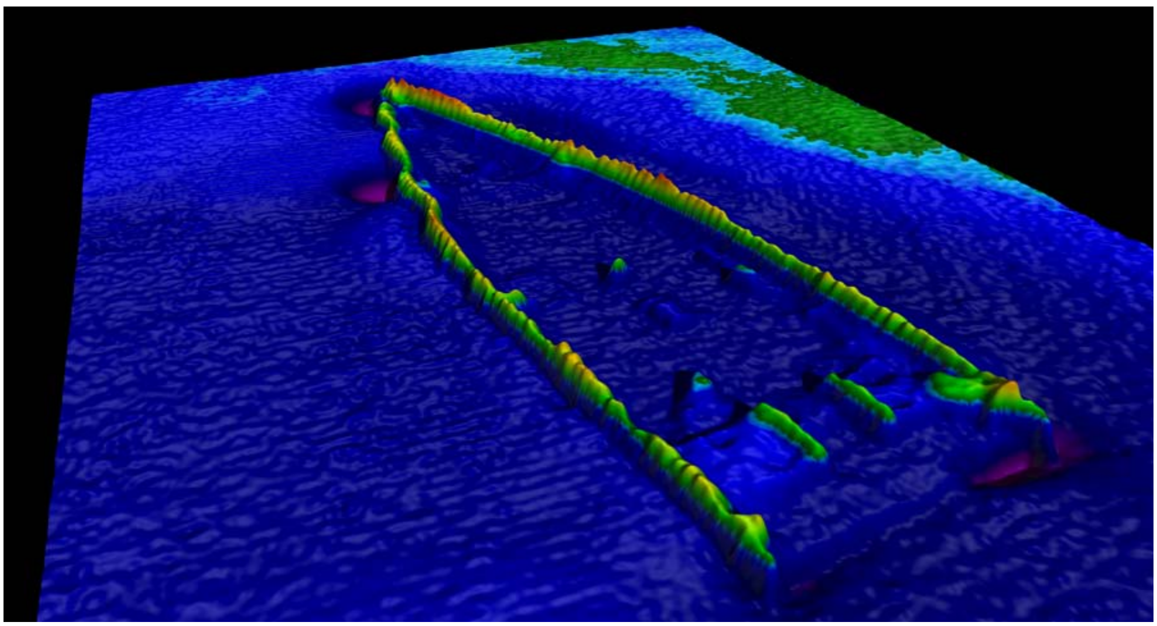
Data Acquisition and Processing Report

OPR-J364-KR-06

February 6, 2006

Mississippi- Alabama Safety Fairways



H11545	H11546
H11547	H11583
H11584	H11602
H11628	

R/V Davidson and Bella Marie

State: Alabama, Mississippi

Locality: Gulf of Mexico

Year: 2006-2007

Lead Hydrographer: Scott Cholmondeley

TERRASOND

A. EQUIPMENT

Vessels

Soundings for this survey were acquired using the Research Vessel *Davidson* and the hydrographic survey vessel *Bella Marie.*

R/V Davidson

Multibeam echosounder and side scan sonar data for surveys H11545, H11546, H11547, H11583, H11584, H11602 and H11628 was acquired using the *R/V Davidson*

The *R/V Davidson*, shown in figure 1, is a 175-foot steel hulled survey vessel with a 38-foot beam and an 18-foot draft. During the survey, the *R/V Davidson* was equipped with a Reson SeaBat 8101 multibeam echo sounder system and towed a EdgeTech 4200-FS side scan sonar towfish. The ship was powered by two GM Electromotive Diesel engines operating between 400 and 800 RPM which drove two controllable-pitch propellers. Electrical power was provided by two General Electric 450 volt AC, 250 KW generating plants powered by one Detroit Diesel. The *R/V Davidson* was outfitted with a starboard-side, pole-mounted Reson 8101 Multibeam Echo Sounder System. Detailed vessel drawings showing the location or all primary survey equipment are included in Section C. of this report.

Figure 1 – R/V Davidson underway in Galveston Channel

Equipment Overview

The equipment on the *R/V Davidson* performed well and within required specifications during the survey.

Major Operational Systems

R/V Davidson Survey Equipment

Table 1 – Table showing the major survey equipment used aboard the R/V Davidson.

Description	*Manufacturer*	*Model / Part*	*Serial Number*
Multibeam Sonar	Reson	SeaBat 8101	1301045
Sonar Processor	Reson	SeaBat 81-P	32030
Positioning System	Seatex	Seapath 200 RTK	799
Motion Sensor	Seatex	MRU-5	1410
SV Probe	Applied Microsystems	Smart Probe	4425
SV Probe	Applied Microsystems	Smart SV&P(50 dBar)	4868
Side scan Sonar	EdgeTech	4200-FS	32761
Topside Processing Unit	EdgeTech	566	32590
Acrobat Towed Vehicle	SeaScience	LTV50	0133
Differential Beacon Receiver	Seapath	MBX 3S	0218-9807-0002

Sounding Equipment

A Reson SeaBat 8101 multi-beam echo sounder (MBES) system was used during this survey.

The 8101 is a 101-beam radial-array system. It employs a 1.5 degree along-track beam angle and a 1.5 degree across-track beam angle. Bathymetric data was output via a serial connection to the collection computer. Range scales, power, gain and depth-filter limits were adjusted during data collection. Time Varied Gain (TVG) with spreading and absorption values within recommended ranges for cold salt water were used during the survey.

Nadir-beam calibration checks were conducted on a weekly basis, when practical. The calibration checks were performed by measuring the depth under the ship with a calibrated sounding lead line and comparing the value with the nadir-beam depths recorded by the MBES. All measurements were corrected to the survey vessels central reference point (CRP). The lead line used for the calibration checks was constructed from a metric fiberglass survey tape with a 36-ounce lead ball attached to the end. The ball was attached in such a way that the bottom of the ball was at the zero mark of the tape. The lead line and nadir-beam MBES values agreed consistently throughout the survey.

Total sounding error limits were determined using the following equation:

$$\pm\sqrt{[a^2 + (b*d)^2]}$$

where: **<u>for d < 100 meters</u>**

a=0.5 m
b=0.013 m
d=depth (m)

The differences between measured and observed values were within sounding error limits specified for this survey.

The <u>Descriptive Report</u> SEPARATE I: ACQUISITION AND PROCESSING LOGS contains a summary of the calibration checks performed for each survey.

Technical Specifications

Table 2 – Reson SeaBat 8101 multibeam echosounder technical specifications.

Reson SeaBat 8101	
Sonar Operating Frequency	240 kHz
Beam Width, Across Track	1.5°
Beam Width, Along Track	1.5°
Number of Beams	101
Swath Coverage	150°
Depth Resolution	1.25 cm

Range Scale	Ping Rate
3.5	40.00
5	40.00
7	40.00
10	40.00
15	40.00
20	35.63
25	28.63
30	23.92
35	20.55
40	18.01
50	14.44
75	9.65
100	7.24
125	5.80
150	4.84
175	4.15
200	3.63
250	2.90
300	2.42
350	2.08
400	1.82

Imaging Sonar Equipment

An EdgeTech 4200-FS side scan sonar system was used aboard the *R/V Davidson* in a towed configuration. The EdgeTech system included a model 4200-FS High Definition, Multi-Pulse, Dual Frequency side scan sonar towfish and Model 566 topside processing unit. The Model 4200-FS was operated at a frequency 410 kHz and had a vertical beam width of 50^{o}. The towfish contained transducers, control electronics, attitude and heading sensors.

Typical tow speeds used were between 6 and 8 knots. Surveys were conducted using the 100 meter range scale except in areas with significant thermoclines. In these areas, the 75 meter range scale was used to maintain a high level of data quality.

Technical Specifications

Table 3 – EdgeTech 4200-FS side scan sonar technical specifications.

EdgeTech 4200-FS Side Scan Sonar System	
Frequency	120 / 410 kHz dual
Modulation	Full Spectrum chirp frequency modulated pulse with amplitude and phase weighting
Operating Range (max)	120 kHz 500 meters p/side; 410 kHz 200 meters p/side
Resolution Across Track	120 kHz 8 cm, 410 kHz 2 cm
Resolution Along Track	120 kHz: 2,5m @ 200 meter range, 410 kHz: 0,5m @ 100 meters range (HDM Mode)
Horizontal Beam Width (HDM)	120 kHz – 0.64^{o}, 410 kHz – 0.3^{o}
Horizontal Beam Width (HSM)	120 kHz – 1.26^{o}, 410 kHz – 0.4^{o}
Vertical Beam Width	50^{o}
Diameter	11.4 cm
Length	125.6 cm
Tow Cable Type	Co-axial

Bella Marie

Multibeam echosounder and side scan sonar data for surveys H11545, H11546, H11547, H11583, and H115628 was acquired using the survey vessel *Bella Marie.* The *Bella Marie* surveys were conducted following the completion of operations by the *R/V Davidson* and focused on areas where earlier coverage was determined to be inadequate during processing.

The *Bella Marie,* shown underway in Figure 2, is an aluminum hulled catamaran hydrographic survey vessel 39 feet in length with a 14 foot beam and a 2.5 foot draft. During the survey it was equipped with a Reson SeaBat 8124 multibeam echo sounder system and a pole mounted EdgeTech 4200-FS side scan sonar. The *Bella Marie* was powered by two 350 H.P. Volvo D-6 diesel engines with one 13 KW Isuzu Marathon generator for electrical service. The *Belle Marie* began the survey outfitted with a pole-mounted Reson 8124 multibeam echosounder located at the bow between the two hulls with the side scan sonar attached to the center-line moon pool pole mount. The side scan and multi-beam transducers were switched on Julian Date 2007-013 and the survey was completed with the side scan on the bow pole mount and the multi-beam on the moon pool mount. Detailed vessel drawings showing the location or all primary survey equipment are included in Section C. of this report.

Figure 2 - Bella Marie underway in Dauphin Island Channel, Alabama

Equipment Overview

The equipment on the *Bella Marie* performed well and within required specifications.

Major Operational Systems

Bella Marie Survey Equipment

Table 4 - Table showing the major survey equipment used aboard the Bella Marie.

Description	*Manufacturer*	*Model / Part*	*Serial Number*
Multibeam Sonar	Reson	SeaBat 8124	23909
Sonar Processor	Reson	SeaBat 81-P	23465
Positioning System	Seatex	Seapath 200 RTK	799
Motion Sensor	Seatex	MRU-5	1410
SV Monitoring Probe	Applied Microsystems	Smart Probe	4425
SV Casting Probe	Odom	Digibar Pro 1200	98440
Side Scan Sonar	EdgeTech	4200-FS	32761
Topside Processing Unit	EdgeTech	701 DL	33911
Differential Beacon Receiver	CSI Wireless	MBX 3S	0218-9807-0002

Sounding Equipment

A Reson SeaBat 8124 MBES system was used during this survey.

The 8124 is an 80-beam radial-array system. It employs a 1.5° along-track beam angle and a 1.5° across-track beam angle. Bathymetric data was output via a serial connection to the collection computer. Range scales, power, gain and depth-filter limits were adjusted by the vessel operators during data collection. Time Varied Gain (TVG) with spreading and absorption values within recommended ranges for cold salt water were used during the survey.

Nadir-beam calibration checks were conducted on a weekly basis using standard bar check procedures, when practical. The bar check and nadir-beam MBES values consistently agreed throughout the survey.

Total sounding error limits were determined using the following equation:

$$\pm\sqrt{[a^2 + (b*d)^2]}$$

where: **for d < 100 meters**

a=0.5 m

b=0.013 m

d=depth (m)

The differences between measured and observed values were within sounding error limits specified for this survey.

The Descriptive Report SEPARATE I: ACQUISITION AND PROCESSING LOGS contains a summary of the calibration checks performed for each survey.

Technical Specifications

Table 5 – Reson SeaBat 8124 technical specifications.

Reson SeaBat 8124	
Sonar Operating Frequency	200 kHz
Beam Width, Across Track at Nadir	1.75° @center
Beam Width, Along Track	1.5°
Beam Spacing	1.5°
Number of Beams	80
Swath Coverage	120°
Depth Resolution	1.4 cm

Range Scale	Ping Rate
5	39.89
7	39.89
10	39.89
15	39.89
20	31.25
25	25.60
30	21.74
35	18.84
40	16.67
50	13.51
75	9.17
100	9.94
125	5.58
150	4.67
175	4.01
200	3.52
250	2.82
300	2.36
350	2.02
400	1.77
500	1.42
750	0.95

Sonar Equipment

An EdgeTech 4200 FS side scan sonar system was utilized aboard the *Bella Marie* in a fixed pole mount configuration.

Technical Specifications

Table 6 – EdgeTech 4200-FS side scan sonar technical specifications.

EdgeTech 4200-FS Side Scan Sonar System	
Frequency	120 / 410 kHz dual
Modulation	Full Spectrum chirp frequency modulated pulse with amplitude and phase weighting
Operating Range (max)	120 kHz 500 meters p/side; 410 kHz 200 meters p/side
Resolution Across Track	120 kHz 8 cm, 410 kHz 2 cm
Resolution Along Track	120 kHz: 2,5m @ 200 meter range, 410 kHz: 0,5m @ 100 meters range (HDM Mode)
Horizontal Beam Width (HDM)	120 kHz – 0.64^{o}, 410 kHz – 0.3^{o}
Horizontal Beam Width (HSM)	120 kHz – 1.26^{o}, 410 kHz – 0.4^{o}
Vertical Beam Width	50^{o}
Diameter	11.4 cm
Length	125.6 cm
Tow Cable Type	Co-axial

Tide Gauges

NOAA tide stations Dauphin Island, AL (873-5180) and Pascagoula, MS (874-1533) provided initial and final tide processing for this project. Verified data from the Dauphin Island and Pascagoula gauges were downloaded from the NOAA internet Hydro Hot list (http://co-ops.nos.noaa.gov/hydro.shtml).

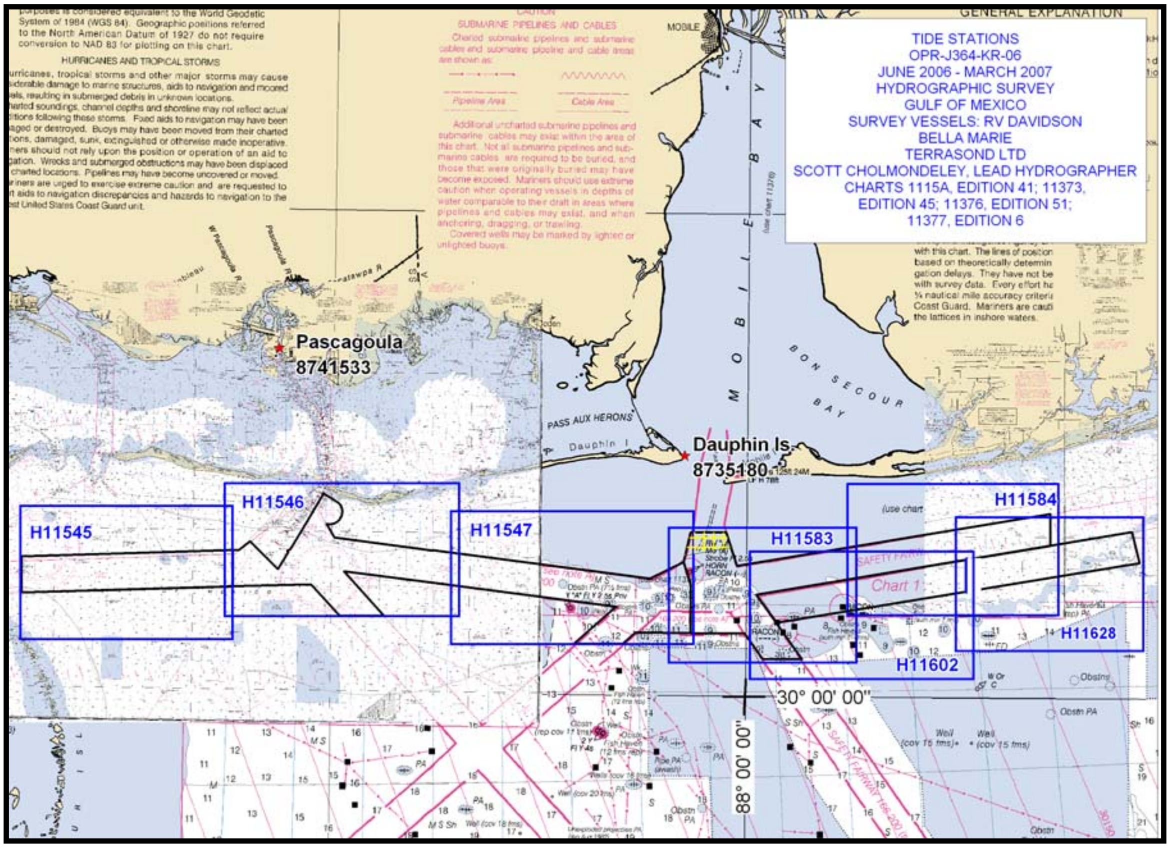


Figure 3 - Location of tide stations used in OPR-J364-KR-06.

Speed of Sound

Speed of Sound data was collected on the *R/V Davidson* using an Applied Microsystems Sound Velocity & Pressure (SV&P) Smart Sensor. The data was collected by vertical cast and by mounting the SV&P Smart Sensor on a Sea Science Acrobat towed vehicle to collect sound speed data concurrently with sounding data. During the progress of the survey, problems developed with the Acrobat towed vehicle and the collection of concurrent data suspended temporarily, restarted, and ultimately discontinued.

The *Bella* Marie collected speed of sound data using an Applied Microsystems Sound Velocity & Pressure (SV&P) Smart Sensor from JD 2006-340 through JD 2007-016. From JD 2007-017 through the end of the survey, the Bella Marie collected speed of sound data using an Odom Digibar Pro Velocimeter. All speed of sound data was collected on the *Bella* Marie by vertical cast.

The *Bella Marie* used an Applied Microsystems Sound Velocity & Pressure (SV&P) Smart Sensor mounted adjacent to the Reson SeaBat 8124 transducer to provide input to the multibeam system for use in beam forming. This sensor fed continuous speed of sound data to the SeaBat 81-P processor via a serial interface.

Sound speed profiles were taken as deep as possible and were geographically distributed within the survey area to meet the criteria specified in NOS Hydrographic Surveys Specifications and Deliverables for water depths of 30m or less. Speed profiles extended to 95% of the anticipated water depth and are representative of local and diurnal variability. No data quality issues related to speed of sound measurements were encountered during the survey.

Refer to the Descriptive Report SEPARATE II: SOUND SPEED DATA for detailed information about specific cast dates and procedures used.

The following instruments were used to collect data for sound speed profiles on the *R/V Davidson* , and *Bella Marie*.

R/V Davidson

Table 7 – Table listing the sound speed measuring equipment used during OPR-J354-KR-06.

Velocimeter (sound speed profiler)	Sound Velocity & Pressure Smart Sensor
Manufacturer	Applied Microsystems Ltd. Sydney, British Columbia, Canada
Serial number	4425
Calibrated	1/17/2007

Towed Vehicle	Acrobat Towed Vehicle/ Sled
Manufacturer	Sea Science Inc. Arlington, Massachusetts, USA
Serial number	0133

Bella Marie

Velocimeter (fixed to Reson 8124)	Sound Velocity Sensor (SV Only)
Manufacturer	Applied Microsystems Ltd. Sydney, British Columbia, Canada
Serial number	4279
Calibrated	SV only, calibration not required

Note: Probe was lost overboard on JD 2007-015 and replaced with AML SV&P Smart Sensor serial number 4425.

Velocimeter (fixed to Reson 8124)	Sound Velocity & Pressure Smart Sensor
Manufacturer	Applied Microsystems Ltd. Sydney, British Columbia, Canada
Serial number	4425
Calibrated	1/17/2007

Velocimeter (sound speed casts)	Sound Velocity & Pressure Smart Sensor
Manufacturer	Applied Microsystems Ltd. Sydney, British Columbia, Canada
Serial number	4868
Calibrated	5/2/2006

Velocimeter (sound speed casts)	Digibar Pro
Manufacturer	Odom Hydrographic Systems Inc. Baton Rouge, LA
Serial number	98014
Calibrated	2/19/2007

Sound speed processing procedures are discussed in Section C: Corrections to Echo Soundings.

Copies of the manufacturer's calibration reports are included in the Descriptive Report, Separate II: SOUND SPEED PROFILE DATA, for each survey.

Positioning Systems

The *R/V Davidson* and *Bella Marie* used Seatex Seapath 200 RTK positioning systems with differential correctors provided by a USCG MBX3 beacon receiver. Vessel position was recorded using QPS QINSy data collection software at 1Hz intervals using National Marine Electronics Association (NMEA) message $GPGGA.

Differential Global Positioning System (DGPS) confidence checks were conducted real-time with a Trimble DSM 212 GPS receiver. Positions obtained by the Seapath 200 RTK and DSM 212 receivers were simultaneously logged using QINSy and position differences were analyzed using Microsoft Excel to ensure position quality. Position inverses, when compared with the fixed baseline length between the two antennas, were well within the required 10-meter accuracy for this survey. Refer to the Descriptive Report, SEPARATE I: ACQUISITION AND PROCESSING LOGS included with each survey for a table of quality control checks to ensure positional accuracy.

Specific details addressing horizontal control activities associated with this project are discussed in the Vertical and Horizontal Control Report.

Attitude Sensors

A Seatex Seapath 200 RTK heading, attitude and positioning sensor in combination with the Seatex MRU-5 marine motion sensor was used to correct sounding data for heave, pitch and roll. Detailed descriptions of all attitude corrections are provided in Section C: Corrections to Echo Soundings.

Data Collection

Overview

The survey was conducted using shallow-water multibeam and side scan sonar techniques with the *R/V Davidson* and *Bella Marie*. No single-beam data was collected. On the *Davidson*, data was collected on a 24 hour basis using two crews with shift changes every 12 hours. The Bella Marie transited to the work area each day and collected data during a 12 hour work day.

Coverage

Full bottom side scan sonar coverage (200%) was obtained in the survey area seaward of the 4-meter curve. Survey lines were spaced 75 meters apart except where a reduction in line spacing was warranted due to the presence of thermoclines or a decrease in water depth.

Line Planning

Pre-planned processing blocks for each assigned sheet were developed prior to the survey to aid in processing organization. In general, survey lines were run the length of each sheet parallel to the shore.

Ping Rates

The NOS Hydrographic Survey Specifications and Deliverables, Section 5.2.2., requires "…that no less than 3.2 beam footprints, center-to-center, fall within 3 m, or a distance equal to 10 percent of the depth, whichever is greater, in the along track direction." To meet specifications, the survey vessels either surveyed at high speeds with a rapid ping rate (reduced range), or at lower speeds with a reduced ping rate (increased range). The disadvantage of surveying at high speeds is loss of swath width as the range scale necessary to meet the footprints/meter requirement is too small to pick up the outer beams. The disadvantage of surveying at lower speeds is reduced production. The following was the base formula for determining ping rate:

3.2 pings per 3 meters = 1.1 pings per 1 meter

1.1 * Speed over Ground (meters per second) = ping rate

Multibeam ping rate settings for each line were determined by recording the speed of the vessel prior to beginning of a line and multiplying the vessel speed by a factor of 1.1.

As a general rule, engine RPM was held constant throughout a survey line and the ping rate was selected as a function of vessel speed over the ground (SOG). During this survey, the selected ping rate met or exceeded the specifications set forth in NOS Hydrographic Survey Specifications and Deliverables, Section 5.2.2. Side scan data was acquired in High Speed Mode. Surveying at vessel speeds at or below 9.6 kts ensured a minimum of 3 pings on a 1 m target at a range of 100 m. All side scan data was collected at a frequency of 410 kHz.

Software and Hardware Summary

Multibeam and side scan data was collected on an Intel Pentium IV PC using QPS QINSy data collection software (multibeam) and Coda GeoSurvey (side scan) operating in a Microsoft Windows 2000 environment. QINSy was used to generate a real-time digital terrain model (DTM) during each survey line. The DTM was used in the field to determine whether the survey had been completed with adequate bottom coverage. The DTM was only used as a field quality assurance tool and was not used during subsequent data processing. All raw bathymetric, position and sensor data was recorded in a QINSy native .db format for follow-up processing using CARIS HIPS and SIPS. Final survey coverage determination was made following data processing with CARIS.

CARIS HIPS & SIPS hydrographic data processing software was used for multibeam and side scan post processing and quality assurance. Coda GeoSurvey was used to process the raw side scan data before it was imported into CARIS. Data post-processing procedures are described in detail in Section B. Quality Control.

The following table lists the software used on the *R/V Davidson and Bella Marie* during the survey and in the office during pre-survey planning and post-survey processing:

Vessel Software

Table 8 – Software used aboard the R/V Davidson and Bella Marie.

Program Name	Version	Date	Primary Function
Reson SeaBat	1.06-3EEB	2002	Reson SeaBat 8101 firmware (wet)
Reson SeaBat	2.04-96C1	2000	Reson SeaBat 8101 firmware (dry)
Reson SeaBat	1.01-82D9	2000	Reson SeaBat 8124 firmware (wet)
Reson SeaBat	2.05-8C94	2000	Reson SeaBat 8124 firmware (dry)
QPS QINSy	7.5	2005	Multibeam data collection software
Coda GeoSurvey	3.10.12	2006	Side scan data collection & processing software
EdgeTech Discover	5.25	2006	Side scan data collection
Seapath 200 RTK	2.01.02	2003	Seapath 200 RTK Firmware
Seapath Control Center	2.01.02	2002	PC Interface to Seatex Seapath 200
Corpscon	5.11	2001	Coordinate conversion
Nautical Software Inc. Tides and Currents for Windows	2.2	1996	Predicted Tides
TerraSond Ltd SVP processing software	1.0.0.0	2002	TerraSond Ltd proprietary software for acquiring and processing sound speed data
TerraSond Ltd GPS logging software	5.0.2195.2722	2001	TerraSond Ltd proprietary software for logging of GPS data for Quality Control

Office Software

Table 9 – Software used in the office during post processing.

CARIS HIPS & SIPS	6.0 & 6.1	2004 & 2006	Multibeam and side scan sonar data processing software
CARIS HOM	3.3	2006	Electronic chart data processing software
CARIS BASE Editor	1.0 & 2.0	2005 & 2006	Bathymetry compilation and analysis software
CARIS GIS Professional	4.4	2001	Marine GIS information management software
Autodesk MAP 3D 2006	4.0	2006	Drafting software
Coda GeoSurvey	3.11.6 & 3.11.8	2006	Side scan data processing software
Blue Marble Geographics Geographic Transformer	5.2	2006	Image georeferencing and reprojection software
MapInfo Professional	6.5 & 8.5	2001 & 2006	Desktop mapping software
Corpscon	5.11	2001	Coordinate conversion software
TerraSond Ltd Multibeam Suite	2.3.1	2004	TerraSond Ltd proprietary software for data analysis and processing.

B. QUALITY CONTROL

Overview

Every effort possible was made to ensure the traceability and integrity of the sounding data as it was moved from the collection phase through processing. Consistency in file and object naming combined with the use of standardized data processing sequences and methods formed an integral part of this process.

CARIS Hydrographic Information Processing System (HIPS) and Sonar Information Processing System (SIPS) were used for the majority of the data processing tasks on this project. HIPS and SIPS were designed to ensure that all edits and adjustments made to the raw data, and all computations performed with the data followed a specific order and were saved separately from the raw data to maintain the integrity of the original data.

Equipment Calibration

Each item of survey equipment was calibrated prior to the survey to assess the accuracy, precision, alignment, timing error, value uncertainty, and residual biases in roll, pitch, heading, and navigation. MBES equipment calibration was completed using a patch test area.

The side scan sonar suite did not require calibration beyond that provided by the manufacturer.

Periodic Confidence Checks

GPS data was collected and stored using TerraSond Ltd GPS logging software concurrently with the survey data collected using QPS QINSy. The GPS data included position information, number of satellites, maximum horizontal dilution of precision (HDOP), and DGPS verification. All data was time-referenced at 1-second intervals.

Side scan sonar confidence checks were conducted by recording a screen shot of the side scan record which included the side scan image and all operational settings. The confidence checks were performed when distinctive bottom features (e.g. trawl scars, submerged vessels, etc.) were continuously visible in the record from the maximum range of one channel to the maximum range of the other channel.

A rub test was performed daily on the port and starboard transducers during the pre-survey checks to confirm proper functioning of the equipment before placing the towfish into the water. As with the multibeam data, initial processing of side scan data was accomplished on board the vessel and instrument settings were adjusted, if necessary, between survey lines to maintain data quality.

Cross lines were run as a confidence check for the multibeam sonar. The total linear nautical miles of crosslines exceeded five percent of the linear nautical miles of main scheme lines. Initial data processing was performed on the collection vessel upon the completion of each survey line. Adjustments were then made to equipment settings based on preliminary processing and, if necessary, survey lines were rerun.

Nadir beam checks were performed on the MBES each week, weather permitting. On the *R/V Davidson* the confidence checks consisted of comparing lead line depths with depths logged by the MBES nadir beams. The *Bella Marie* used conventional bar-check procedures to verify the function of the MBES.

Data Collection

Multibeam sounding data collection was performed using QPS QINSy Multibeam data-collection software. File naming conventions were established to ensure that individual survey lines had unique names. Lines were assigned consecutive numbers with a letter designator corresponding to the sheet being surveyed. QINSy software generated database files using associated filenames, with the extension ".db," which contained survey data and equipment settings specific to each line.

Side scan sonar data was collected using CODA GeoSurvey. The same file naming convention was used for side scan and multibeam data files to maintain the relationship of concurrently collected data. All side scan file names were prefixed by an "SS_" designator for ease in identification. CODA GeoSurvey generated database files with the extension ".cod" containing survey data and equipment settings specific for each line. All raw data files were stored on the acquisition computer's hard drive.

Chronological logs containing information specific to each line were maintained as an independent reference to aid in data integration and error tracking. Multibeam logs included the line name, start and end times, ping rate, range and power settings, TVG gain, and any additional comments deemed significant by the operator. Side scan logs included the side scan line name, the corresponding multibeam line name, where applicable, line start and end times, survey vessel speed and heading, side scan sonar frequency, range settings, gain settings, and towfish altitude (height off bottom) and cable out.

Initial File Handling

Initial multibeam data processing was completed on the survey vessel. At the end of each survey line, the raw data file and converted ".xtf" file were organized by sub-locality and Julian day into a CARIS directory on the local network server. Each Julian day was divided into four sub-folders according to file type (.db, .xtf, raw and processed .cod files) CARIS HIPS and SIPS organized processed data in a separate directory on the network server based on project name, vessel name, and Julian date. All server data was backed up twice each day onto LT02 tapes. This system of data storage and frequent backups minimized the potential for data loss due to equipment malfunction or failure.

Figure 4 illustrates the major steps in the data acquisition and reduction process. The text following the diagram provides a detailed explanation of each step.

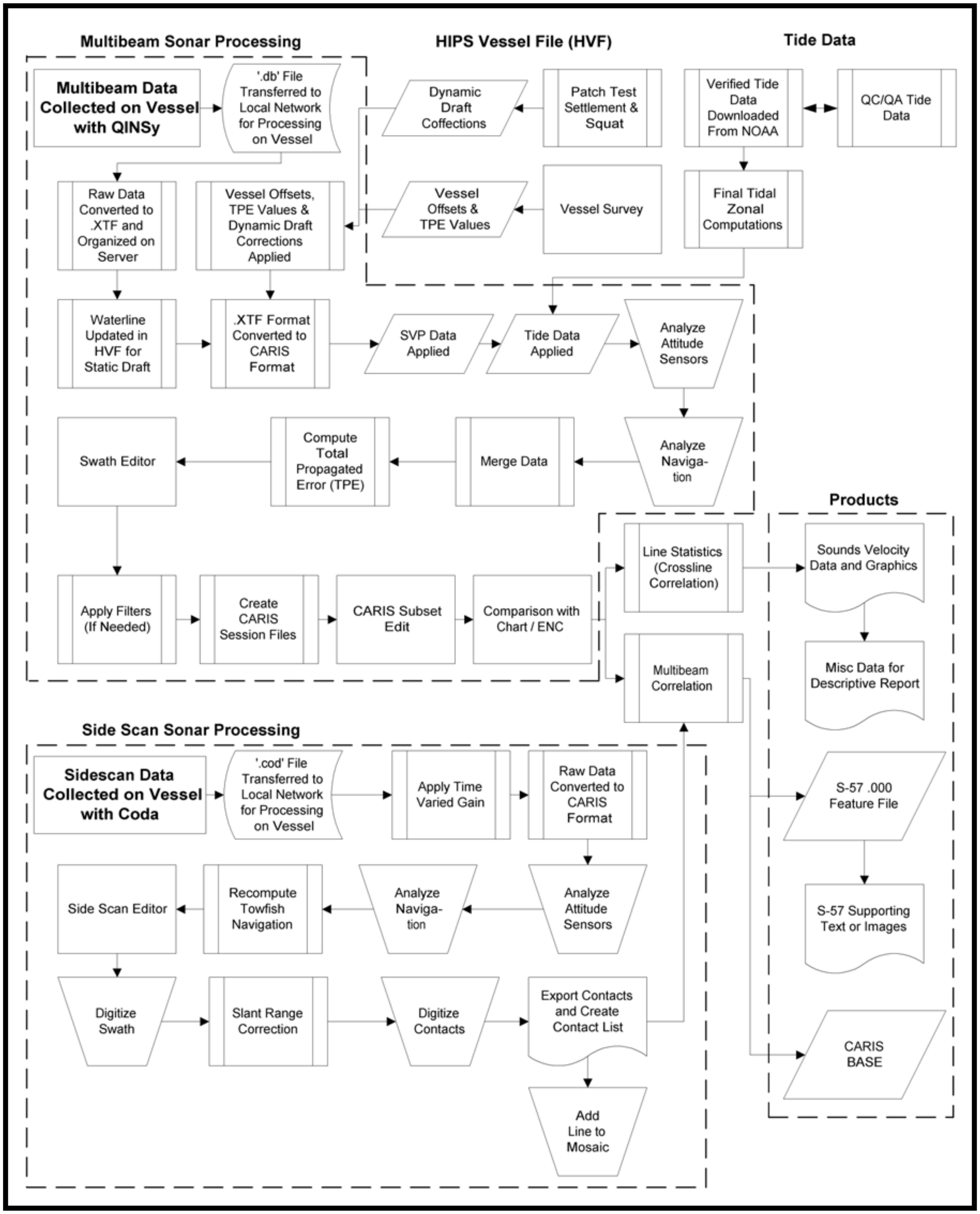


Figure 4 – Data Acquisition and Processing Flow Diagram

Initial Data Processing

Multibeam

CARIS HIPS and SIPS software was used to create a file organized by project, vessel, and Julian day to store data. Multibeam raw data (.db) files were converted to Triton Extended Format (.xtf) files using the QPS QINSy ExportXTF module. The ".xtf" files were then imported into CARIS HIPS and SIPS using the CARIS conversion wizard module. The wizard was used to create a directory for each line and separate the ".xtf" files into sub-files which contained individual sensor information. All data entries were time-referenced using the time associated with the ".xtf" file to relate the navigation, azimuth, heave, pitch, roll and slant range depths sensor files.

CARIS HIPS and SIPS were used for the majority of the processing and adjustments made during sounding reduction. CARIS HIPS and SIPS do not allow raw data manipulation during processing. All raw data is maintained in the original, unmodified, format to ensure data integrity. TerraSond Ltd. uses well defined procedures during the sounding reduction process and all actions are tracked to ensure that no steps are omitted or performed out of sequence.

Sensor data was reviewed and edited with CARIS HIPS and SIPS to remove obvious systemic errors or environmental artifacts. Survey lines were opened in HIPS' line editor mode by selecting the project, vessel, day and desired line(s). The data was then edited referenced by time rather than horizontal position.

Sound speed and tide corrections were applied during initial data processing. Delta draft was not yet available and therefore was not applied.

Preliminary soundings were tide adjusted using data from the National Water Level Observation Network (NWLON) station at Dauphin Island, AL (873-8151) and the Pascagoula NOAA Lab, MS water level station (874-1533) through March 26, 2007. Refer to Section C. Corrections to Echo Soundings, of this report, for detailed information concerning final sounding reduction and the Horizontal and Vertical Control Report (HVCR) for tidal zoning methods and operations.

Sound speed data was acquired using a combination of vertical casts and, on the *R/V Davidson*, a Moving Vessel Profiler (MVP). The MVP data was collected real-time using an Applied Microsystems (AML) Sound Velocity & Pressure (SV&P) Smart Sensor mounted on a Sea Sciences Acrobat towed vehicle. The Acrobat undulated up and down in the water column as it was towed behind the *R/V Davidson*. Communication with the Acrobat was through a laptop computer set up in the acquisition lab using Sea Sciences, Inc. proprietary software LTV4.

The Acrobat was configured to continuously undulate through the water column with a vertical velocity of approximately one meter per second. Minimum and maximum depth limits were set as specified in NOAA Hydrographic Surveys Specifications and Deliverables, Section 5.4.3.

The Acrobat vehicle was inoperative on multiple occasions during the survey due to hardware failure. Sound speed was measured during these periods using the AML SV&P Smart Sensor and conventional vertical casting procedures. Sound speed cast locations were selected to ensure spatial variety and casts were made more frequently in areas of frequently changing sound velocity. In an effort to minimize the impact of the Acrobat hardware problems, the automatic undulation feature was eventually discontinued and the Acrobat was towed behind the *R/V Davidson* at a constant depth equal to the multibeam echosounder. Vertical sound speed casts were then taken by manually lowering and raising the sled using a control box installed in the acquisition lab.

All sound speed casts made by the *Bella Marie* were performed using an AML SV&P Smart Sensor or Odom Digibar Pro following standard vertical cast procedures.

Sound speed raw data was converted to a CARIS compatible format using TerraSond's proprietary SVP software. All profiles were combined into a file for each line using data headers to indicate the time of each cast. The sound speed adjustment in CARIS HIPS and SIPS uses slant range data, applies motion correctors to determine launch angles, and adjusts for range and ray-bending resulting in an sound speed-corrected observed-depths file. During initial processing this data was not yet available and a predicted sound speed file was applied to the raw data. Field collected sound speed data and delta draft were applied during final processing.

Navigation data was reviewed using the CARIS Navigation Editor. The review consisted of a visual inspection of plotted fixes noting any gaps in the data or unusual jumps in vessel position. Discrepancies were rare and were handled on a case-by-case basis. Unusable data was rejected with interpolation using a loose Bezier curve. Data was queried for time, position, delta time, speed, and status and, if necessary, the status of the data was changed from accepted to rejected. Azimuth, heave, pitch, roll data was viewed in the CARIS Attitude Editor which displayed simultaneous graphical representation of all attitude data using a common x-axis scaled by time. The Attitude Editor, like the Navigation Editor, was used to query the data and reject erroneous values. After inspecting the navigation and attitude data the tide and sound speed corrected data were merged with the navigation and attitude data. The merging process converted time-domain depths into spatial-domain, geographically referenced, sounding data.

CARIS Swath Editor was used to review the merged sounding data graphically. The swath editor facilitated viewing of sounding data from different perspectives including plan view, side view, rear view, and single-profile view. This simplified the task of differentiating between real data and data generated by environmental conditions or system artifacts. Filters were applied to each line to exclude clearly erroneous data and simplify the cleaning process. The primary filters were: a minimum depth of one meter from the sonar head; quality flags zero and one; and port and starboard, forward and aft, any 2 of 4 missing neighbors.

Side Scan

Time Varied Gain (TVG) was applied to the .cod files using Coda GeoSurvey. While CODA GeoSurvey initially applied a basic TVG setting to the side scan record, fine tuning of this setting was required during post processing to produce a high quality record over different range scales and bottom types. This resulted in a mosaic that displayed high and low backscatter values in a uniform manner. Following the application of TVG, the suffix "_p" was added to the file name and the processed data was filed in a Cod-processed folder.

Processed side scan data was imported into CARIS HIPS and SIPS using the Conversion Wizard and filed by vessel name and Julian date. After conversion, the side scan data was opened using CARIS HIPS and SIPS Navigation Editor and Attitude Editor. Vessel attitude, gyro and towfish height were examined for consistency. Vessel navigation data was visually scanned for speed, course made good and speed jumps. Erroneous attitude data and navigation data with speed jumps greater than 2 kts were rejected with interpolation.

Following the attitude and navigation check, the side scan lines were opened in CARIS HIPS and SIPS Side Scan Editor. Altitude tracking was examined and manually corrected if necessary. The data was then slant range corrected.

Using slant range corrected data, the side scan record was then carefully examined for significant contacts. Significant contacts included, but were not limited to, contacts with a shadow indicating a contact height of 1m or greater in water depths of 20m or less or contacts with heights measuring 10% of the water depth in water deeper than 20m.

Contacts were digitized using the point contact tool in the CARIS Side Scan Editor. Each contact was automatically assigned a unique identifier based on the line name and the sequence in which a contact was identified in the line.

Contact length and width were measured with the Measure Distance tool. Contact shadow length was measured using the Measure Shadow tool. These measurements were then combined to determine the contact height which was displayed in the Side Scan Editor Control Window, Contact Details tab. All contacts were described in detail in the Remarks field of the Control Window.

Following the contact identification procedure, all contacts selected for a given line were exported to a CARIS contact file using the CARIS HIPS and SIPS Export Wizard. The contact file was organized by vessel name, Julian date, and side scan line number. The Export Wizard created a geo-referenced TIFF image for use in creating a mosaic as well as a text file containing all recorded information specific to the contact.

Contact information was imported from the text file into a Microsoft Excel database where contacts were then sorted and analyzed.

HIPS Final Processing

TerraSond, Ltd. incorporates a systematic, rigorous approach to the editing and development of survey data received from the field. Prior to the following area- and uncertainty-based editing processes, a verified tide and zoning scheme was tested and applied to the entire survey area. Daily static draft observations as well as dynamic draft values were entered in the HIPS vessel file. A special examination of vessel speed using Navigation Editor was conducted to ensure accuracy as HIPS interpolates draft values to depth positions during the merge process. The number and time of sound velocity profiles per survey day were tracked graphically to ensure that time-appropriate profiles were applied to the entire survey

Area Editing

Following the individual line (swath) editing conducted in the field and quality assurance of draft and tide applications, several area-based editing processes in CARIS HIPS and SIPS Subset Editor were performed during the office review of survey soundings. During subset editing, the operator was presented with two and three-dimensional views of the soundings and a moveable bounding box to restrict the number of soundings being reviewed. Soundings were viewed from the south (looking north), from the west (looking east) and in plan view (looking down). These perspectives, as well as controlling the size and position of the bounding box, allowed the operator to compare lines, view features from different angles, measure features, query soundings and change sounding status flags. Soundings were also examined in the three-dimensional window as points, wireframe or a surface which could be rotated on any plane. Vertical exaggeration was increased as required to amplify trends or features. Soundings were be flagged as accepted, rejected, designated, outstanding or examined.

In the first phase of area editing, processors examined the entire survey area in CARIS HIPS and SIPS Subset Editor and rejected outlying soundings unsupported by data from adjacent survey lines. Simultaneously, the data were scrutinized for any potential verified tide and sound velocity issues that would require further investigation.

TPE

Subsequent area-based editing incorporated uncertainty values derived from Total Propagated Error (TPE). Caris HIPS and SIPS TPE calculation assigned a horizontal and depth error estimate to each sounding. TPE values represent, at a 95% confidence level, the difference between computed horizontal and vertical sounding positions and their true position values. CARIS HIPS and SIPS computed TPE error values by aggregating individual error sources such as navigation, gyro(heading), heave, pitch, roll, tide, latency, sensor offsets and individual sonar model characteristics. Stored in the HIPS Vessel File, these error sources were obtained from manufacturers during the instrument calibration process, determined during the vessel survey (sensor offsets) or while running operational tests (patch test, settlement & squat). The error budget for the *R/V Davidson* and *Bella Marie* are found in Tables 1 and 2 on the following pages.

Table 10 – R/V Davidson error values used in computing Total Propagated Error (TPE).

Error Source	**Method**	**Error Value**
Motion Gyro	Published by Manufacturer	0.050 (deg)
Heave	Published by Manufacturer	0.050 (m)
Roll	Published by Manufacturer	0.020 (deg)
Pitch	Published by Manufacturer	0.020 (deg)
Position Navigation	Published by Manufacturer	0.700 (m)
Transducer Timing	Estimated	0.001 (sec)
Navigation Timing	Estimated	0.050 (sec)
Gyro Timing	Estimated	0.005 (sec)
Heave Timing	Estimated	0.005 (sec)
Pitch Timing	Estimated	0.005 (sec)
Roll Timing	Estimated	0.005 (sec)
Offset X	Direct Measurement	0.020 (m)
Offset Y	Direct Measurement	0.020 (m)
Offset Z	Direct Measurement	0.020 (m)
Vessel Speed	Published by Manufacturer	0.200 (m/sec)
Loading	Published by Manufacturer	0.050 (m)
Draft	Published by Manufacturer	0.050 (m)
Delta Draft	Direct Measurement	0.010 (m)
MRU Alignment Gyro	Direct Measurement	0.500 (m)
MRU Alignment Roll/Pitch	Direct Measurement	0.500 (m)
Sound Velocity	Published by Manufacturer	0.05 (m/sec)
Tide Gauge	Published by Manufacturer	0.02 (m)

Table 11 – Bella Marie error values used in computing Total Propagated Error (TPE).

Error Source	**Method**	**Error Value**
Motion Gyro	Published by Manufacturer	0.050 (deg)
Heave	Published by Manufacturer	0.050 (m)
Roll	Published by Manufacturer	0.020 (deg)
Pitch	Published by Manufacturer	0.020 (deg)
Position Navigation	Published by Manufacturer	0.700 (m)
Transducer Timing	Estimated	0.001 (sec)
Navigation Timing	Estimated	0.050 (sec)
Gyro Timing	Estimated	0.005 (sec)
Heave Timing	Estimated	0.005 (sec)
Pitch Timing	Estimated	0.005 (sec)
Roll Timing	Estimated	0.005 (sec)
Offset X	Direct Measurement	0.020 (m)
Offset Y	Direct Measurement	0.020 (m)
Offset Z	Direct Measurement	0.020 (m)
Vessel Speed	Published by Manufacturer	0.200 (m/sec)
Loading	Published by Manufacturer	0.050 (m)
Draft	Published by Manufacturer	0.050 (m)
Delta Draft	Direct Measurement	0.010 (m)
MRU Alignment Gyro	Direct Measurement	0.500 (m)
MRU Alignment Roll/Pitch	Direct Measurement	0.500 (m)
Sound Velocity	Published by Manufacturer	0.05 (m/sec)
Tide Gauge	Published by Manufacturer	0.02 (m)

Uncertainty values derived from CARIS HIPS and SIPS TPE computation were used to create International Hydrographic Organization (IHO) S-44 compliant datasets as well as calculate depth surfaces weighted by uncertainty. Following the TPE computation, all survey lines were filtered to reject soundings with uncertainty values that did not meet

IHO Order 2 survey standards. IHO Order 2 uncertainty thresholds were determined using the following equation:

$$\pm\sqrt{[a^2 + (b*d)^2]}$$

where: **<u>for d < 100 meters</u>**
a=0.5 m
b=0.013 m
d=depth (m)

CUBE

A Combined Uncertainty and Bathymetry Estimator (CUBE) surface was created next, using CARIS HIPS and SIPS BASE surface wizard, to locate areas requiring further investigation and, potentially, further cleaning. A CUBE surface is a grid of nodes to which sounding values are propagated based on their uncertainty values. On a CUBE surface, soundings with lower uncertainty are given more influence than those with higher uncertainty. The CUBE algorithm created hypotheses representing the potential variations in sounding depth values at each node. CUBE used a process of disambiguation to select the hypothesis which best represented the depth at a given node. The number of hypotheses per node, the hypothesis strength (confidence), and the nodal uncertainty values were then displayed as individual attribute layers to the surface.

The CUBE algorithm provided tools which allowed the operator to nominate the most appropriate hypothesis for a given node, regenerate the surface to incorporate nominations and subsequently filter survey data with the CUBE surface

The CUBE Hypothesis Count Child Attribute layer was an effective tool for locating areas of high uncertainty. High hypothesis counts did not necessarily indicate erroneous soundings as slopes, rocks, cultural items and other features not representative of the prevailing sea bottom could be assigned multiple hypotheses. Correlating features resolved in side scan sonar data with the multibeam data aided in the identification of areas requiring detailed cleaning. This was performed by examining areas in which CUBE surface nodes were assigned multiple hypotheses. These areas were carefully examined using CARIS HIPS and SIPS Subset Editor and all spurious soundings were rejected. A 20 meter resolution BASE surface was the created as an additional check and a shoal-biased child layer was displayed to identify additional areas requiring further investigation and potential editing. Data anomalies were readily detected when coarse resolution grid nodes were populated with the shoalest sounding values.

Multibeam Correlation / S-57

Multibeam data were then thoroughly cleaned and processed with verified tides and sound velocity values. The next processing task involved correlating side scan sonar contacts with multibeam data for the development of S-57 feature objects. This was accomplished by exporting all side scan contact attributes from CARIS HIPS and SIPS to a Microsoft Excel spreadsheet. The spreadsheet was used as a master record for all contacts identified in the field and during office processing. The spreadsheet eventually became the data source from which the S-57 attributed features were created using

CARIS HOM. Care was taken to ensure that no contacts were ever deleted from the spreadsheet. CARIS HIPS and SIPS Subset Editor was then used to thoroughly examine multibeam data in locations corresponding to each side scan sonar contact. The side scan sonar contacts were either disproved (if sufficient multibeam data did not reveal a feature) or verified. Side scan contacts with insufficient multibeam data were re-surveyed in accordance with Task Order T0001.

Verified contacts were determined to be significant or not significant. Significant contacts were those with least depths rising 1 meter above the sea floor in water depths of 20 meters or less, or 10% of the overall depth in water depths greater than 20 meters. All significant contacts were assigned attributes and included in the S-57 data set. Significant contact heights were measured by assigning the CARIS HIPS and SIPS designated sounding flag to the shoalest sounding of each contact and measuring its distance from the sea floor.

The Caris HIPS and SIPS designated sounding status flag was used to locate and preserve the least depth of a feature and was an important component of the multibeam / side scan contact correlation process. The attribute of designated soundings which represented the least depth of significant contacts was queried in CARIS HIPS and SIPS. The query results were then merged with the corresponding records in the Excel contact spreadsheet. Contacts from multiple survey lines often identified the same feature. This resulted in a field being added to the spreadsheet to cross reference contacts which appeared on multiple lines. A description of each feature (wreck, obstruction etc.) was included in the spreadsheet based on the best information available.

It is important to note that depths of structures rising to the ocean surface such as buoy anchors and oil rigs were not accurately represented in multibeam data due to beam pattern and orientation. Soundings associated with these features were rejected to avoid their inclusion in the final depth grid, however, soundings on the sea floor best representing the horizontal position of uncovered structures, such as the center of an oil rig base, were designated and added to the contact spreadsheet.

After significant contact heights, least depths, positions and feature types were verified, the contact spreadsheet was converted to an attributed ESRI point shapefile. The shapefile was then imported into CARIS HOM and formatted to S-57 specifications. The contact spreadsheet and the geographically referenced images of all sidescan contacts are included in each Descriptive Report, SEPARATE V: SIDE SCAN CONTACT LISTING AND IMAGES OF SIGNIFICANT CONTACTS.

Sounding Reduction / Final QC

Since final, processed multibeam depths are no longer delivered as a fixed-scale smooth sheet of selected, shoal-biased soundings, it was not necessary to decimate multibeam data to this extent. However, a sounding selection process was performed as a final quality control check and to provide a means of effectively comparing processed survey depths to those appearing on the current editions of the printed charts and Electronic Navigation Charts (ENC) of the area. CARIS HIPS and SIPS Field Sheet Editor was used to bin survey data to a 10 meter grid from which shoal-biased soundings were extracted on a 60 meter radius. The binned surface and soundings were then assigned depth dependent color attributes to visually emphasize soundings and/or bins with unique depths. A final inspection of the survey data was then made by investigating areas where soundings and/or bins disagreed with neighboring values. Areas involving a charting recommendation, such as the addition of a new feature or shoaling area were thoroughly examined. Although depth contouring, a component of the fixed-scale smooth sheet, is no longer required, contours were created using final processed data for use when comparing the survey to currently charted contours and for future charting recommendations in each Descriptive Report Section D.2 Additional Results.

Gridded Surfaces

The final depth information for this survey is submitted as a Caris BASE surface which best represents the seafloor at the time of survey. All steps have been taken to ensure the data have been correctly processed and appropriate designated soundings, representing the least depth of significant contacts, have been selected and retained in the finalized surface.

The submittal of several grids of varying resolution was unnecessary due to the shallow depths and relatively flat bottom throughout the survey area. A grid spacing of 2 meters was used for all BASE surfaces and Digital Terrain Models (DTM).

In accordance with the statement of work, line spacing was set to achieve the desired side scan sonar coverage. This was not optimal for shallow water multibeam (SWMB) coverage and resulted in SWMB coverage gaps as the outer beams of adjacent lines did not meet and the use of a grid resolution smaller than two meters resulted in data holidays which could preclude features from inclusion on the surface.

2006 survey depths were submitted as a Caris BASE Uncertainty surface which was weighted by the greater of either the standard deviation of sounding values, or *a priori* uncertainty values derived from HIPS TPE calculation. Additionally, one sun-illuminated, geographically referenced Digital Terrain Model image depicting the coverage of the survey area is submitted. All grids are projected to UTM Zone 16 North, NAD 1983. Naming conventions for each grid are as follows:

Caris BASE Uncertainty Surface: H11545_1_OF_1.hns
Sun-Illuminated Elevation DTM: H11545 _1_OF_1.tif

A data set containing a single S-57 (.000) base cell file and supporting files was submitted in conjunction with the other 2006 survey deliverables. The base cell contains information on objects not represented in the depth grid, including, but not limited to, the nature of the seabed (bottom samples). Each feature object includes the mandatory S-57 attributes, contract specific attributes, and any additional attributes assigned. Side scan contact image (.tif) geographically referenced files are included in the data set, referenced as PICREP (Pictorial Representation attributes).

SIPS Final Processing

Two mosaics were created in Caris HIPS and SIPS using a 1m grid size for each multiple of 100% coverage specified in Task Order T0001. For each of these mosaics, one was created with range filters applied and the second mosaic was created without applying range filters. When range filters were applied, lines run with the same range scales were added together as the changing range scale necessitated the use of a different filter.

Outside Edge mosaic filter settings were applied to the following ranges:

Range Scale	Max across track / altitude ratio	Max altitude limit for ratio	Max across track distance
100 m	12.50	8.0 m	100.0 m
75 m	12.50	6.0 m	75.0 m
50 m	12.50	4.0 m	50.0 m

The mosaics were used to verify side scan sonar coverage for each multiple of 100%. A Microsoft Excel spreadsheet was used to ensure that lines were neither duplicated nor omitted from the mosaics. All mosaics were named using the following convention:

Filters applied: Sheet_Layer_Resolution (m)
Example: C_200_1_0; Represents Sheet C, with filters and a 1.0 m resolution

No Filters applied: Sheet_Layer_nosettings_Resolution(m)
Example: C_200_nosettings_1_0; Sheet C, no filters and a 1.0 m resolution

Crossline Analysis

Crossline analysis was performed using CARIS HIPS and SIPS, in conjunction with Microsoft Excel. A BASE (Bathymetry Associated with Statistical Error) surface encompassing an area defined by the beam width of the swath over the full length of the survey line was created for each crossline using CARIS HIPS. The disambiguation method selected for creating the base surface was density and locale.

CARIS QC Report was used for preliminary analysis of each crossing. Individual mainscheme lines were selected and compared in QC Report to the depth attribute of the BASE surface created for each crossline. QC Report then generated a table of statistics, grouped by beam number, based on the requirements of the S-44 IHO standards at both the Special Order and Order 1 levels.

The QC Report table was imported into Microsoft Excel and compared with a table of survey sounding properties from the crossline. These properties included entries for each profile and beam with associated depth information. The output of the crossline analysis was a report containing three graphs which were used to assess the quality of each intersection. A description of these graphs is given below:

Depth Plot – Depth vs. Beam Number. The depth is the average depth of the crossline at each beam. The purpose of this graph is to show any steep slopes or erratic seabed features that may deteriorate the quality of the comparison.

Percent Passing and Sounding Count – Number of Soundings vs. Beam Number. The sounding count is a bar scale showing the number of comparisons for each beam. An insufficient number of comparisons may result in poor statistics. Percent Passing is the percentage of comparisons by beam with residuals less than the allowable sounding error. Percent Passing values less than 95% resulted precipitated in a closer inspection of the intersection in the Residual Scatter plot.

Residual Scatter Plot – The residuals are computed by subtracting the depth of each sounding from the mean depth of all soundings from a given beam number. This plot is helpful in diagnosing error sources in the crossline. Any errors caused by the use of incorrect tide or sound velocity data, roll bias and or sounder noise were clearly visible in this plot.

The individual intersection reports and the sheet-wide summary report are in each Descriptive Report SEPARATE V: CROSSLINE REPORTS.

C. CORRECTIONS TO ECHO SOUNDINGS

The following methods were used to determine, evaluate and apply corrections to instruments and soundings:

Vessel Offsets

All sensor locations were established by a precise, conventional survey of each vessel using a level and metric tape. Sensors for all vessels were referenced to previously established control points. Sensor offsets, stationing and elevations were determined and applied during the appropriate sensor or data processing stage. Separation distances between the two Seapath GPS antennas were resolved during the Seapath calibrations. The azimuth offset between the antenna baseline and the sensor head was resolved during a patch test, and applied in the "yaw bias" in the CARIS HIPS Vessel File (HVF). Detailed vessel drawings and offset descriptions are provided at the end of this section.

Heave, Roll and Pitch

Heave, roll and pitch data for all vessels were measured by a Seatex MRU-5 Marine Motion Sensor and output as a binary data string via RS-232 serial line to QPS QINSy acquisition software at 10Hz. Heave, roll and pitch corrections were applied during the sound velocity correction process in CARIS HIPS.

Patch Test Data

Patch tests was performed on *R/V Davidson* and the *Bella Marie* to determine the composite offset angles (roll, pitch and azimuth) for the transducer and motion sensor and the latency (time delay) from the positioning system.

Patch test lines were run as described to determine the following offsets:

Navigation/Latency

One survey line was run twice, in the same direction, at different speeds over a distinct up or down slope.

Pitch

After determining and entering the corrector values for time delay, Pitch offset ($\delta\theta_p$) was determined by running two pairs of reciprocal survey lines at the same speed over a distinct up or down slope and comparing profiles.

Azimuth

After compensating for time delay and pitch offset, the azimuth offset was calculated by running two adjacent pairs of reciprocal lines at the same speed alongside a distinct object on the sea bed. Each line was run on a different side of the object and the longitudinal displacement of the bathymetric feature between the lines was measured.

Roll

The roll offset was determined after the time delay, pitch and azimuthal offsets had been calculated and compensated for by running a pair of reciprocal survey lines at the same speed over a regular and flat sea floor.

The offset values for pitch, azimuth and roll and navigation latency from the positioning system were resolved using the calibration editor in CARIS Subset Editor. The time-referenced values were then stored in the appropriate HVF file. Offset and latency corrections were applied to the raw sounding data during the merge process in CARIS.

Patch tests were conducted prior to the beginning of the 2006 survey and whenever there was a configuration change involving the position of the multibeam transducer. A listing of the patch tests performed for the 2006 survey is provided in Table 3.

Table 12 – Patch tests performed for instrument calibration during OPR-J364-KR-06.

Vessel	**Julian Date**	**Longitude (DMS)**	**Latitude (DMS)**	**Reason**
R/V Davidson	2006-166	088° 06’ 12.171” W	30° 05’ 45.538” N	Initial calibration
R/V Davidson	2006-142	094° 45’ 08.789” W	29° 20’ 20.039” N	Port call
R/V Davidson	2006-185	087° 52’ 32.881” W	30° 09’ 06.657” N	Port call
R/V Davidson	2006-210	087° 43’ 02.555” W	30° 06’ 42.389” N	Port call
Bella Marie	2006-314	088° 37’ 59.156” W	30° 07’ 35.861” N	Initial calibration
Bella Marie	2007-013	087° 33’ 51.731” W	30° 15’ 13.218” N	MBES / Side scan sensor switch

Speed of Sound through Water

Two Applied Microsystems Ltd. Sound Velocity & Pressure (SV&P) Smart Sensors and two Odom Digibar Pro velocimeters were used to collect sound speed data for OPR-J364-KR-06. The sensors were set to record one sample per second during casts and were lowered through the water column at approximately one meter per second. The TerraSond Ltd. SVP program was used to download SV&P sensor data and provide graphs and statistics for each cast. The SV&P sensors recorded time, temperature, pressure, speed of sound, and voltage. The raw pressure data was converted from dBars to depth in meters using a conversion equation provided by Applied Microsystems Ltd (Saunders and Fofonoff (1976)):

The raw sound speed data was reduced to one measurement per meter of depth and converted to CARIS format. Sound speed corrections were then applied to the raw sounding data. The most recent sound speed data was applied to the soundings, except where it was deemed more appropriate to apply the data from a cast that was geographically closer to the sounding location.

The Descriptive Report SEPARATE II: SOUND SPEED DATA contains a detailed listing of the sound speed profiles and applicable cast dates used during the 2006 survey.

Static Draft

Static draft was determined by measuring from a control point on the hull of each survey vessel to the waterline. The draft was recorded twice daily in the vessel survey log except when sea state or vessel operations precluded measurement. The static draft readings were recorded in the vessel CARIS HVF and used in conjunction with settlement and squat data to create a dynamic draft which was applied to sounding data during processing.

Settlement and Squat

R/V Davidson

Settlement and squat measurements for *R/V Davidson* were conducted using On The Fly Real Time Kinematic (OTF-RTK) GPS Survey Procedures in Galveston, Texas on May 21, 2006 prior to transiting to the survey area. Measurements were made using a Trimble 4000 SSE GPS receiver, Pacific Crest radio modems, Seatex Seapath 200 RTK heading, attitude and positioning sensor with a Seatex MRU-5 attitude sensor and were recorded in 1 knot increments for vessel speeds from 2 – 7 knots. These speeds were selected as representative of the practical operational limits of possible vessel survey speeds.

A Kinematic base station (Trimble 4000 SSE), was set up on beach 1km from the survey vessel. The base station used telemetry (Pacific Crest radios) to transmit Real Time Carrier Phase corrections to the Seapath 200 RTK installed on *R/V Davidson*. The Seapath used the carrier phase corrections to determine the position of the navigation antenna on the *Davidson* relative to the base station with a vertical accuracy under 2 cm. The position of the antenna was reduced to the vessel's reference point (RP) using attitude data from the Seapath 200 and offset measurements made for each piece of equipment during a vessel survey. The measurements were made in real-time using QINSy data collection software. An output file was created from the beginning of the first drift to the end of the second drift that contained Time, Easting, Northing and Height.

Measurements were logged for several minutes with no way on; the engine RPM / propeller pitch was then increased to achieve the desired vessel speed. Once the vessel was at the desired speed, measurements were logged for several more minutes. Power was then removed and the vessel was brought to a drift. Several more minutes of data was logged. This procedure was repeated throughout the RPM / propeller pitch range used when surveying.

Settlement was calculated by averaging the static measurements at the beginning and end of lines and comparing this average with the average measurements while the vessel was under way throughout the speed range. A graph was then constructed to illustrate settlement changes as a function of vessel speed.

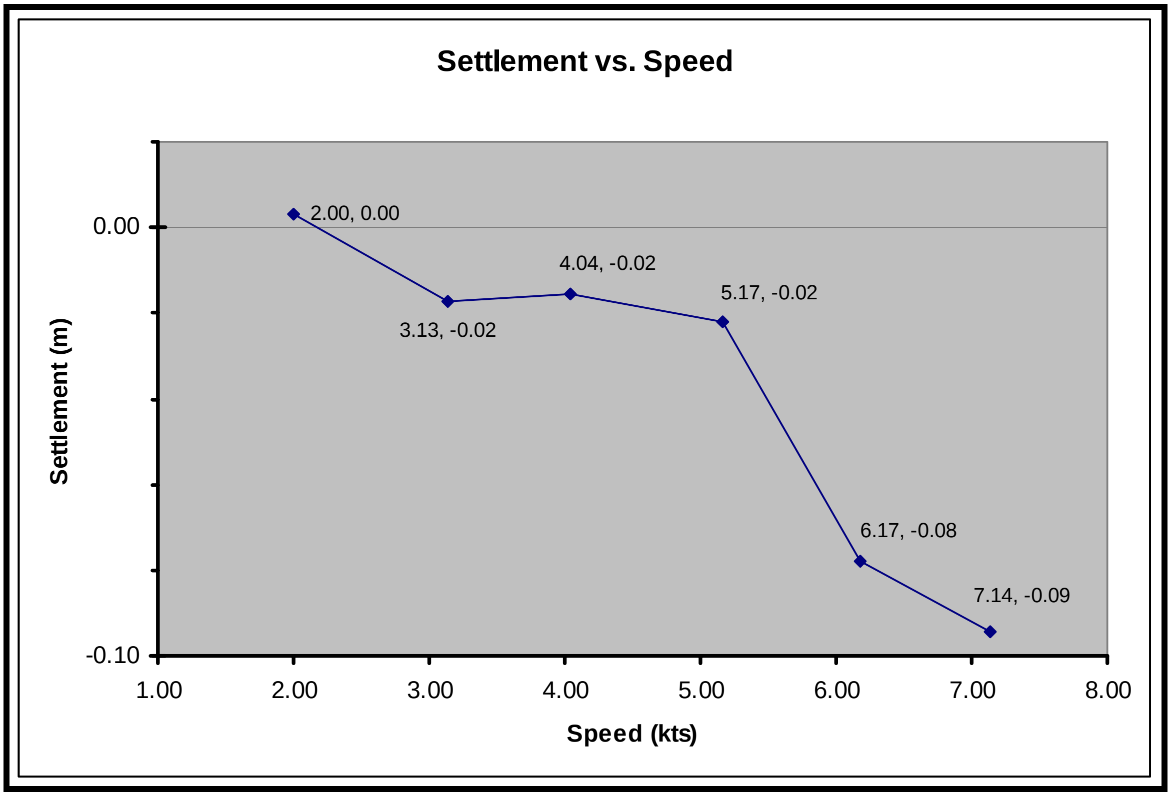


Figure 5 - R/V Davidson Settlement & Squat Measurements.

Table 13 – R/V Davidson average speed vs. settlement measured during Settlement & Squat survey on JD 2006-141.

Average Speed (Kts)	Settlement (m)
2.00	0.00
3.13	-0.02
4.04	-0.02
5.17	-0.02
6.17	-0.08
7.14	-0.09

Bella Marie

Settlement and squat measurements for *Bella Marie* were conducted on December 16, 2006 and again on January 19, 2007 using On The Fly Real Time Kinematic (OTF-RTK) GPS Survey Procedures in the Gulf of Mexico approximately one mile south of Perdido Key, FL. The second measurement was performed after exchanging the installations of the side scan sonar and multibeam transducers and modifying the underwater hull in the vicinity of the moon pool. All measurements were made with the side scan and multibeam transducers deployed in their survey configuration.

Measurements were made using a Trimble 4000 SSE GPS receiver, Pacific Crest radio modems, Seatex Seapath 200 RTK heading, attitude and positioning sensor with a Seatex MRU-5 attitude sensor and were recorded in 200 RPM increments from 600 RPM to 2200 RPM. The RPM range was selected as representative of practical operational limits producing vessel speeds between 2 and 10 kts.

A Kinematic base station (Trimble 4000 SSE), was set up on beach 1km from the survey vessel. The base station used telemetry (Pacific Crest radios) to transmit Real Time Carrier Phase corrections to the Seapath 200 RTK installed on *Bella Marie*. The Seapath used the carrier phase corrections to determine the position of the navigation antenna on the *Bella Marie* relative to the base station with a vertical accuracy under 2 cm. The position of the antenna was reduced to the vessel's reference point (RP) using attitude data from the Seapath 200 and offset measurements made for each piece of equipment during a vessel survey. The measurements were made in real-time using QINSy data collection software. An output file was created from the beginning of the first drift to the end of the second drift that contained Time, Easting, Northing and Height.

Measurements were logged for several minutes with no way on; the engine RPM was then increased to the desired RPM. Once the vessel was at the desired speed, measurements were logged for several more minutes. For the December 16, 2006 measurement, power was then removed and the vessel was brought to a drift. Several more minutes of data was logged. This procedure was repeated throughout the RPM range used when surveying. The January 19, 2007 measurements followed a procedure which involved increasing the RPM by 200 after logging each setting. The vessel conducted the zero speed drift measurements at the beginning and end of each full-range run.

Settlement was calculated by averaging the static measurements at the beginning and end of lines and comparing this average with the average measurements while the vessel was under way throughout the speed range. A graph was then constructed to illustrate settlement changes as a function of vessel speed.

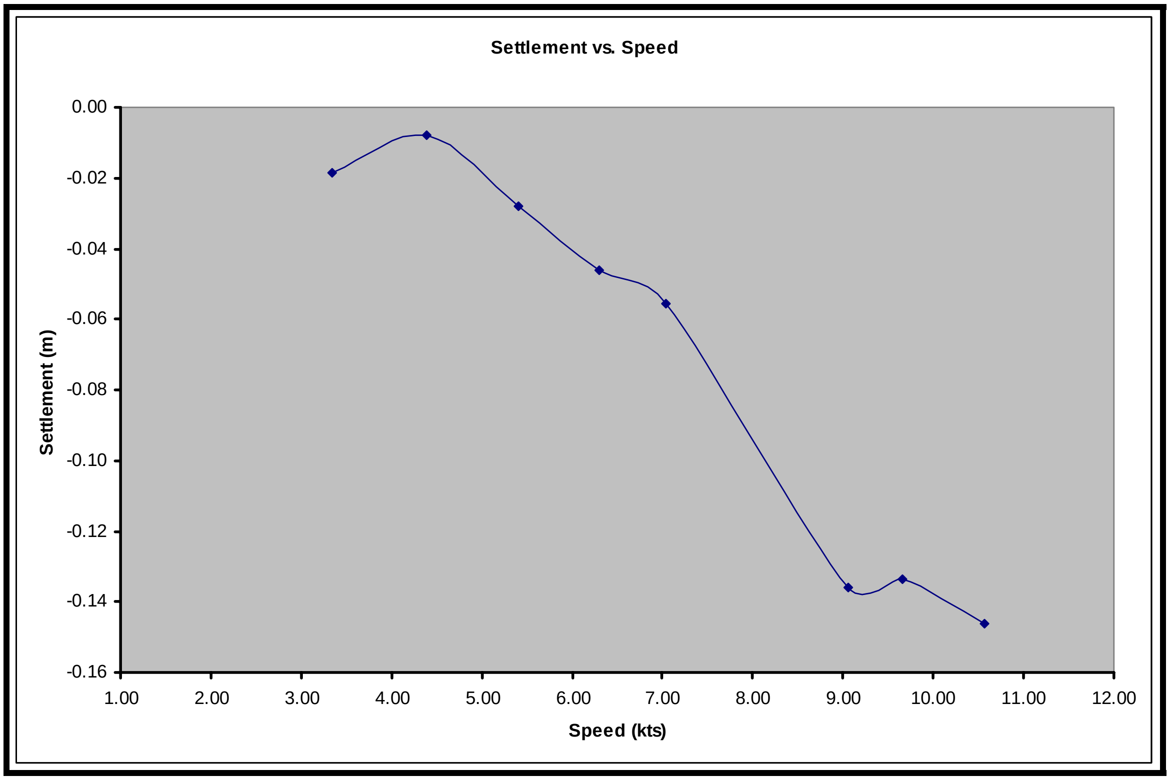


Figure 6 – Bella Marie Settlement & Squat Measurements.

Table 14 – Bella Marie average speed vs. settlement measured during Settlement & Squat survey on JD 2006-141.

Average Speed (kts)	Settlement (m)
3.35	-0.02
4.38	-0.01
5.41	-0.03
6.30	-0.05
7.04	-0.06
9.05	-0.14
9.66	-0.13
10.56	-0.15

Tide Correctors

The National Water Level Observation Network (NWLON) station at Dauphin Island, AL (873-8151) served as datum control for this survey. The tidal datum for the survey was Chart Datum, Mean Lower Low Water (MLLW).The Dauphin Island station and the Pascagoula NOAA Lab, MS water level station (874-1533) provided predicted tides and weekly verified tide data. Verified data was downloaded from the NOAA internet Hydro Hot list (http://co-ops.nos.noaa.gov/hydro.shtml in ASCII format and applied to the raw data in CARIS HIPS and SIPS during the merge step of initial data processing.

Project Wide Tide Correction Methodology

The tidal zoning scheme was provided in the statement of work. The water level stations at Dauphin Island, AL (873-8151) and the Pascagoula NOAA Lab, MS (874-1533) were used as references stations for the zoning scheme. Refer to the Vertical and Horizontal Control Report for tide zone methods and operations.

R/V Davidson

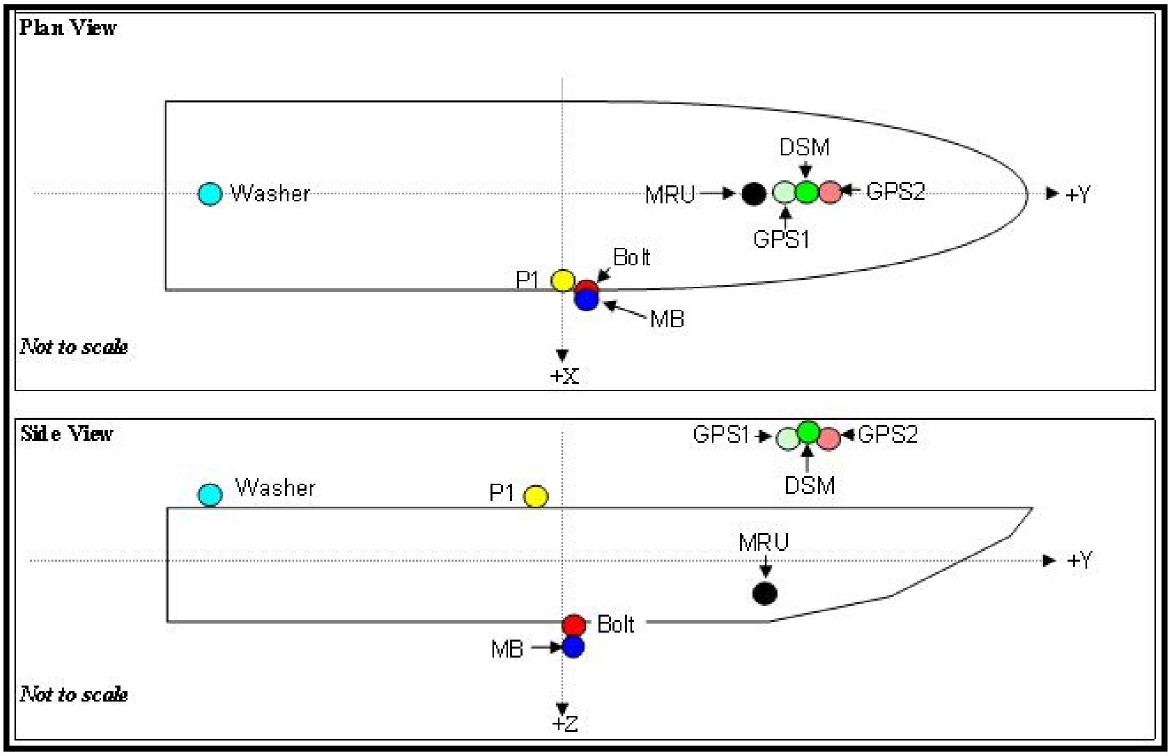


Figure 7 - R/V Davidson vessel survey effective from JD 2006-144 through JD 2006-300.

Table 15 – R/V Davidson offset measurements determined during the initial vessel survey. The CARIS convention of + down (z), + starboard (x) and + forward (y) was used for all measurements.

Equipment	Manufacturer / Model	Offset from CRP (m) based on CARIS Convention		
		X	Y	Z
MRU	Seatex MRU-5	±0.000	±0.000	±0.000
Washer	N/A	±0.000	-27.080	-5.480
P1	N/A	+5.520	-10.780	-5.480
Top Aft Bolt	N/A	+6.120	-9.570	+2.020
MB Transducer	Reson Sebat 8101	+6.120	-9.590	+2.320
GPS1 (Primary)	Seapath 200 RTK	±0.000	+2.920	-23.750
GPS2 (Secondary)	Seapath 200 RTK	±0.000	+4.920	-23.790
DSM	Trimble DSM 212	±0.000	+3.670	-23.710

Bella Marie

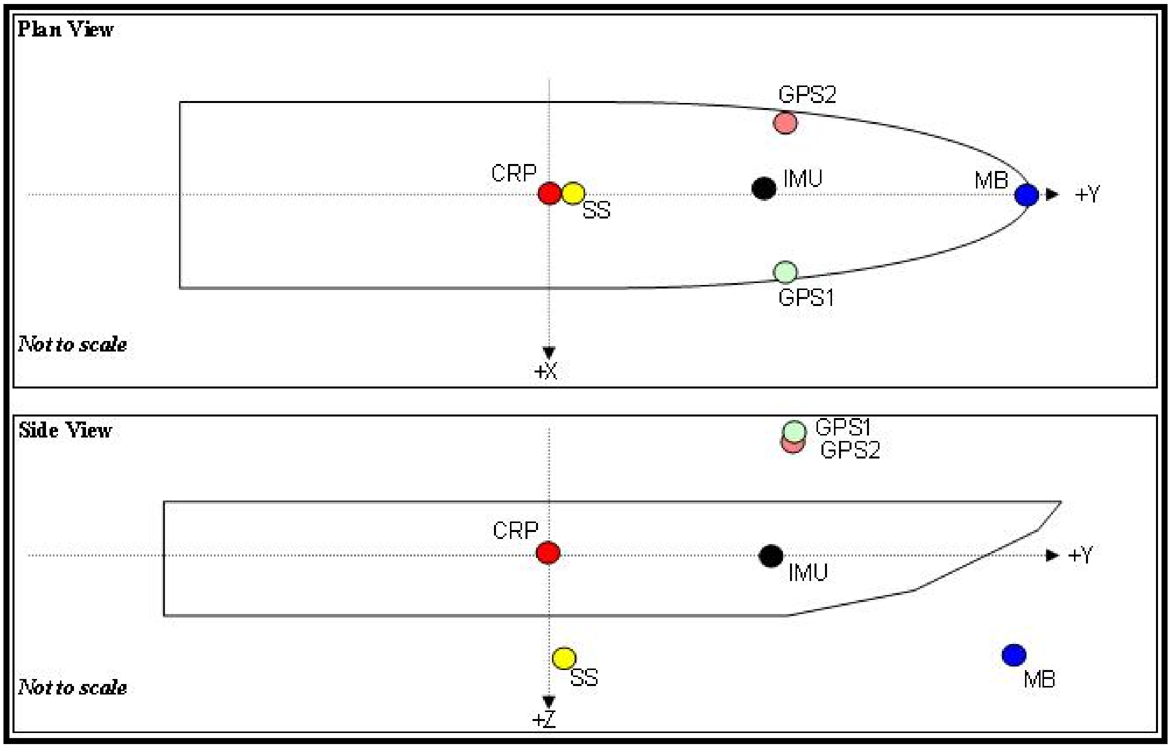


Figure 8 – Bella Marie vessel survey effective JD 2006-314 through JD 2007-012.

Table 16 – Bella Marie offset measurements determined during the initial vessel survey. The CARIS convention of + down (z), + starboard (x) and + forward (y) was used for all measurements.

Equipment	**Manufacturer / Model**	**Offset from CRP (m) based on CARIS Convention**		
		X	**Y**	**Z**
IMU	Seatex MRU-5	-0.099	+2.957	-0.295
CRP	N/A	±0.000	±0.000	±0.000
MB Transducer	Reson SeaBat 8124	+0.000	+7.154	+1.991
Side Scan Sonar	EdgeTech 4200 FS	+0.000	+0.484	N/A
GPS 1 (Primary)	Seapath 200 RTK	+1.472	+2.283	-5.101
GPS 2 (Secondary)	Seapath 200 RTK	-1.436	+2.298	-5.108

Bella Marie

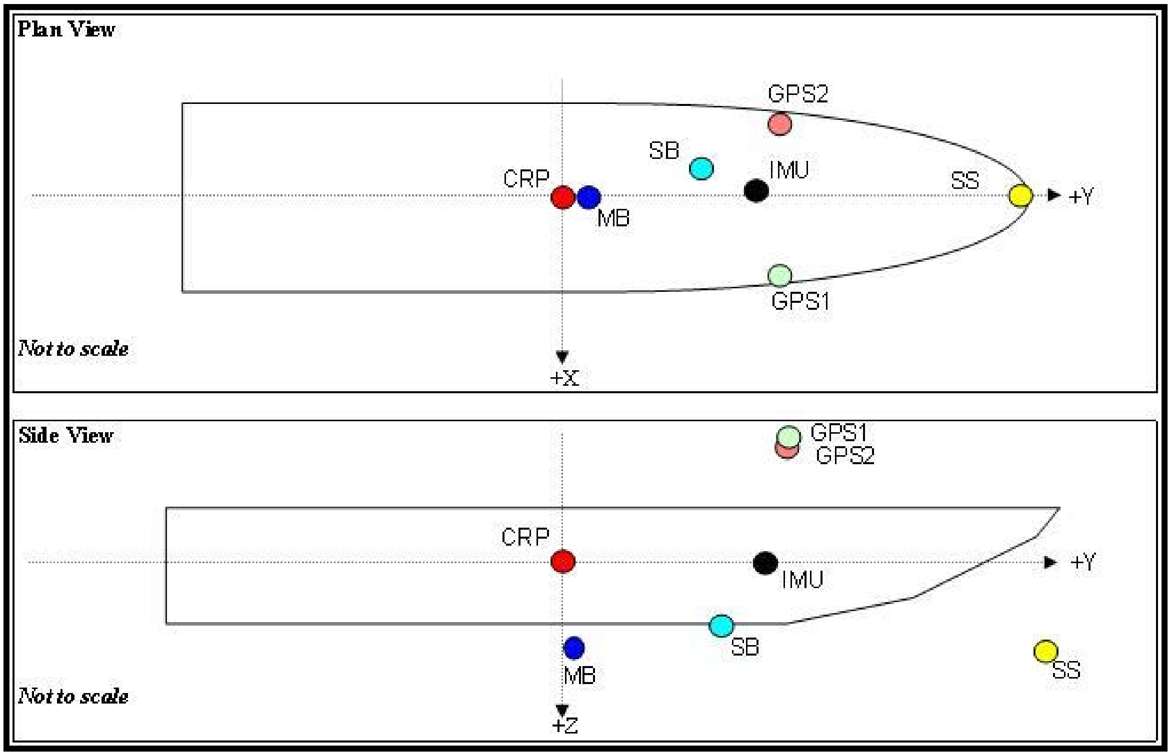


Figure 9 - Bella Marie vessel survey effective JD 2007-013 through JD 2007-084.

Table 17 – Bella Marie offset measurements determined during the initial vessel survey. The CARIS convention of + down (z), + starboard (x) and + forward (y) was used for all measurements.

Equipment	Manufacturer / Model	Offset from CRP (m) based on CARIS Convention		
		X	Y	Z
IMU	Seatex MRU-5	-0.099	+2.957	-0.295
CRP	N/A	±0.000	±0.000	±0.000
MB Transducer	Reson SeaBat 8124	+0.005	+0.484	+1.843
Side Scan Sonar	EdgeTech 4200 FS	+0.000	+7.154	N/A
SB Transducer	Hydrotrac 40 KHz	-1.088	+2.326	+0.972
GPS 1 (Primary)	Seapath 200 RTK	+1.472	+2.283	-5.101
GPS 2 (Secondary)	Seapath 200 RTK	-1.436	+2.298	-5.108