacey Marie* had the singlebeam transducer pole mounted on the port side amid ships. The Odom Echotrac CVM is a dual frequency singlebeam sonar system transmitting both 24 kHz and 200 kHz. Because the survey was in relatively shallow water, the Odom control unit on each vessel was set such that only the 200 kHz frequency was active. A Reson SeaBat 8101 multibeam sonar system was also utilized during the item investigation portion of this survey. The SeaBat 8101 multibeam transducer replaced the singlebeam transducer within the moon pool onboard the *M/V Sea* Beneath. The Reson multibeam system is a 240 kHz, 101 beam, 150° swath bathymetry system. Multibeam data were collected at full swath however a 64° beam angle was used as the cutoff for acceptable multibeam data. A 64° beam angle yielded an effective swath width of approximately 3 times the water depth. SAIC's **ISS-2000** software provided navigation, system control and collected the bathymetry data in Generic Sensor Format (GSF).

Confidence checks of the singlebeam depths were made using a bar that was lowered to a known depth directly below the transducer. Depths displayed by the Odom controller and SAIC's **ISS-2000** system are verified and entered into a bar check log. The following procedure was established to make a bar check comparison:

1. Take and apply a CTD cast
2. Set the Odom draft to 0.0 in the ISS-2000.
3. Disable tide corrector
4. Set RPM to 0

5. Set the bar to 1 meter under the transducer.
6. Verify that the tide corrector in the MB Manager window is 0 and the depth corrector is 0.
7. Open the sbcdtc.exe Video32 display from the task bar
8. Open the ODOM CVM DTC Display. Verify tide correct is 0, transducer offset is 0, and applied squat is 0.
9. In the Odom Controller window go to the calibrate tab and enter the bar depth.
10. Enter the time bar depth, depth in the video 32 display, ODOM CVM DTC display, and the channel 1 depth in the Odom Controller.
11. In the MB Manager display select Display/Examine Data and look at the last depth values in the recorded file. Also verify tide and depth correctors in the file are 0.
12. Set the bar to 2 meters and repeat steps 9-11 changing the bar depth in the Odom controller calibrate window to 2.
13. Repeat at 1 meter intervals for as deep as possible.

Bar checks were taken approximately once per week during the survey.

Confidence checks of the multibeam depths were made using a bar that was lowered to a known depth directly below the transducer. Depths displayed by the Reson display and SAIC's **ISS-2000** system are verified and entered into a bar check log. The procedure for conducting the bar checks for the multibeam system was similar to the procedure established for the singlebeam system.

1. Take and apply a CTD cast
2. Set the Odom draft to 0.0 in the ISS-2000.
3. Disable tide corrector
4. Set RPM to 0
5. Set the bar to 1 meter under the transducer.
6. Set the range and depth filters in the Reson display +/- 0.5 meters of the current bar depth.
7. Verify that the tide corrector in the MB Manager window is 0 and the depth corrector is 0.
8. In the MB Manager display select Display/Examine Data and look at the last depth values in the recorded file. Also verify tide and depth correctors in the file are 0.
9. Record the information in the appropriate logs.
10. Set the bar to 2 meters and repeat steps 6 – 8.
11. Repeat at 1 meter intervals for as deep as possible.

Bar Checks were conducted prior to and upon completion of the items survey effort.

SIDESCAN SONAR SYSTEMS AND OPERATIONS ON THE *M/V SEA BENEATH* AND THE *F/V LACEY MARIE*

The sidescan system installed on the vessels included the following:

- Klein 3000 digital Sidescan Sonar Towfish in a bow mounted configuration
- Klein 3000 Windows XP computer for data collection and logging of sidescan sonar data with Klein **SonarPro** version 9.6 software
- Klein 3000 Transceiver Processing Unit (TPU) was used on the *F/V Lacey Marie.*
- Klein 3000 Transceiver Processing Unit (TPU) was used on the *M/V Sea Beneath* with intermittent use of a Klein 3900 Transceiver Processing Unit (TPU) during times when the Klein 3000 TPU was inoperable.
- Uninterrupted power supplies (UPS) for protection of the computer system

The Klein 3000 is a conventional dual frequency sidescan towfish. At a range scale of 25 (50) meters, a ping rate of 30 (15) pings/second is set by the transceiver. With 30 (15) pings/second and a maximum survey speed of 9 (8) knots, a minimum of three pings per meter was ensured along-track, allowing for the detection of objects that measure 1.0 x 1.0 meters horizontally and 1.0 meter vertically (from shadow length measurements). During the survey operations on all sheets, the range scale used was based on the charted depths within the area.

During survey operations, digital sidescan sonar data from the Klein 3000 TPU were sent directly to the Klein 3000 computer for display and logging by Klein **SonarPro** software. Raw digital sonar data from the Klein 3000 were collected in eXtended Triton Format (XTF) and maintained at full resolution, with no conversion or down sampling techniques applied. Sidescan data file names were changed automatically every hour and manually at the completion of a survey line. At the end of each survey day (i.e. Julian Day, JD) the raw XTF sidescan data files were backed up on USB hard drives and digital data storage (DDS) tapes.

Towfish positioning was provided by **ISS-2000** through a program module called "rtcatnry." This program used the offsets of the bow mounted sidescan sonar from the POS/MV IMU and the vessel heading to compute the sidescan positioning in a catenary format file.

Because of the towfish being bow mounted and the extremely shallow waters where the surveys were conducted, the towfish altitude was rarely between the recommended 8% and 20% of the range (2-5 meters for 25-meter range). However, periodic confidence checks on linear features (e.g. trawl scars or sediment boundaries) were made to verify the quality of the sonar data across the full range of the sonar record.

DATA ACQUISITION AND PROCESSING SOFTWARE

Navigation data acquisition and survey control for both vessels was carried out using the SAIC **ISS-2000** software on a Windows XP computer. **ISS-2000** version 4.0.0.3.0 was the software version used on the *M/V Sea Beneath* and on the *F/V Lacey Marie*.

Klein's **SonarPro** version 9.6, running on a Windows XP platform, was used for Klein sidescan data acquisition on the *M/V Sea Beneath and F/V Lacey Marie* for the entire survey. For work pertaining to the interim deliverable of weekly contacts, **SonarPro** version 11.2 was utilized.

Survey planning, data processing and analysis were carried out using the SAIC **Survey Planning** and **SABER** software packages on LINUX operating systems. SABER version 4.2.0.7 was used from the beginning of the survey until 02 December 2008 (Julian Day 337); whereby **SABER** 4.0.2.7.2 was installed. On 20 August 2009 SABER version 4.3.0.12.2 was installed in the Data Processing Center and used until delivery.

Isis version 6.06, running on Windows XP, was used for sidescan data quality review, and contact identification.

B. QUALITY CONTROL

A systematic approach to tracking data has been developed to maintain data quality and integrity. Several forms and checklists identify and track the flow of data as it is collected and processed. These forms are presented in the Separates section included with the report for each survey.

During data collection, the watch standers continuously monitor the systems, checking for errors and alarms. Thresholds set in the **ISS-2000** system alert the watch stander by displaying alarm messages when error thresholds or tolerances are exceeded. These alarms, displayed as they occur, are reviewed and acknowledged on a case-by-case basis. Alarm conditions that may compromise survey data quality are corrected and then noted in both the navigation log and the message files. Warning messages such as the temporary loss of differential GPS, excessive cross track error, or vessel speed approaching the maximum allowable survey speed are addressed by the watch stander and automatically recorded into a message file. Approximately every 1-2 hours the real-time watch standers complete checklists to ensure critical system settings and data collection are valid.

Following data collection, initial processing was performed in the field data center at the Louisiana Universities Marine Consortium (LUMCON) facility in Cocodrie, LA. This included the first level of quality assurance:

- Initial swath editing of singlebeam data flagging invalid beams
- Identification of items for investigation
- Turning unacceptable data “offline”
- Turning additional data “online”
- Identification and flagging of obstructions and wrecks
- Track plots
- Preliminary bathymetry coverage grids
- Crossline checks
- Generation of preliminary sidescan coverage mosaics
- Initial review of sidescan data for object detection (if possible)

On a daily basis the data were binned to minimum depth layers. The following binned grids were created and used for crossline analysis. Results of this analysis were reviewed to determine adequacy of data and sounding correctors.

- Main scheme, item, and holiday fill survey lines
- Crosslines

Approximately once a week, a complete backup of all raw and processed bathymetry data and sidescan data were sent to the Newport, RI Data Processing Center. Analysis of the data at the Newport facility includes the following steps:

- Generation of bathymetry and sidescan track line plots
- Generation of sidescan Contact Files and Contact Plot
- Calculation and application of verified tide correctors to bathymetry data
- Application of delayed heave to the singlebeam data
- Calculation of Total Propagated Errors on the bathymetry data
- Generation of PFM CUBE surface(s) of the bathymetry data
- Set designated soundings on wrecks and obstructions
- Quality control reviews of sidescan data and contacts
- Correlation of sidescan contacts with bathymetry data
- Convert PFM(s) to BAG(s)
- Generate S-57 Feature File
- Coverage plots of bathymetry data
- Crossline analysis of bathymetry data
- Comparison with existing charts
- Final coverage mosaic plots of sidescan sonar data
- Final quality control of all delivered data products

Processing and quality control procedures for bathymetry and sidescan data acquisition are described in detail in the following pages.

BATHYMETRY DATA PROCESSING

The process flow for the Odom CVM singlebeam data and the Reson 8101 multibeam data was essentially the same. Data from both sonars were collected in Generic Sensor Format (GSF) within the **ISS-2000** software with predicted tides, sound speed profile (SSP) data, attitude data and dynamic and static draft applied in real-time. The bathymetry data were then processed within **SABER**. Data were transferred from the survey vessel to the field processing center at LUMCON via a USB hard drive on a daily basis. File lists were made, track lines created, and tracks reviewed for appropriate on-line and off-line flags as well as any navigation errors. Files were then reviewed using **SABER's Multi-view Editor** (MVE) for fliers and navigational errors. After corrections were made for delayed heave and verified tides, the singlebeam data were gridded into 1-meter CUBE PFM grids and were reviewed in an area based mode. Once the multibeam data were collected at the end of the survey, the multibeam data were also reviewed using **SABER's Multi-view Editor** (MVE) for fliers and navigational errors and then were appended into the same 1-meter CUBE PFM grids that contained the singlebeam data.

Selected soundings were generated (at chart scale) from the 1-meter CUBE depth surfaces and these selected soundings were included in the S-57 Feature File for each sheet. The **SABER get_ds_features** routine was run which extracts flagged features and designated soundings from the GSF bathymetry data. The 1-meter CUBE depth surfaces were also exported as XYZ files.

Survey System Error Model

The Total Propagated Uncertainty (TPU) model that SAIC has adopted had its genesis at the Naval Oceanographic Office (NAVOCEANO), and is based on years of work by Rob Hare and others. The fidelity of any error model is coupled to the applicability of the equations that are used to estimate each of the components that contribute to the overall error that is inherent in each sounding. SAIC's approach to quantifying the TPE is to decompose the cumulative errors into their individual components and then compute their effects on the horizontal and vertical error components. The model then combines the horizontal and vertical error components to yield an estimate of the system error as a whole. This cumulative system error is the Total Propagated Error (TPE). By using this approach, SAIC can more easily incorporate future error information provided by sensor manufacturers into the model. This also allows SAIC to continuously improve the fidelity of the model as our understanding of the sensors increases or as more sophisticated sensors are added to a system.

The data needed to drive SAIC's error model are captured as parameters within the Error Parameters File (EPF), which is a text file typically created during survey system installation and integration. The parameters are also obtained from values recorded in the GSF file(s) during data collection and/or processing. While the input units vary, all error values that contribute to the cumulative TPE estimate are converted to meters by **SABER's Errors** program or have units of meters to begin with. The cumulative TPE estimates are separated into a horizontal and vertical component, and are recorded as the Horizontal Error and Vertical Error records for each sounding in the GSF file. These error values are at the two sigma or 95% confidence level. The intent is to use these error estimates to gauge the accuracy of each sounding's coordinates and depth.

Table B-1, though Table B-5 show the values entered in the Error Parameters File used for the Gulf of Mexico surveys. All parameter uncertainties in these files are entered at the one sigma level of confidence, but the outputs from **SABER's Errors** program are at the two sigma or 95% confidence level. Sign conventions are: X = positive forward, Y = positive starboard, Z = positive down.

The values presented in Table B-1, Table B-2 and Table B-3 were used for the duration of the singlebeam surveys. On 27 June 2009 the *M/V Sea Beneath* was outfitted with a Reson 8101 pole mounted unit, replacing the Odom singlebeam transducer. For the multibeam data, a separate Error Parameter File was used; these values are presented in Table B-4. Table B-5 indicates the values for the Reson 8101, as derived from the *M/V Sea Beneath* multibeam Error Parameter File.

Table B-1. 2009 *M/V Sea Beneath* Error Parameters (Odom CVM)

Parameter	Value	Units
VRU Offset – X	0.975	Meters
VRU Offset – Y	0.00	Meters
VRU Offset – Z	1.341	Meters
VRU Offset Error – X (uncertainty)	0.02	Meters
VRU Offset Error – Y (uncertainty)	0.02	Meters
VRU Offset Error – Z (uncertainty)	0.02	Meters
VRU Latency	0.00	milliseconds (msec)
VRU Latency Error (uncertainty)	1.00	milliseconds (msec)
Heading Measurement Error (uncertainty)	0.02	Degrees
Roll Measurement Error (uncertainty)	0.02	Degrees
Pitch Measurement Error (uncertainty)	0.02	Degrees
Heave Fixed Error (uncertainty)	0.05	Meters
Heave Error (% error of height) (uncertainty)	5.00	Percent
Antenna Offset – X	-0.466	Meters
Antenna Offset – Y	-0.044	Meters
Antenna Offset – Z	-3.186	Meters
Antenna Offset Error – X (uncertainty)	0.02	Meters
Antenna Offset Error – Y (uncertainty)	0.02	Meters
Antenna Offset Error – Z (uncertainty)	0.02	Meters
Estimated Error in Vessel Speed (uncertainty)	0.2999999	Knots
GPS Latency	0.00	milliseconds (msec)
GPS Latency Error (uncertainty)	1.00	milliseconds (msec)
Horizontal Navigation Error (uncertainty)*	0.75	Meters
Vertical Navigation Error (uncertainty)*	0.00	Meters
Static Draft Error (uncertainty)	0.01	Meters
Loading Draft Error (uncertainty)	0.02	Meters
Settlement & Squat Error (uncertainty)	0.03	Meters
Predicted Tide Measurement Error (uncertainty)	0.09	Meters
Observed Tide Measurement Error (uncertainty)	0.09	Meters
Unknown Tide Measurement Error (uncertainty)	0.50	Meters
Tidal Zone Error (uncertainty)	0.10	Meters
Surface Sound Speed Error (uncertainty)	1.00	meters/second (m/s)
SEP Uncertainty	0.00	Meters
SVP Measurement Error (uncertainty)	1.00	meters/second (m/s)
Depth Sensor Bias	0.00	Meters
Depth Measurement Error (% error of depth) (uncertainty)	0.00	Percent
Wave Height Removal Error (uncertainty)	0.00	Meters

*NOTE: These values would only be used if not included in the GSF file

Table B-2. 2009 *F/V Lacey Marie* Error Parameters (Odom CVM)

Parameter	Value	Units
VRU Offset – X	-1.10	Meters
VRU Offset – Y	1.326	Meters
VRU Offset – Z	-2.260	Meters
VRU Offset Error – X (uncertainty)	0.02	Meters
VRU Offset Error – Y (uncertainty)	0.02	Meters
VRU Offset Error – Z (uncertainty)	0.02	Meters
VRU Latency	0.00	milliseconds (msec)
VRU Latency Error (uncertainty)	1.00	milliseconds (msec)
Heading Measurement Error (uncertainty)	0.02	Degrees
Roll Measurement Error (uncertainty)	0.02	Degrees
Pitch Measurement Error (uncertainty)	0.02	Degrees
Heave Fixed Error (uncertainty)	0.05	Meters
Heave Error (% error of height) (uncertainty)	5.00	Percent
Antenna Offset – X	-2.386	Meters
Antenna Offset – Y	1.632	Meters
Antenna Offset – Z	-4.796	Meters
Antenna Offset Error – X (uncertainty)	0.02	Meters
Antenna Offset Error – Y (uncertainty)	0.02	Meters
Antenna Offset Error – Z (uncertainty)	0.02	Meters
Estimated Error in Vessel Speed (uncertainty)	0.2999999	Knots
GPS Latency	0.00	milliseconds (msec)
GPS Latency Error (uncertainty)	1.00	milliseconds (msec)
Horizontal Navigation Error (uncertainty)*	0.75	Meters
Vertical Navigation Error (uncertainty)*	0.00	Meters
Static Draft Error (uncertainty)	0.01	Meters
Loading Draft Error (uncertainty)	0.01	Meters
Settlement & Squat Error (uncertainty)	0.02	Meters
Predicted Tide Measurement Error (uncertainty)	0.09	Meters
Observed Tide Measurement Error (uncertainty)	0.09	Meters
Unknown Tide Measurement Error (uncertainty)	0.50	Meters
Tidal Zone Error (uncertainty)	0.10	Meters
Surface Sound Speed Error (uncertainty)	1.00	meters/second (m/s)
SEP Uncertainty	0.00	Meters
SVP Measurement Error (uncertainty)	1.00	meters/second (m/s)
Depth Sensor Bias	0.00	Meters
Depth Measurement Error (% error of depth) (uncertainty)	0.00	Percent
Wave Height Removal Error (uncertainty)	0.00	Meters

*NOTE: These values would only be used if not included in the GSF file

Table B-3. SONAR Parameters Odom CVM

Parameter	Value	Units
Transducer Offset – X *	0.000	Meters
Transducer Offset – Y *	0.000	Meters
Transducer Offset – Z *	0.000	Meters
Transducer Offset Error – X (uncertainty)	0.02	Meters
Transducer Offset Error – Y (uncertainty)	0.02	Meters
Transducer Offset Error – Z (uncertainty)	0.02	Meters
Roll Offset Error (uncertainty)	0.01	Degrees
Pitch Offset Error (uncertainty)	0.05	Degrees

Parameter	Value	Units
Heading Offset Error (uncertainty)	0.05	Degrees
Model Tuning Factor	6.0	Unitless
Amplitude Phase Transition	99	Samples
Latency*	0.00	milliseconds (msec)
Latency Error (uncertainty)	0.00	milliseconds (msec)
Installation Angle	0.00	Degrees

*NOTE: These values would only be used if not included in the GSF file

Table B-4. 2009 *M/V Sea Beneath* Error Parameters (Reson 8101)

Parameter	Value	Units
VRU Offset – X	0.838	Meters
VRU Offset – Y	-0.013	Meters
VRU Offset – Z	1.132	Meters
VRU Offset Error – X (uncertainty)	0.02	Meters
VRU Offset Error – Y (uncertainty)	0.02	Meters
VRU Offset Error – Z (uncertainty)	0.02	Meters
VRU Latency	0.00	milliseconds (msec)
VRU Latency Error (uncertainty)	1.00	milliseconds (msec)
Heading Measurement Error (uncertainty)	0.02	Degrees
Roll Measurement Error (uncertainty)	0.02	Degrees
Pitch Measurement Error (uncertainty)	0.02	Degrees
Heave Fixed Error (uncertainty)	0.05	Meters
Heave Error (% error of height) (uncertainty)	5.00	Percent
Antenna Offset – X	-0.466	Meters
Antenna Offset – Y	-0.044	Meters
Antenna Offset – Z	-3.186	Meters
Antenna Offset Error – X (uncertainty)	0.02	Meters
Antenna Offset Error – Y (uncertainty)	0.02	Meters
Antenna Offset Error – Z (uncertainty)	0.02	Meters
Estimated Error in Vessel Speed (uncertainty)	0.2999999	Knots
GPS Latency	0.00	milliseconds (msec)
GPS Latency Error (uncertainty)	1.00	milliseconds (msec)
Horizontal Navigation Error (uncertainty)*	0.75	Meters
Vertical Navigation Error (uncertainty)*	0.00	Meters
Static Draft Error (uncertainty)	0.01	Meters
Loading Draft Error (uncertainty)	0.02	Meters
Settlement & Squat Error (uncertainty)	0.03	Meters
Predicted Tide Measurement Error (uncertainty)	0.09	Meters
Observed Tide Measurement Error (uncertainty)	0.09	Meters
Unknown Tide Measurement Error (uncertainty)	0.50	Meters
Tidal Zone Error (uncertainty)	0.10	Meters
Surface Sound Speed Error (uncertainty)	1.00	meters/second (m/s)
SEP Uncertainty	0.00	Meters
SVP Measurement Error (uncertainty)	1.00	meters/second (m/s)
Depth Sensor Bias	0.00	Meters
Depth Measurement Error (% error of depth) (uncertainty)	0.00	Percent
Wave Height Removal Error (uncertainty)	0.00	Meters

*NOTE: These values would only be used if not included in the GSF file

Table B-5. SONAR Parameters Reson 8101

Parameter	Value	Units
Transducer Offset – X *	0.838	Meters
Transducer Offset – Y *	-0.013	Meters
Transducer Offset – Z *	1.132	Meters
Transducer Offset Error – X (uncertainty)	0.02	Meters
Transducer Offset Error – Y (uncertainty)	0.02	Meters
Transducer Offset Error – Z (uncertainty)	0.02	Meters
Roll Offset Error (uncertainty)	0.02	Degrees
Pitch Offset Error (uncertainty)	0.02	Degrees
Heading Offset Error (uncertainty)	0.02	Degrees
Model Tuning Factor	6.0	Unitless
Amplitude Phase Transition	1.0	Samples
Latency*	0.00	milliseconds (msec)
Latency Error (uncertainty)	1.00	milliseconds (msec)
Installation Angle	0.00	Degrees

*NOTE: These values would only be used if not included in the GSF file

All soundings that have horizontal or vertical uncertainties which are greater than the IHO Order 1 maximum allowed values are flagged as invalid by the **SABER Errors** program. Therefore all individual soundings that were applied to the Bathymetric Attributed Grids (BAGs) meet the horizontal position accuracy and vertical accuracy specified in the NOS Specifications and Deliverables. There are, however, areas where the BAG node uncertainties exceed the IHO Order 1 allowable values. Many of the nodes which exceed the IHO Order 1 allowable uncertainties are related to features. Singlebeam data crossing a small target such as a pipeline many times will result in a node which will exhibit an increased uncertainty value. Because the bottom sediments within the Gulf of Mexico can be very soft, there were discrete areas in which there was penetration by the echosounder. This also accounted for many of the nodes which exceeded uncertainties for the IHO Order 1 allowable values. A **SABER** process called "**Check PFM Uncertainty**" flags nodes which exceed specified uncertainty limits. The output of this process produces text files which list node positions, depth and uncertainty values for nodes which failed the specified uncertainty. These text files are included in Appendix V of each sheet's Descriptive Report.

SIDESCAN SONAR DATA PROCESSING

On the *M/V Sea Beneath* and the *F/V Lacey Marie* sidescan data were collected with a Klein 3000 sidescan sonar. In real-time, the Klein 3000 digital data were recorded in XTF format on the hard disk of the Klein's **SonarPro** acquisition system. Sidescan data files collected each day were backed up onto USB hard drives for transfer to the field Data Processing Center.

Initial processing of the XTF data took place at the field processing center located at LUMCON in Cocodrie, LA, and included re-navigating the towfish to apply more accurate towfish positions using the **SABER navup** routine. This routine replaced the towfish position recorded in the original sidescan XTF file with the towfish position recorded in the catenary data file recorded by **ISS-2000**. This program also computed a unique position and heading for each ping record. Additional processing included generation of towfish track plots and generation of initial mosaics for coverage verification and quality control, and if possible, the initial review of sidescan data for object detection. All original and processed sidescan data files were then backed up onto USB hard drives for transfer to the Newport, RI Data Processing Center.

Once the sidescan data files arrived at the Data Processing Center in Newport, the data were reviewed on a line-by-line basis and a sidescan review log was generated or updated. This review log contains information about each file, including the line begin and line end times, survey line name, corresponding bathymetry and sidescan file names, line azimuth, data gap information, and notes pertaining to hazards of navigation (i.e. contacts), and other points of interest (e.g. large schools of fish that may partially obstruct data). Other pertinent information regarding the interpretation of the imagery was also logged in the spreadsheet.

Sidescan Quality Review

A processor conducted a quality review of each sidescan file using Triton **Isis** to replay the data. During this review the processor assessed the quality of the data and defined holidays in the data where the quality was insufficient to determine the presence of contacts. The times of these data holidays were entered into the sidescan review log. Data holidays were generally characterized by:

- Surface noise (vessel wakes, sea clutter, and/or waves)
- Towfish motion (yaw and heave)
- Electrical noise
- Acoustic noise
- Density layers (refraction)
- Turbidity clouds

Sidescan Coverage Analysis

A time window file listing the times of all valid online sidescan data were created for the 100% coverage mosaic. The time window file and the file lists were then used to create towfish track lines and mosaics in **SABER.** The mosaics were viewed using tools in **SABER** to verify swath coverage and to plan further survey lines to fill in any data holidays. These additional lines were run and appended to the mosaics. Any remaining coverage holidays are discussed in the descriptive report for the affected sheet.

The Statement of Work states that the 75 most significant items for each survey shall be investigated with multibeam sonar to obtain a least depth. However, both H11783 and H11784 had fewer than 75 significant sidescan contacts identified, while H11785 had many more. On H11783 28 multibeam investigations were performed, on H11784 49 multibeam investigations were performed, and on H11785 195 multibeam investigations were performed providing a total of 272 multibeam investigations (225 were required for three sheets). This approach is in line with the e-mail received from Crescent Moegling on 09 December 2008 which states:

"The SOW indicates that 75 targets are required per sheet. I am sure there are instances when there are not 75 targets within a sheet and I would like to clarify that this number should encompass the entire project. That is to say, if Sheet A has 50 targets and Sheet B has 100, the budget of 150 alloted targets should be weighed between both sheets."

Items which were covered with multibeam data were reviewed in the field data center at the Louisiana Universities Marine Consortium (LUMCON) facility in Cocodrie, LA. on 07 July 2009. Representatives from FEMA, the state of Louisiana and NOAA were present for the review. The multibeam data were displayed within SAIC's **SABER** software as PFM's and within **SABER's Multiview Editor** software in conjunction with the sidescan contact information and sidescan images posted to the Share Point web site.

Sidescan Contact Analysis

During sidescan review, sonar contacts were selected and measured using the **Isis Target** utility. Significant sidescan contacts were chosen based on size and height or a unique sonar signature. In general, contacts with a height greater than or equal to 50 centimeters were selected. Contacts with a unique sonar signature (e.g. size, shape, and reflectivity) were typically selected regardless of height. Contact information was saved in a ".CON" file, which included a snapshot of the image and the following information regarding the acquisition of the target data:

- Year and JD
- Time
- Position
- Fish Altitude
- Slant range to contact (Note: port = negative #, starboard = positive #)
- Contact length, width, and height (based on shadow length, fish altitude, and slant range)

Note that when digitizing contacts within Triton **Isis**, the length measurement is always the along track dimension and the width measurement is always the across track dimension. Therefore you can have a width measurement that is longer than the length measurement.

Wrecks and large objects were positioned at their highest point. Additional contacts were made on other man-made objects such as piles, pipelines, and platforms. Additional information regarding objects not included as contacts but still noted in the sidescan review log include descriptions of other non-significant objects. The sidescan review log is included in Separates I of the Descriptive Report for each sheet.

The **Isis** contact files (*.CON) were converted into a sidescan contact (*.CTV) file using a **SABER** program called **isis2ctv**. The resulting CTV file is a text file that documents all of the contact attributes contained in the individual contact files. In addition a tiff image file is made of each individual contact sonar image. In **SABER**, the CTV file was displayed and sidescan contacts were correlated to bathymetry data by overlaying them on the gridded depth layer. By comparing bathymetry data with the sidescan contact data, significant features were selected for the sheets S-57 Feature File. Positions and depths of these features were determined directly from the bathymetry data (when available) in SAIC's **MVE** swath editor by flagging the shoalest depth as a feature. A feature file (*.CNT) was created using the **SABER get_features** routine which extracted flagged features from the GSF bathymetry data. The final correlation process updated the CNT file with the type of feature (obstruction, wreck, etc.) and the CTV file with the feature-to-contact correlation.

Unique to the Gulf of Mexico surveys was the interim delivery of contacts, on a weekly basis. The weekly delivery consisted of an Excel spreadsheet of the contacts and images corresponding to the described contacts. The spreadsheet outlined specifics about each contact such as:

- Sheet
- Contact Name
- Date the feature was found
- Latitude and Longitude, in decimal degrees
- Height of the contact from the seafloor, in meters and feet
- Length in meters and feet
- Width in meters and feet
- Nearest Charted Depth, in meters and feet
- Depth from echosounder, when available, in meters
- Estimated least depth, in meters and feet
- Estimated clearance, in meters and feet
- Remarks
- Object type
- If the feature was a submitted Danger to Navigation, DTON
- Image name

Note that when digitizing contacts within Triton **Isis**, the length measurement is always the along track dimension and the width measurement is always the across track dimension. Therefore you can have a width measurement that is longer than the length measurement.

Imagery files were generated for the weekly deliveries by the **SABER** process **isis2ctv**, **Isis** Sonar version 6.06, and **SonarPro** version 11.2. Images were referenced for scale based on the sidescan range that was run when the feature was found. Additionally, images saved through **Isis** Sonar version 6.06 and **SonarPro** versions 11.2 were taken from the high frequency channels; **isis2ctv** creates the tiff images from the low frequency channels.

Often there were contacts identified where there was not a least depth recorded within any bathymetry record. In these cases the least depth of the object was estimated using the sidescan record to estimate the least depth. The object was measured for length, width and height based on the sonogram. The measured height was then subtracted from the depth recorded within bathymetry record adjacent to the object yielding the estimated least depth of the object.

The weekly deliveries of sidescan contacts that were made for the Gulf of Mexico surveys were preliminary data products. The final results of the survey are presented with each sheet. Discussions regarding differences between the weekly deliveries and the final delivery are included in each sheet's Descriptive Report.

S-57 FEATURE FILE

All features that are recommended to be compiled to the nautical charts are included in the S-57 feature file.

C. CORRECTIONS TO ECHO SOUNDINGS

The Odom Echotrac CVM singlebeam and Reson 8101 multibeam data are submitted fully corrected; therefore the CARIS vessel file will be all zeros. Both multibeam and singlebeam data are attributed with horizontal and vertical uncertainty values for each sounding. The bathymetry data are in GSF version 3.01 format, which is fully compatible with Caris version 7.0 with HotFix 5.

VESSEL CONFIGURATION PARAMETERS (*M/V SEA BENEATH*)

The *M/V Sea Beneath* sensor configuration and offsets are tabulated in Table C-1 and depicted in Figure C-1. Offsets for the *M/V Sea Beneath* Trimble GPS were revised on 29 October 2008, Julian Day 303. The results of the positioning confidence checks from the GPS monitor were favorable. On 06 November 2008 offsets within **ISS-2000** for the sidescan measurements were revised after reviewing contact alignments on adjacent passes when the data was collected with the same azimuth versus opposing direction. Values were retroactively applied to collected data. The final values appear in the respective table and figure below. All measurements are in meters. The reference point for the entire system is located at the top centerline of the POS/MV IMU. The Odom transducer was pole mounted in the moon pool and the Klein 3000 was bow mounted. The POS/MV IMU was mounted on centerline 1.34 meters above and 0.975 meters aft of the transducer.

The SAIC Integrated Survey System (**ISS-2000**) and the POS/MV utilize a coordinate system where "Z" is considered to be positive down, "X" is considered to be positive forward, and "Y" is considered to be positive athwart ship to starboard. Sensor offsets are entered into either the POS/MV or **ISS-2000** and all sensors connected to **ISS-2000** have their coordinate system transformed to match the one used by **ISS-2000**.

Table C-1. *M/V Sea Beneath* Antenna and Transducer Offsets (Meters) Relative to the POS/IMU Reference Point as set up for use with the Odom Transducer Pole Mounted

Sensor	Offset in ISS-2000		Offset in POS/MV	
Odom Transducer Pole Mount			X	+ 0.975
			Y	0.000
			Z	+ 1.341
Vessel Center of Rotation			X	0.00
			Y	0.00
			Z	0.00
POS/MV Master GPS Antenna			X	+ 0.509
			Y	- 0.044
			Z	- 1.845
Trimble GPS Antenna	X	+ 0.467		
	Y	- 0.044		
	Z	- 2.428		
Sidescan Bow Mount	X	+ 5.832		
	Y	- 0.044		
	Z	- 0.552		

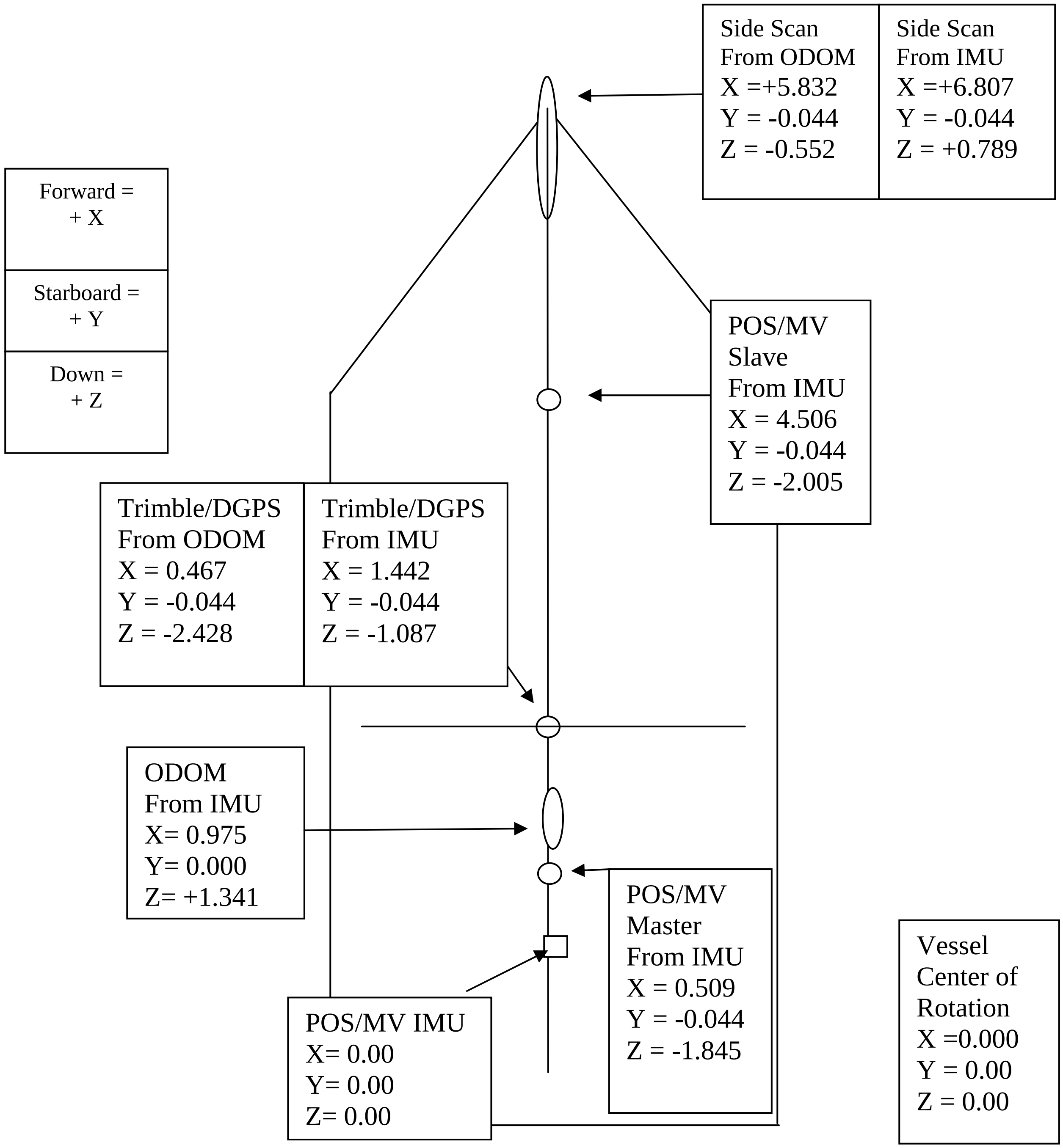

Figure C-1. Configuration and Offsets of the *M/V Sea Beneath* Sensors (measurements in meters)

On 27 June 2009, the *M/V Sea Beneath* was outfitted with a Reson 8101 multibeam echosounder, for the item investigations. Figure C-2 depicts the revised sensor configurations and vessel offsets are tabulated in Table C-2. The Reson 8101 was pole mounted within the moon pool, just forward of the IMU. Offset measurements were made from the IMU with the final position being computed and reported as the acoustic center of the Reson 8101. The reference point for the entire system was located at the Reson 8101 transducer acoustic center. There were no changes made to the position of the POS/MV. The distance from the bottom of the moon pool doors to the acoustic center, the reference point for the system, of the Reson 8101 multibeam is 1.27 meters.

Table C-2. *M/V Sea Beneath* Transducer Offsets (Meters) Relative to the POS/IMU Reference Point as set up for use with the Reson 8101 Transducer Pole Mounted

Sensor	Offset in ISS-2000		Offset in POS/MV	
Reson 8101 Transducer Pole Mount			X	+ 0.838
			Y	- 0.013
			Z	+ 1.132
Vessel Center of Rotation			X	0.00
			Y	0.00
			Z	0.00
POS/MV Master GPS Antenna			X	+ 0.509
			Y	- 0.044
			Z	- 1.845
Trimble GPS Antenna	X	+ 0.467		
	Y	- 0.044		
	Z	- 2.428		
Sidescan Bow Mount	X	+ 5.832		
	Y	- 0.044		
	Z	- 0.552		

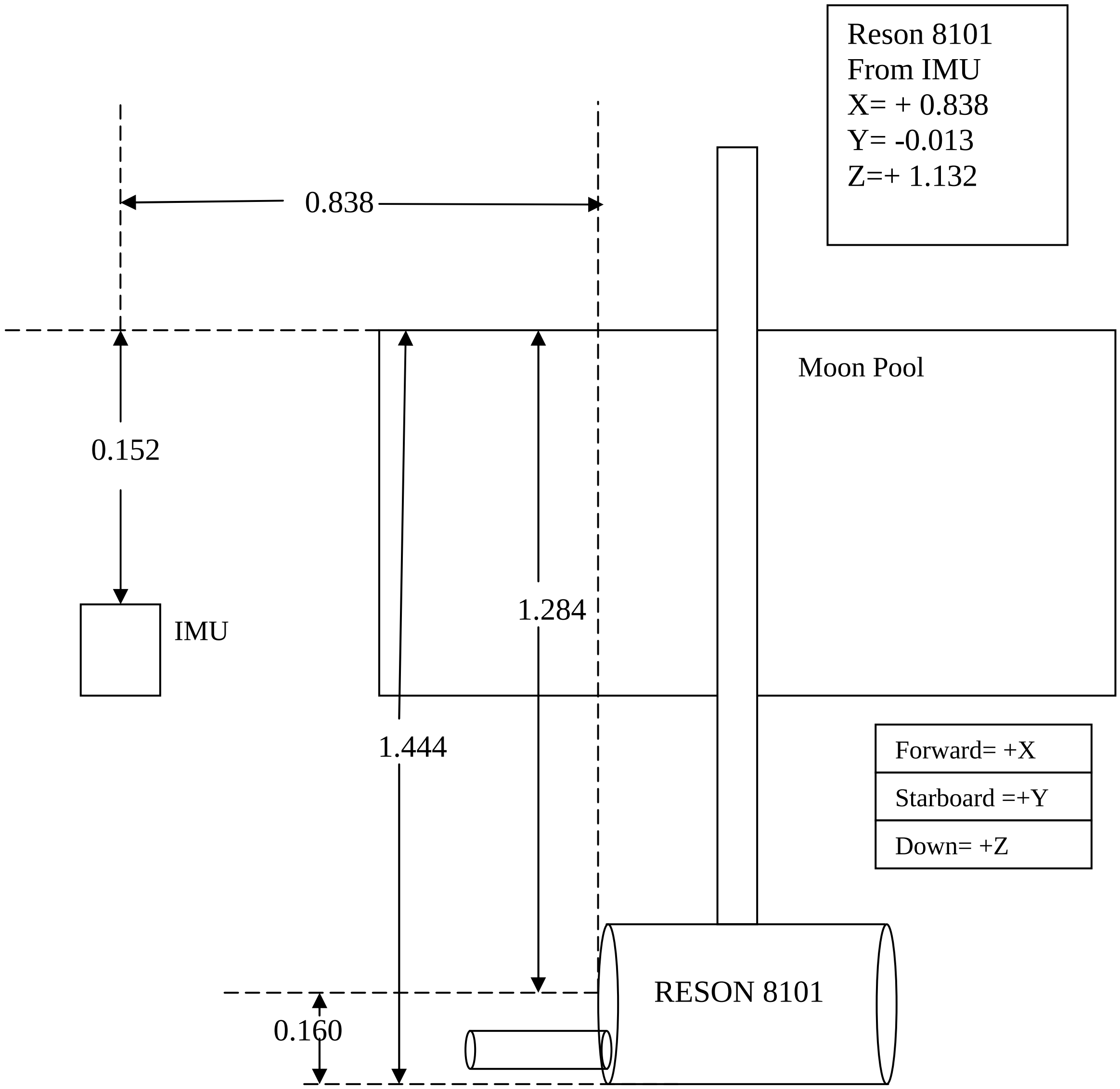

Figure C-2. Configuration and Offsets of the *M/V Sea Beneath* Sensors with Reson 8101 (measurements in meters)

VESSEL CONFIGURATION PARAMETERS (*F/V LACEY MARIE*)

The *F/V Lacey Marie* sensor configuration and offsets are tabulated in Table C-3 and depicted in Figure C-3. The reference point for the entire system is located at the top centerline of the POS/MV IMU. The Odom singlebeam transducer was mounted on the port side through the use of an over-the-side pole while the Klein 3000 was bow mounted with a retractable bow mount. The POS/MV IMU was mounted port of the centerline 2.31 meters above and 1.10 meters aft, and 1.33 meters inboard of the transducer.

The SAIC Integrated Survey System (**ISS-2000**) and the POS/MV utilize a coordinate system where "Z" is considered to be positive down, "X" is considered to be positive forward, and "Y" is considered to be positive athwart ship to starboard. Sensor offsets are entered into either the POS/MV or **ISS-2000** and all sensors connected to **ISS-2000** have their coordinate system transformed to match the one used by **ISS-2000**.

Table C-3. *F/V Lacey Marie* Transducer Offsets (Meters) Relative to the POS/IMU Reference Point

Sensor	Offset in ISS-2000		Offset in POS/MV	
POS/MV Master GPS Antenna			X	- 1.286
			Y	+ 0.306
			Z	- 2.536
Odom Transducer Pole Mount			X	+ 1.100
			Y	- 1.326
			Z	+ 2.260
Vessel Center of Rotation			X	0.000
			Y	+ 1.305
			Z	+ 1.325
Trimble GPS Antenna	X	- 2.386		
	Y	+ 2.631		
	Z	- 4.796		
Sidescan Bow Mount	X	+ 7.731		
	Y	+ 2.631		
	Z	- 0.123		

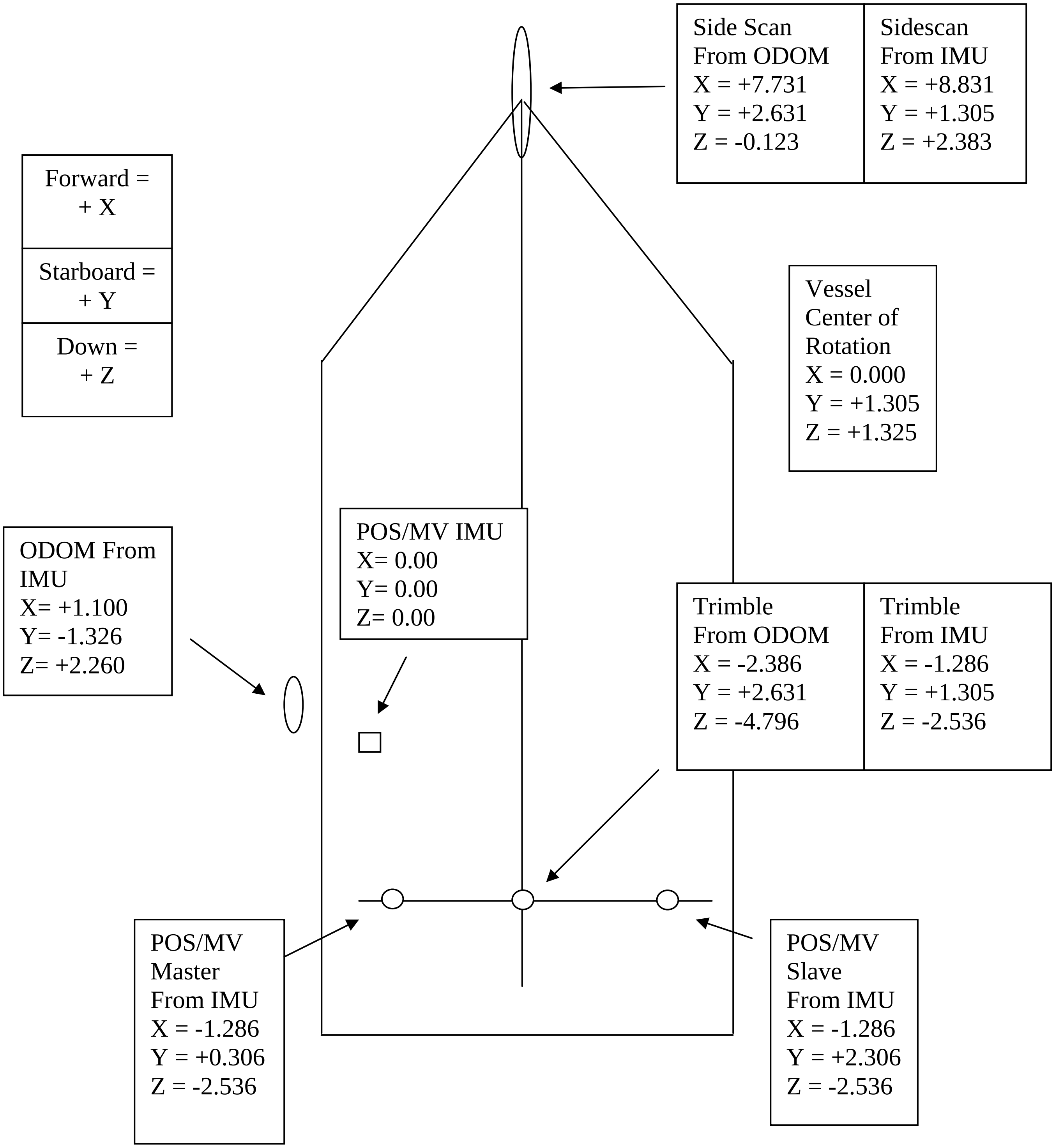

Figure C-3. Configuration and Offsets of the *F/V Lacey Marie* Sensors (measurements in meters)

STATIC AND DYNAMIC DRAFT MEASUREMENTS

M/V Sea Beneath Static Draft

Figure C-4 shows the draft calculations for the *M/V Sea Beneath*. Depth of the transducer's acoustic center (1.46 meters) was determined during the SAT in October 2008. When the *M/V Sea Beneath* switched from the use of the Odom CVM echosounder to using the Reson 8101 multibeam echosounder the multibeam draft was measured at 1.27 meters.

Static draft measurements for the *M/V Sea Beneath* were taken where the singlebeam transducer was located, at the moon pool, prior to departure and after arrival to the dock each day of survey. The draft value was recorded in the real-time Navigation Log. The static draft value was entered into the **ISS-2000** system, and was checked daily to ensure that the daily draft value was correct in the system. When the collected static draft measurement was different from the value internal to the **ISS-2000**, the new value was entered into the system. If the draft value taken at the beginning of the day differed from the draft value taken at the end of the day (usually by no more than 1-2 cm), then the average draft value was post-applied during processing. The observed and applied static draft for each survey is included with the survey data in Section I of the Separates of each Sheet's Descriptive Report.

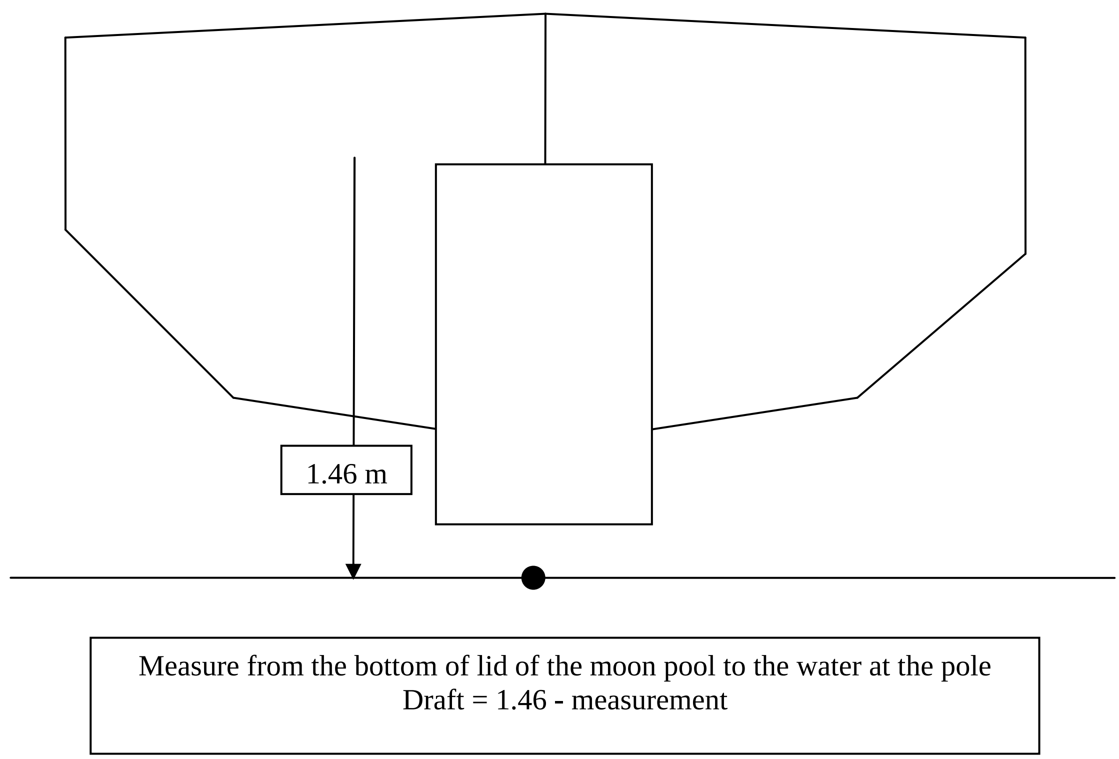

Figure C-4. *M/V Sea Beneath* Draft Determination

F/V Lacey Marie **Static Draft**

Figure C-5 shows the draft calculations for the *F/V Lacey Marie*. The depth of the transducer's acoustic center (1.57 meters) was determined during the SAT in January 2009.

Static draft measurements for the *F/V Lacey Marie* were taken on the port side adjacent to the singlebeam transducer, both before departure and after arrival to the dock each day of survey. The draft value was recorded in the real-time Navigation Log. The static draft value was entered into the **ISS-2000** system, and was checked daily to ensure that the draft value in the system matched the measurement. When the collected static draft measurement was different from the value internal to the **ISS-2000**, the new value was entered into the system. If the draft value taken at the beginning of the day differed from the draft value taken at the end of the day (usually by no more than 1-2 cm), then the average draft value was post-applied during processing. The observed static draft for each survey is included with the survey data in Section I of Separates of each Sheet's Descriptive Report.

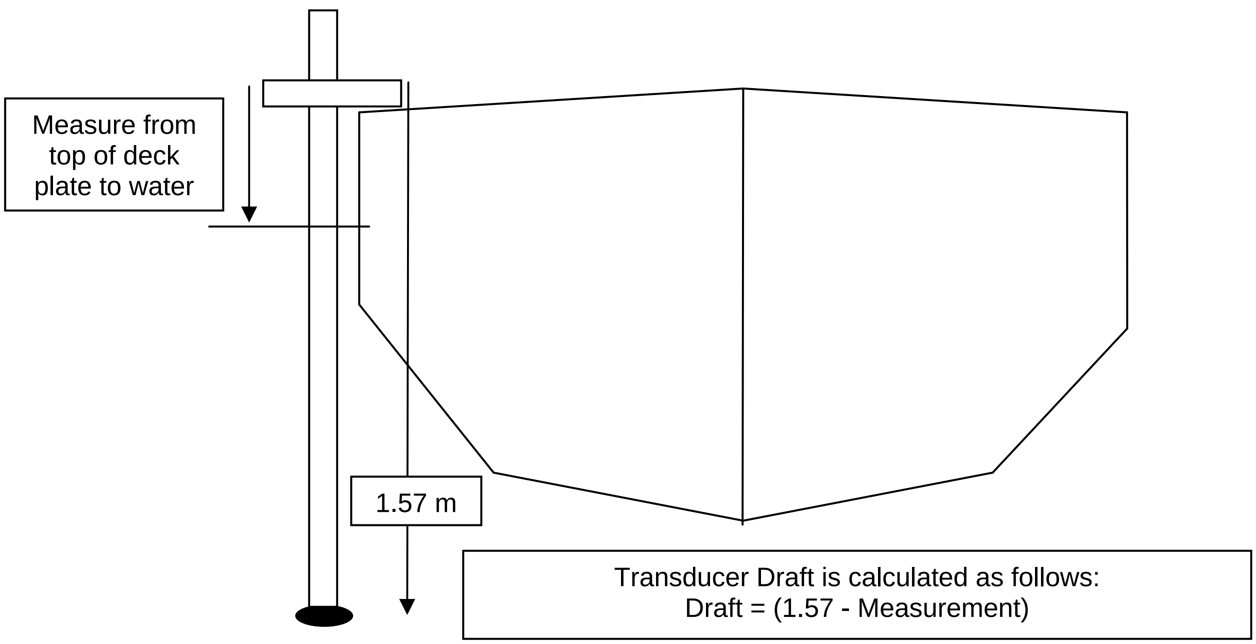

Figure C-5. ***F/V Lacey Marie*** **Draft Determination**

M/V Sea Beneath Settlement and Squat – Dynamic Draft

The *M/V Sea Beneath* settlement and squat values were determined on Julian Day 292 and confirmed on Julian Day 294 of 2008. Two drift lines and reference lines were established for the settlement and squat determination. An average difference was computed for each RPM as presented in Table C-4. These values were then entered into the **ISS-2000** vessel configuration file and the test repeated on Julian Day 294. The Sea Beneath did not have an RPM sensor interfaced to **ISS-2000**. Therefore the RPM value was manually entered in the system for proper computation of the settlement and squat corrector.

Table C-4. *M/V Sea Beneath* Settlement and Squat Determination

Shaft RPM	Depth Corrector	Average Speed (Kts)	Files Julian Day 292	Verification Files Julian Day 294
0	0.00	0	sbsbh08292.d05	sbsbh08294.d19
1000	0.02	3.7	sbsbh08292.d06	sbsbh08294.d20 sbsbh08294.d22
1300	0.02	4.0	sbsbh08292.d07 sbsbh08292.d08	sbsbh08294.d24 sbsbh08294.d25
1700	0.03	7.2	sbsbh08292.d09 sbsbh08292.d10	sbsbh08294.d26 sbsbh08294.d27
2000	0.03	8.4	sbsbh08292.d13 sbsbh08292.d14	sbsbh08294.d28 sbsbh08294.d29
2300	0.04	8.9	sbsbh08292.d15 sbsbh08292.d16	sbsbh08294.d30 sbsbh08294.d31
2600	0.07	9.0		sbsbh08294.d32 sbsbh08294.d33
2800	-0.03	9.7	sbsbh08292.d16 sbsbh08292.d17	sbsbh08294.d34 sbsbh08294.d35

F/V Lacey Marie Settlement and Squat – Dynamic Draft

Settlement and Squat values for the *F/V Lacey Marie* were determined on Julian Day 005 of 2009. A soundings reference was established by bringing the vessel to "all stop" and drifting. Two drift lines and reference lines were established for the settlement and squat determination. Depth differences between the drift line (0 RPM) and each RPM run were determined at locations where depth positions were within five meters. The depth differences were averaged to compute the settlement and squat for each RPM as presented in Table C-5. These values were then entered into the **ISS-2000** configuration and vessel configuration files. The *F/V Lacey Marie* was outfitted with an RPM sensor which provided the ISSC with a shaft RPM value. This value is logged and used as the input to the Settlement and Squat look-up table in the vessel configuration file.

Table C-5. *F/V Lacey Marie* Settlement and Squat Determination

RPM	Depth Corrector	Average Speed (Kts)	Files Julian Day 005
0	0.00	0	lmsbh009005.d10
285	0.01	2.2	lmsbh009005.d11 lmsbh009005.d12
405	0.01	3.7	lmsbh009005.d13 lmsbh009005.d14
500	0.02	5.0	lmsbh009005.d15 lmsbh009005.d16
630	0.03	6.5	lmsbh009005.d17 lmsbh009005.d18
710	0.05	7.5	lmsbh009005.d19 lmsbh009005.d20
830	0.11	9.0	lmsbh009005.d21 lmsbh009005.d22
960	0.14	10	lmsbh009005.d23 lmsbh009005.d24

SPEED OF SOUND

Seabird Electronics SBE-19 CTDs were used to collect sound speed profile (SSP) data on both vessels. NOS Hydrographic Surveys Specifications and Deliverables, dated April 2008, require that SSP data be obtained once a week, for singlebeam data, and at a higher sampling rate when acquiring multibeam data. While operating with singlebeam, the frequency of casts for both vessels was an opening cast and closing cast for each day of survey. If during the day, the vessel switched between the three Gulf of Mexico surveys; additional casts were taken and applied. While operating the multibeam on the *M/V Sea Beneath*, casts were taken more frequently as required.

A table including all SSP casts made on each vessel is located in Section II of the Separates in each Sheet's Descriptive Report. The table includes the Julian Day, location, and maximum depth of the cast.

On the *M/V Sea Beneath* and the *F/V Lacey Marie* SSP casts were copied to **ISS-2000** where the profiles were reviewed for quality and compared to the preceding cast. After review, the cast was "applied" in **ISS-2000**; which applied the cast to the real-time data collection. Once applied, **ISS-2000** used the cast for speed and ray tracing corrections to the singlebeam sounding data. If sounding depths exceeded the cast depth, the **ISS-2000** used the deepest sound speed value of the cast to extend the profile to the maximum depth.

Weekly confidence checks were obtained using consecutive casts in the same locality with two different Seabird 19 CTDs. After downloading the SSP casts, graphs and tabulated lists were used to compare the two casts for discrepancies.

Serial numbers and calibration dates for the CTD units used on these surveys are listed below. Sound sped data and calibration records are included with the survey data in Section II of the Separates for each Sheet's Descriptive Report.

- Seabird Electronics, Inc., CTD, Serial Number 2710
  Calibration Dates: 08 February 2008 and 31 July 2009

- Seabird Electronics, Inc., CTD, Serial Number 0648
  Calibration Dates: 08 February 2008 and 1 July 2009

- Seabird Electronics, Inc.,., CTD, Serial Number 0565
  Calibration Dates: 08 February 2008 and 31 July 2009

SYSTEM BIAS DETERMINATION

As the *M/V Sea Beneath* and *F/V Lacey Marie* were originally configured with a singlebeam depth sounder and sidescan, a patch test to determine roll, pitch and heave biases for alignments was therefore not required during the Sea Acceptance Test (SAT). Upon mobilizing the *M/V Sea Beneath* with the Reson 8101 multibeam on 28 June 2009, a full patch test was performed.

Timing Bias – *M/V Sea Beneath*

A ping-timing test was completed on 21 October (Julian Day 295), 2008 to verify that no timing errors exist within the survey system installed on board the *M/V Sea Beneath*. The fundamental measurement tool is the event marking capability of the Symmetricom BC635PCI IRIG-B card in the ISSC and Klein TPU. An event is characterized by a positive-going TTL pulse occurring on the event line of the IRIG-B connector on the back of the ISSC. The pulses of interest are the transmit trigger of the IRIG-B and 1ppS timing pulses from the internal GPS in the POS/MV. The test verifies that no timing errors exist within the system by ensuring that the ISSC's IRIG-B clock is synchronized to the POS/MV and that the Odom timing is synchronized to the ISSC's IRIG-B clock.

This test demonstrated that all the GSF ping times matched the corresponding IRIG-B event times to within 2 milliseconds or less (with a standard deviation of 1 millisecond). The times in each file were compared and the results are plotted in Figure C-6. Timing tests of **ISS-2000** were successfully completed prior to any other calibration tests.

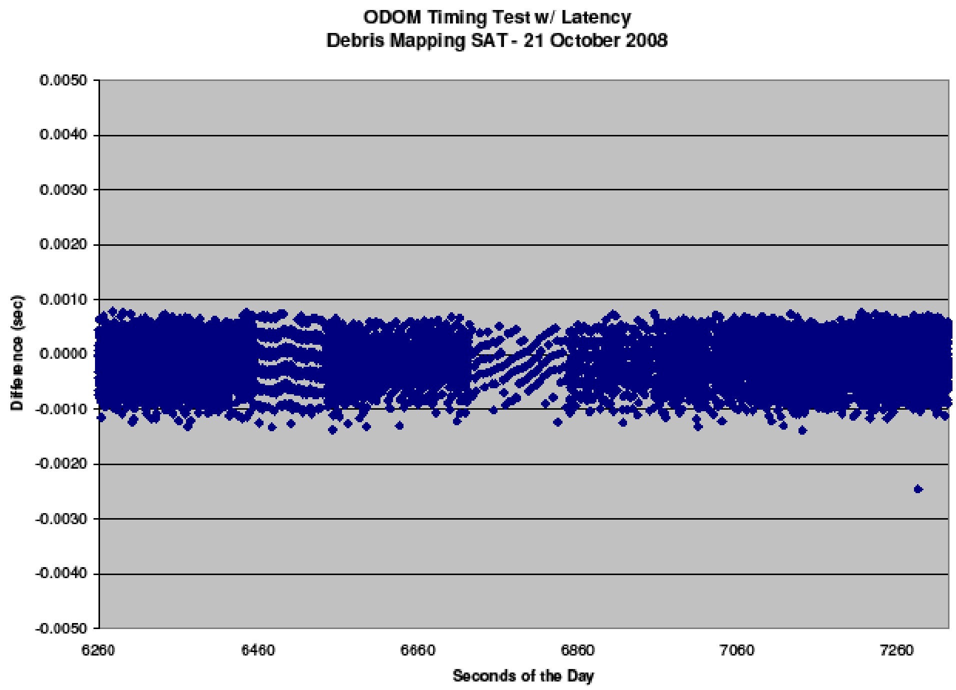

Figure C-6. Timing Test Results *M/V Sea Beneath*

Timing Bias – *F/V Lacey Marie*

A ping-timing test was completed on 03 January 2009 to verify that no timing errors exist within the survey system installed on board the *F/V Lacey Marie*. The fundamental measurement tool is the event marking capability of the Symmetricom BC635PCI IRIG-B card in the ISSC and Klein TPU. An event is characterized by a positive-going TTL pulse occurring on the event line of the IRIG-B connector on the back of the ISSC. The pulses of interest are the transmit trigger of the IRIG-B and 1ppS timing pulses from the internal GPS in the POS/MV. The test verifies that no timing errors exist within the system by ensuring that the ISSC's IRIG-B clock is synchronized to the POS/MV and that the Odom timing is synchronized to the ISSC's IRIG-B clock.

This test demonstrated that the average GSF ping times compared to the corresponding IRIG-B event times was 2 milliseconds with a standard deviation of 1 millisecond. The times in each file were compared and the results are plotted in Figure C-7. Timing tests were successfully completed prior to any other calibration tests.

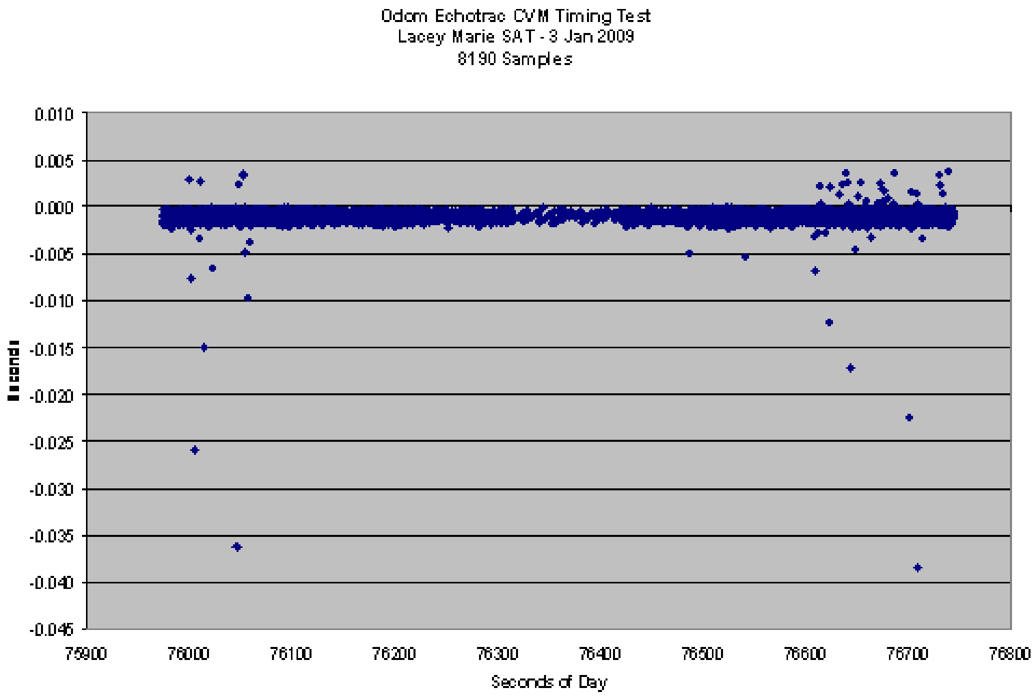

Figure C-7. Timing Test Results *F/V Lacey Marie*

Multibeam Bias Calibration

A multibeam alignment calibration and timing test was performed on the *M/V Sea Beneath* prior to commencing the item investigations, which utilized the Reson 8101. The timing test results are presented in Figure C-8. The calibration resulted in bias values shown in Table C-6. Before running bias calibration lines, all instrument offsets were entered into **ISS-2000** and all bias values were set to zero. Bias determinations were made using the **SABER Swath Alignment Tool** (SAT) program.

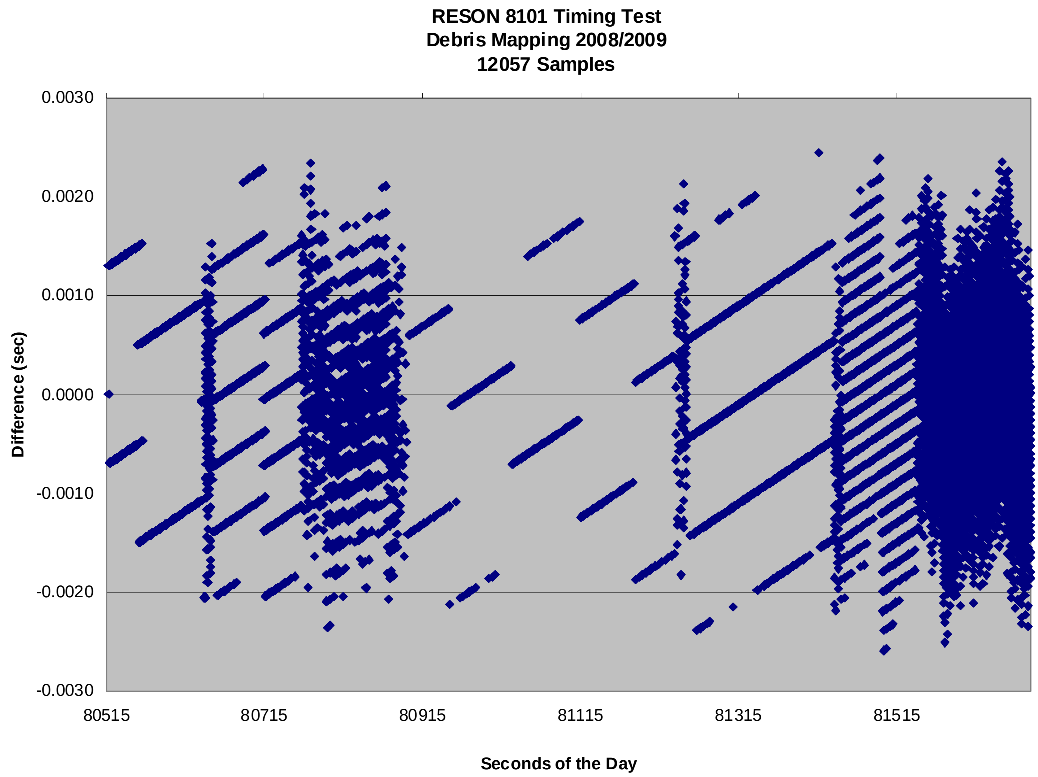

Figure C-8. 8101 Multibeam Timing Test Results *M/V Sea Beneath*

Table C-6. Alignment Biases Calculated Using Swath Alignment Tool

Component	Multibeam Files (pairs)		Bias
Pitch	emmba09179.d29	emmba09179.d30	- 1.2
Roll	emmba09179.d29	emmba09179.d30	- 0.6
Gyro	emmba09179.d31	emmba09179.d32	- 1.0

Pitch Alignment

Two sets of lines were collected for pitch bias calculation. All lines were run along the same survey transect so that separate comparisons could be made. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the pitch bias. Figure C-9 and Figure C-10 are images of the SAT tool depicting data collected with a -1.2° pitch bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

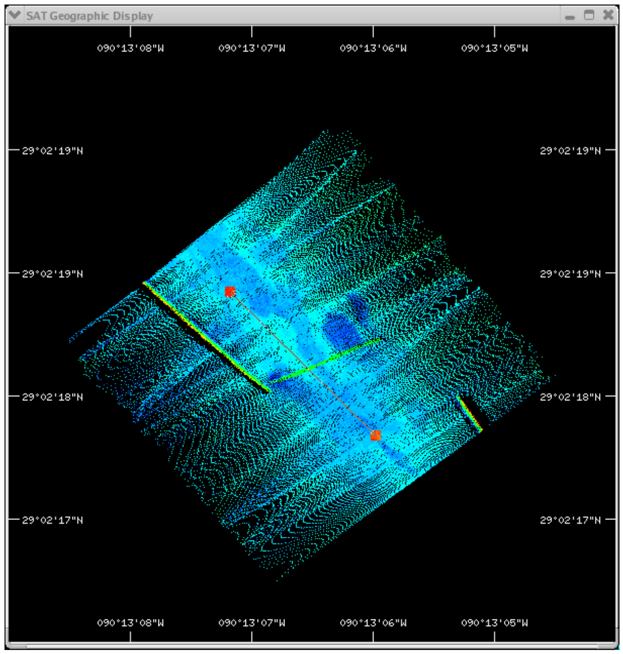

Figure C-9. SAT Tool, Plan View Depicting -1.2 Pitch Bias

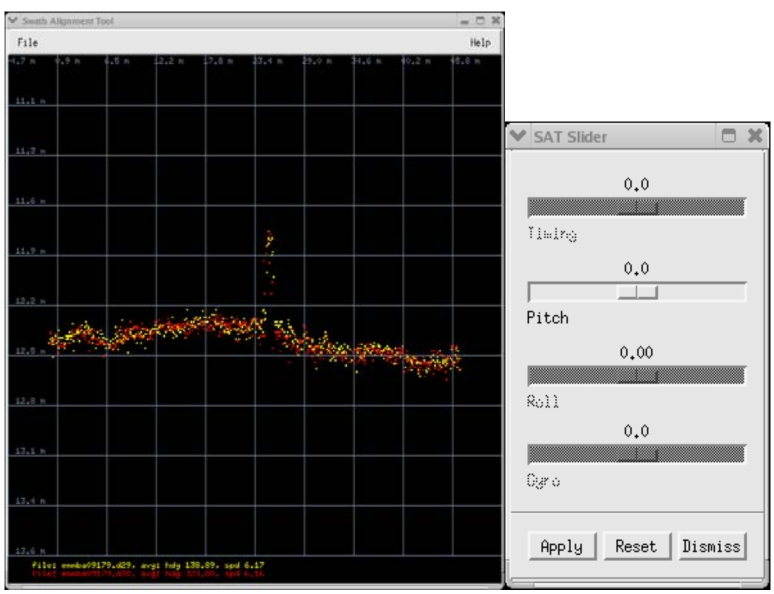

Figure C-10. SAT Tool, Depth vs. Distance Plot Depicting 0.00 Pitch Bias

Roll Bias

Two sets of lines were collected for roll bias calculation. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the roll bias. Figure C-11 and Figure C-12 are images of the SAT tool depicting data collected with the -0.6 roll bias entered in the **ISS-2000** system. Therefore the SAT tool roll value indicated a bias as zero.

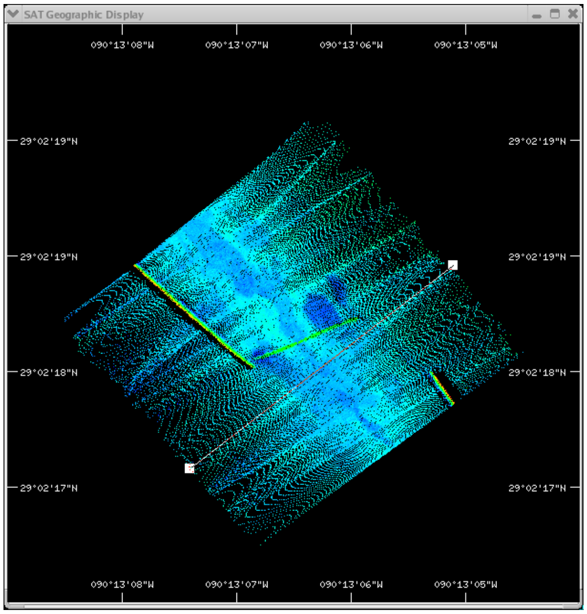

Figure C-11. SAT Tool, Plan View Depicting -0.6 Roll Bias

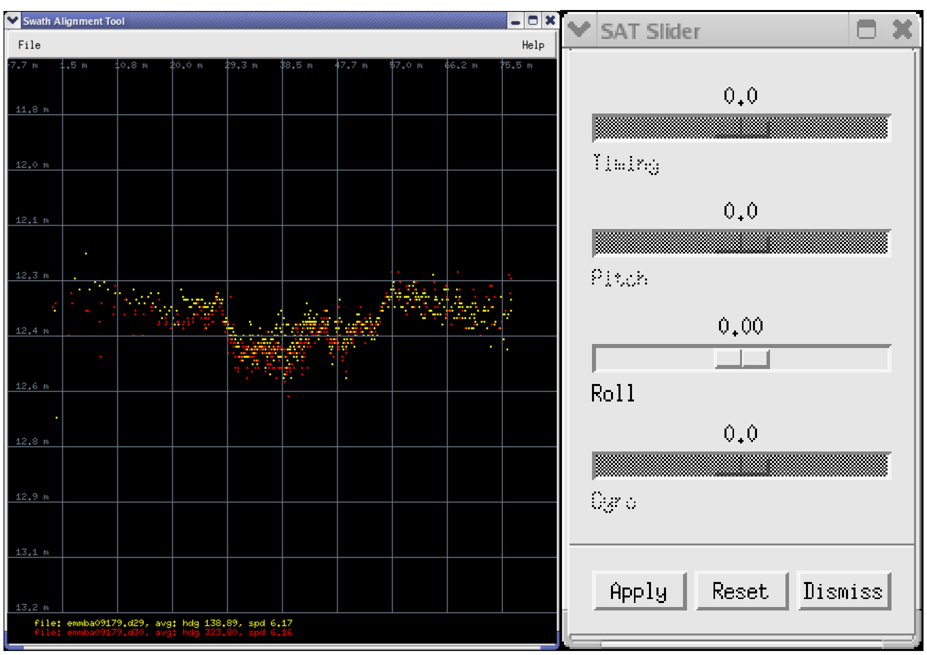

Figure C-12. SAT Tool, Depth vs. Distance Depicting 0.00 Roll Bias

Heading Bias

Two sets of lines were collected for heading bias calculation. Lines were run in opposite directions such that separate comparisons could be made. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the heading bias. Figure C-13 and Figure C-14 are images of the **SAT** tool depicting data collected with a -1.0 heading bias entered in the **ISS-2000** system; therefore the indicated gyro value bias is zero.

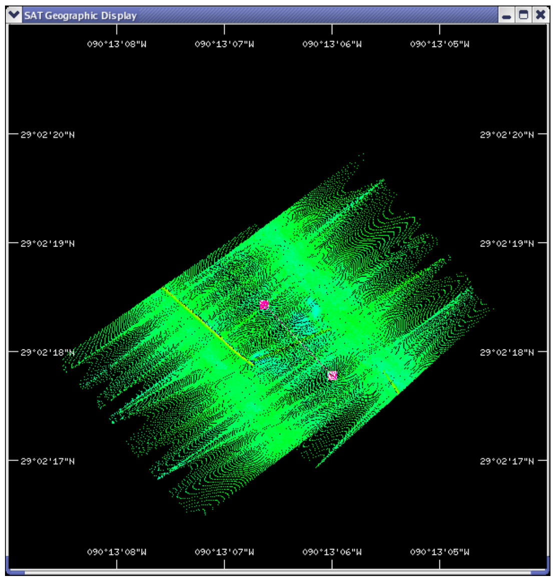

Figure C-13. SAT Tool, Plan View Depicting -1.0 Heading Bias

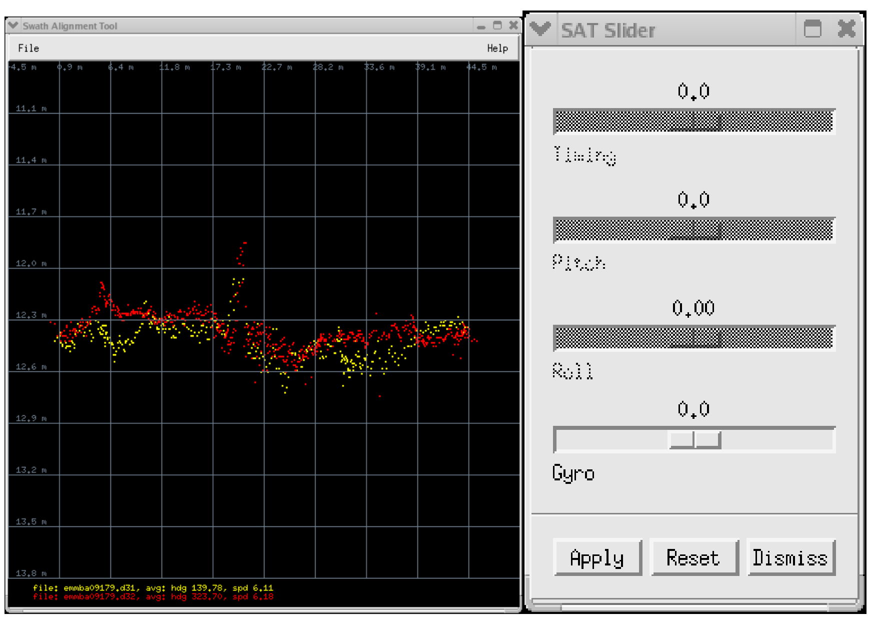

Figure C-14. SAT Tool, Depth vs. Distance Depicting -1.0 Heading Bias

Junction Analysis Between Singlebeam and Multibeam Data

During the systems acceptance test, lines were run over an area that contained singlebeam data from both the *F/V Lacey Marie* and the *M/V Sea Beneath*. Junction analysis was performed between the multibeam data and the singlebeam data for each individual vessel as well as cumulative analysis. Depth difference grids were computed between the grids of singlebeam data from both vessels and a grid of the multibeam data (Figure C-15). The **SABER Junction Analysis** routine was then run to summarize the results of these depth difference comparisons. The data used for the junction analysis had predicated tides applied. Tables C-7 thru C-9 illustrates the results of the three junction analyses.

The junction analysis results showed that there was reasonable agreement between the three systems. Specifically, 89.86% of the soundings were within a depth difference of 0.10 meters with 100% within 0.15 meters when the analysis was run comparing multibeam to *M/V Sea Beneath* singlebeam (Table C-7). Multibeam data to *F/V Lacey Marie* singlebeam data 90.18% of the soundings were within the depth difference of 0.15 meters with 100% within 0.25 meters (Table C-8). Table C-9 compares the singlebeam data from both boats to the multibeam data. In this comparison, 95.93% of the soundings were with 0.20 meters and 100% within the range of 0.25 meters. While the analysis shows that there is good agreement between the singlebeam data and the multibeam data, a non equal distribution in differences between negative and positive values was seen. The junction analysis identified a larger number of cells exhibiting a negative value than positive values indicating that the data collected with the multibeam system is slightly deeper than the data collected with the singlebeam systems. There was no indication that there were any errors in the offset values for the multibeam system and agreement in observed depths during bar checks supported the multibeam offsets. No changes were made in the multibeam system as a result of the junction analysis results.

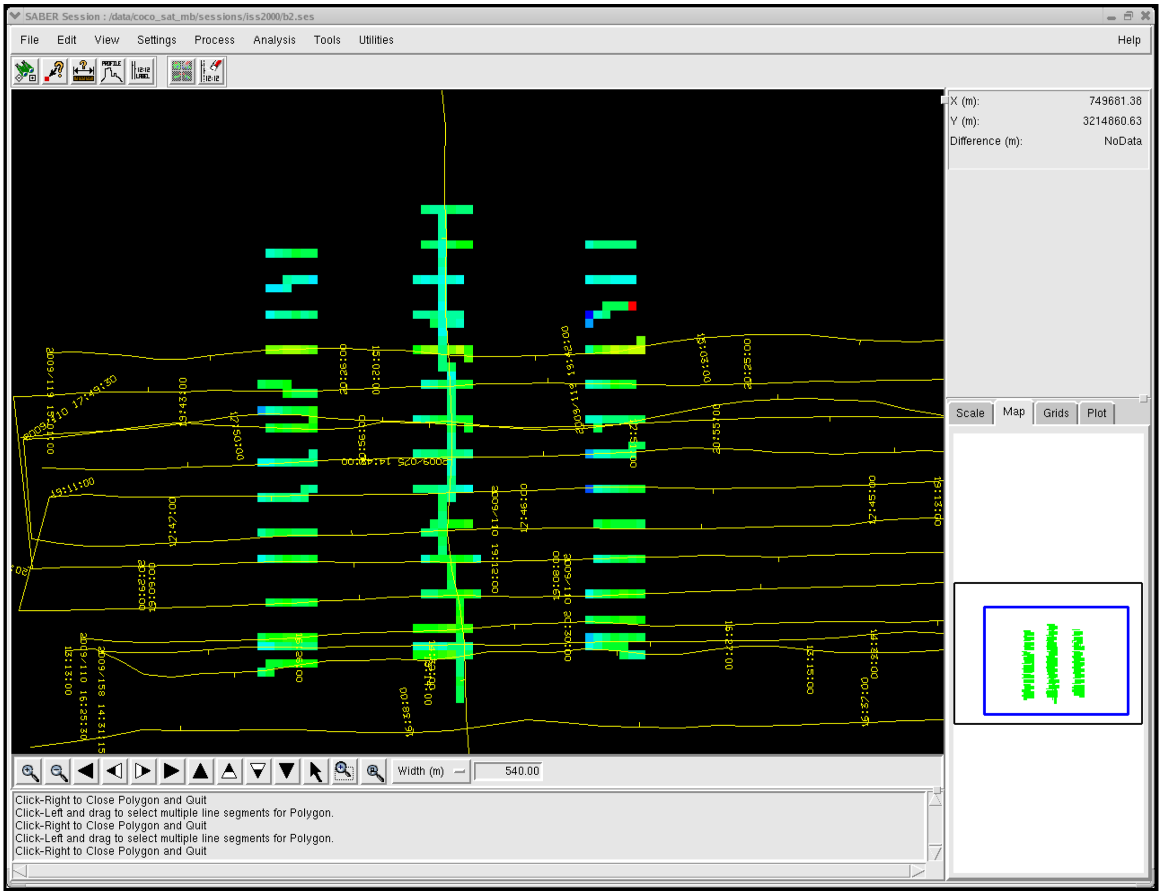

Figure C-15. Difference grid overlaid *F/V Lacey Marie* track lines

Table C-7. Junction Analysis between collected Multibeam data to *M/V Sea Beneath* Singlebeam data

Depth Difference Range(cm)	All		Positive		Negative		Zero	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
0-> 5	31	44.93	1	100	28	42.42	2	100
5-> 10	31	89.86	0	100	31	89.39		
10-> 15	7	100	0	100	7			
TOTALS	69	100%	1	1.45%	66	95.65%	2	2.90%

Table C-8. Junction Analysis between collected Multibeam data to *F/V Lacey Marie* Singlebeam data

Depth Difference Range(cm)	All		Positive		Negative		Zero	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
0-> 5	31	11.27	2	50	29	10.7	0	100
5-> 10	109	50.91	2	100	107	50.18		
10-> 15	108	90.18	0	100	108	90.04		
15-> 20	13	94.91	0	100	13	94.83		
20-> 25	14	100	0	100	14	100		
TOTALS	248	100%	4	1.61%	244	98.39%	0	0.00%

Table C-9. Junction Analysis between collected Multibeam data to *M/V Sea Beneath* Singlebeam data and *F/V Lacey Marie* Singlebeam data

Depth Difference Range(cm)	All		Positive		Negative		Zero	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
0 ->5	62	18.02	3	60	57	16.91	2	100
5 -> 10	140	58.72	2	100	138	57.86		
10 ->15	115	92.15	0	100	115	91.99		
15 ->20	13	95.93	0	100	13	95.85		
20 ->25	14	100	0	100	14	100		
TOTALS	317	100%	5	1.58%	310	97.79%	2	0.63%

TIDES AND WATER LEVELS

NOAA Preliminary Zoning

There were two NOAA preliminary zoning reference stations as listed below.

- 8764227 LAWMA, approximately 25 miles west of the survey area. GT = 0.480m, Mn = 0.344m
- 8762075 Port Fourchon, eastern end of survey area, 2miles inside of Belle Pass. GT = 0.376m, Mn = 0.368m

The preliminary NOAA tidal zoning shows the tide range decreasing from west to east, while the phase of the tide progresses from offshore to onshore, roughly south to north.

A comparison of the zoned data between boundary zones WGM417 (controlled by LAWMA) and CGM733 (controlled by Port Fourchon) shows that while the zoned data sets are well centered (mean is close to 0), there are significant differences between the two tide curves.

Difference between zoned tides with different control stations (NOAA preliminary)

Zone WGM417 (8764227) Range Ratio: 0.98 Time Offset (minutes): 42.0

Zone CGM733 (8762075) Range Ratio: 1.17 Time Offset (minutes): -6.0

Mean (m): 0.014

1 sigma (m): 0.1577

2 sigma (m): 0.309

Min (m): -0.576

Max (m): 0.548

A direct comparison of LAWMA and Texas Gas Platform tide produces significantly different zoning factors for zone WGM413 (the zone the Texas Gas Platform station is in) than the NOAA preliminary zoning (Table C-10).

Table C-10. Zone WGM413 Zoning Factors

Zone WGM413	NOAA preliminary	Compare Highs and Lows from LAWMA and Texas Gas	Least Squares Optimized Zoning (LAWMA to Texas Gas)
Time offset (minutes)	42	-56	-72
Range ratio	1.04	n/a	0.94

The time offsets computed in Table C-10 could make sense given the general progression of the tide in the NOAA preliminary zoning from south to north. LAWMA is north inside of Atchafalaya Bay, while Texas Gas Platform is further south. The standard deviation for the High and Low time comparison was 94 minutes. The computed range ratio is closer to that derived from a comparison of the GT's at both stations (0.437/0.480 = 0.91 range ratio). However, if you compare the mean range at each station, you get a range ratio closer to NOAA's preliminary zoning (0.363/0.344 = 1.06 range ratio).

SAIC Revised Zoning

There were two tide stations used by SAIC for the final zoning as listed below.

- 8762075 Port Fourchon, eastern end of survey area, 2 miles inside of Belle Pass. GT = 0.376m, Mn = 0.368m
- 8763535 Texas Gas Platform, west end of the survey area in Caillou Bay. GT = 0.437m, Mn = 0.363m (based on unverified monthly means comparison, holding Grand Isle)

The SAIC revised tidal zoning alters the geometry of the zoning scheme to cover the final survey area. The islands which form the northern boundary of the survey area have migrated north, so the northern zones were extended to cover this newly wet area. The tide zones inshore of the islands have been omitted since they are not needed for this survey. The zones further offshore that were not required for the survey were also discarded.

Comparison of the WGM413 zone data from the NOAA 8764227 LAWMA station to the observed data at the SAIC 8763535 Texas Gas Platform station revealed differences in the tide curve that made use of the LAWMA data unacceptable for this survey area.

All tide data were in meters and annotated with Coordinated Universal Time (UTC).

Application of Tidal Correctors

Final water level files for each tide zone were created from verified tide data using the **SABER Create Water Level Files** tool. Water level files contained water level heights that were algebraically subtracted from depths to correct the soundings for tides and water levels. These water level files were applied to the bathymetry data using the **SABER Apply Tides** program within the **SABER** software.

When it was necessary to apply updated tide correctors to the GSF files, the program removed the previous tide corrector and applied the new corrector. Each time a routine was run on the GSF data file, a history record was appended to the end of the GSF file. For quality assurance, the **Check Tides** program was run on all GSF files to confirm that the appropriate water level corrector had been applied to the GSF file.

Quality Control of Tidal Correctors

After confirmation that verified water levels were applied to all bathymetry data, grids were created and analyzed using various color change intervals. The color intervals provided a means to check for significant, unnatural changes in depth across zone boundaries due to water level correction errors, unusual currents, storm surges, etc.

The primary means for analyzing the adequacy of zoning was observing zone boundary crossings in the navigated swath editor, SAIC's **MVE**. In addition, crossline analysis using SAIC's **Analyze Crossings** software was used to identify possible depth discrepancies resulting from the applied water level corrector. Discrepancies were further analyzed to determine if they were the result of incorrect zoning parameters or weather (wind) conditions between the tide station and the survey area.

The zone to zone comparisons presented in Table C-11 are valid for the days when survey data acquisition was accomplished, but they include the entire day, not just the times of survey. The large differences at the FTxGS005 to FPtFn749 zone boundary occur during times when the weather conditions made water levels deviate from normal at the Port Fourchon station which is inside the harbor. Surveys were not conducted near the zone boundary in H11783 and H11784 at the times of these large differences.

Table C-11. Water Level Differences across Zone Boundaries, Verified

	FTxGs001 - FTxGs002	FTxGs002 - FTxGs003	FTxGs003 - FTxGs004	FTxGs004 - FTxGs005	FTxGs005 - FPtFn749	FPtFn749 - FPtFn750	FPtFn750 - FPtFn364	FPtFn750 - FPtFn394	FPtFn364 - FPtFn394
stdev	0.002	0.006	0.002	0.002	0.068	0.015	0.010	0.002	0.010
Avg	0.003	0.002	0.003	0.003	0.025	0.012	-0.002	-0.002	0.000
Min	-0.005	-0.034	-0.005	-0.005	-0.491	-0.106	-0.203	-0.009	-0.108
Max	0.010	0.046	0.010	0.010	0.255	0.220	0.106	0.005	0.201

The final tide zoning used for the H11783, H11784 and H11785 surveys is presented in Table C-12 and Figure C-16.

Table C-12. Tide Zone Parameters Applied on Sheets H11783, H11784, H11785

Zone	Time Corrector (hours:minutes)	Range Ratio	Reference Station
FPtFn394	00:00	1.0900	8762075
FPtFn364	00:06	1.0900	8762075
FPtFn750	00:00	1.0800	8762075
FPtFn749	00:06	1.1400	8762075
FTxGs005	-00:06	0.9600	8763535
FTxGs004	-00:06	0.9700	8763535
FTxGs003	-00:06	0.9800	8763535
FTxGs002	00:00	0.9900	8763535
FTxGs001	00:00	1.0000	8763535

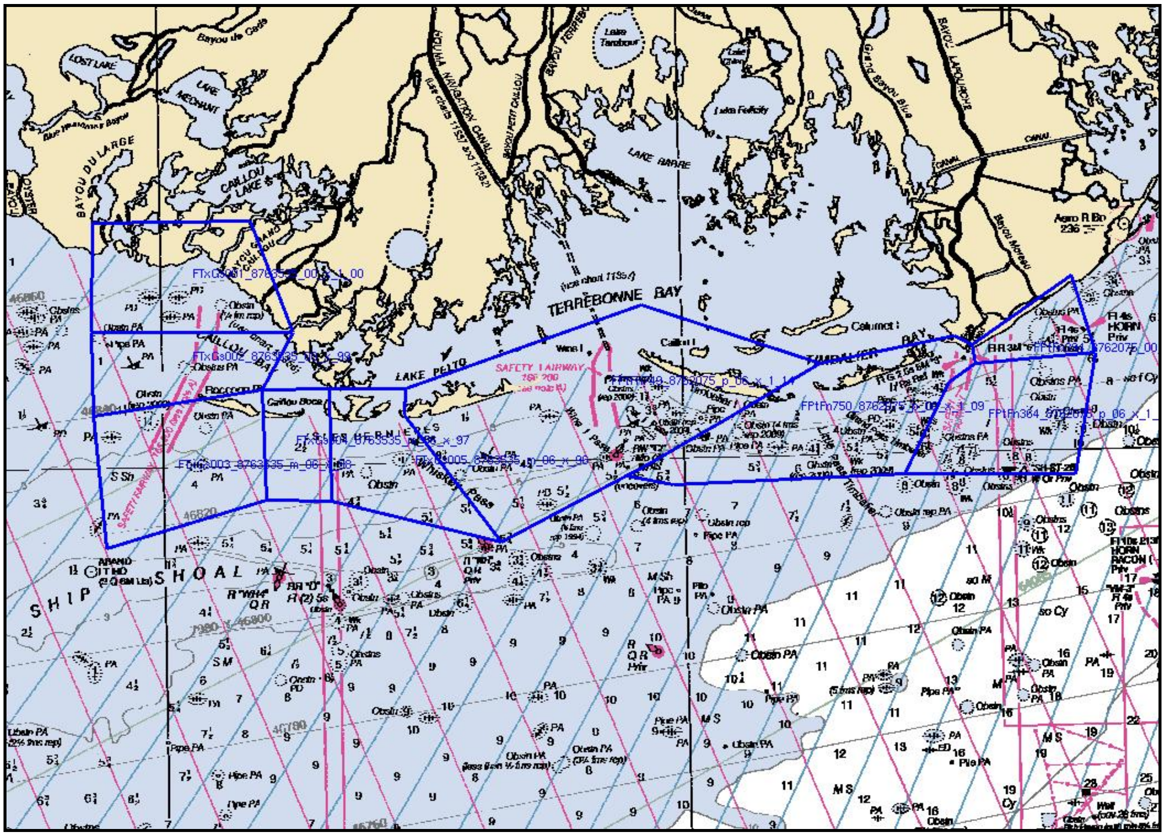

Figure C-16. SAIC Final Tide Zones for H11783, H11784, H11785

D. APPROVAL SHEET

06 November 2009

LETTER OF APPROVAL

REGISTRY NUMBERS: H11783, H11784, H11785

This report and the accompanying digital data for project OPR-K977-SA-08, Terrebonne Bay, Louisiana are respectfully submitted.

Field operations and data processing contributing to the accomplishment of surveys H11783, H11784 and H11785 were conducted under supervision of me and other SAIC lead hydrographers with frequent personal checks of progress and adequacy. This report has been closely reviewed and is considered complete and adequate as per the Statement of Work.

Reports concurrently submitted to NOAA for this project include:

Report	Submission Date
H11785 Descriptive Report 09-TR-014	06 November 2009

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Paul L. Donaldson

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Date: 2009.11.06 12:54:01 -05'00'

Paul L. Donaldson
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Science Applications International Corporation
06 November 2009